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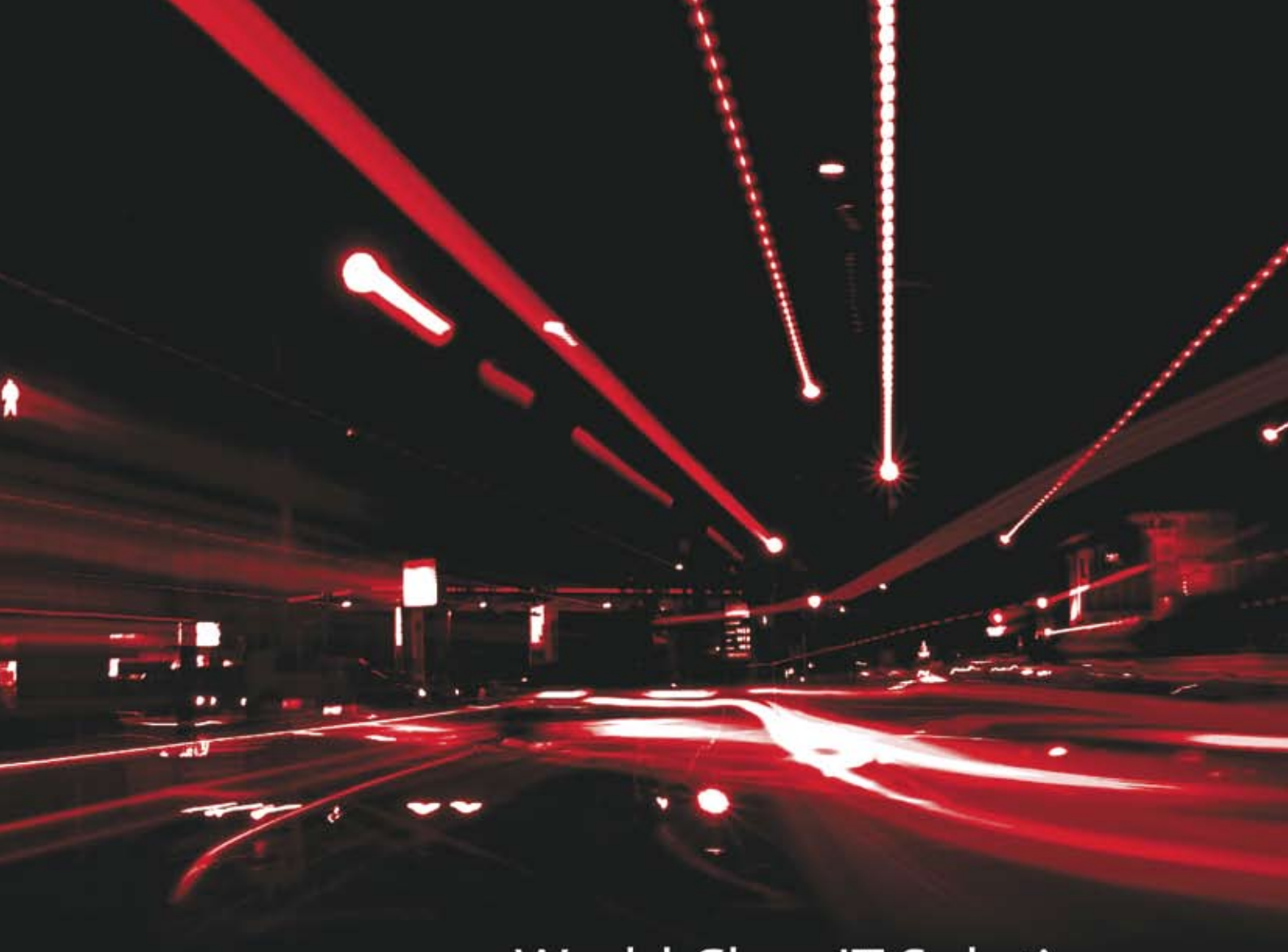

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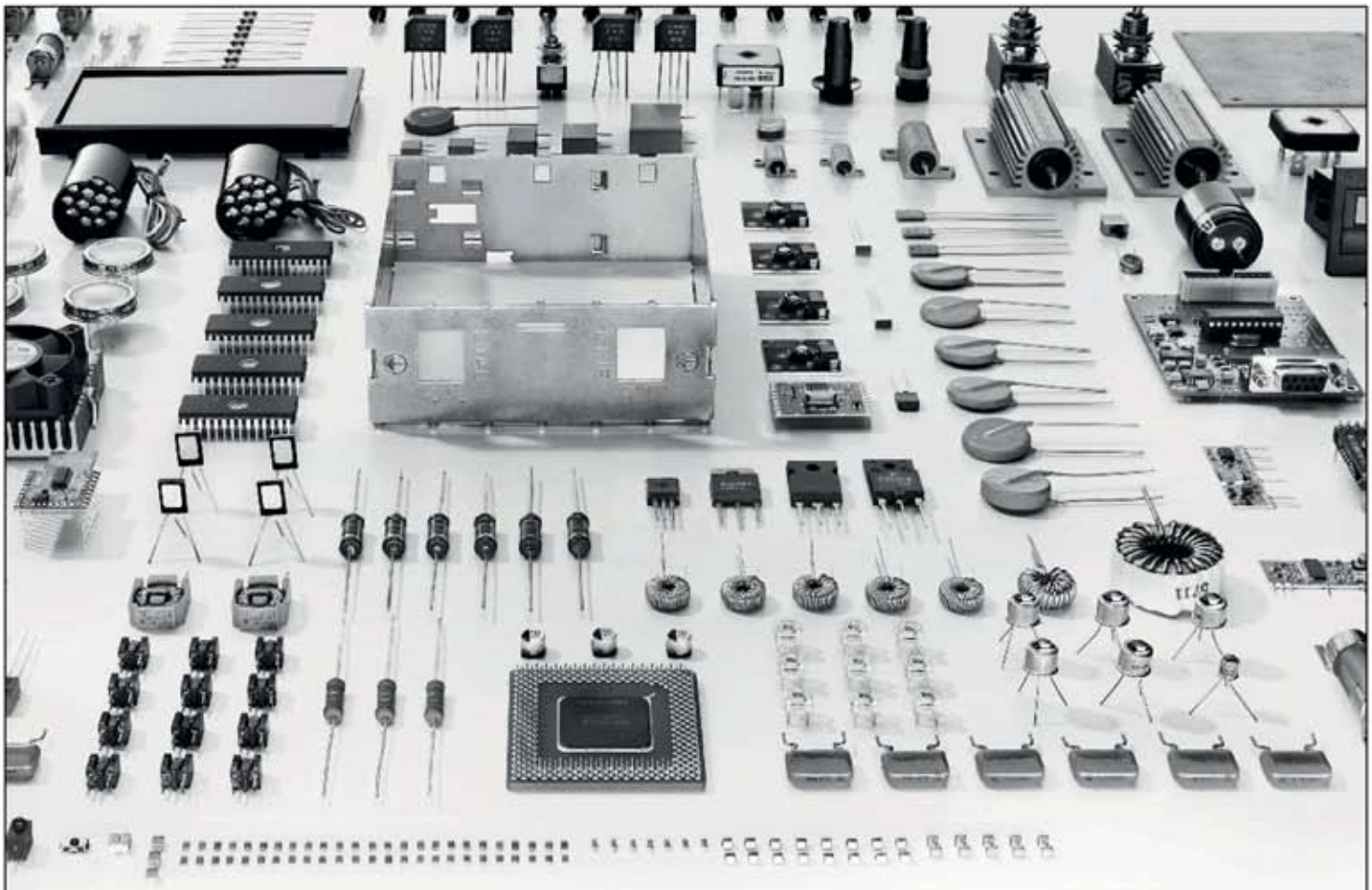

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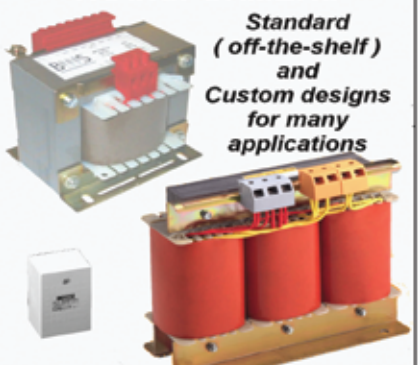
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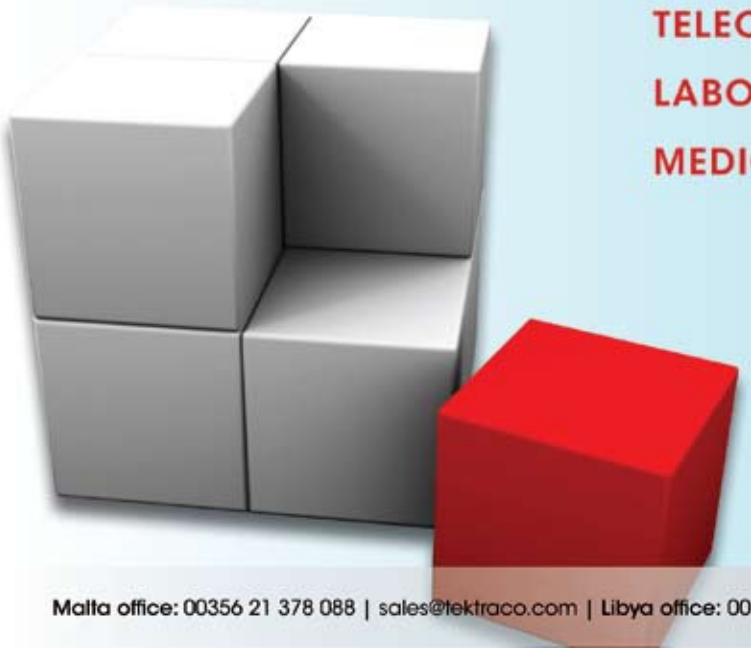

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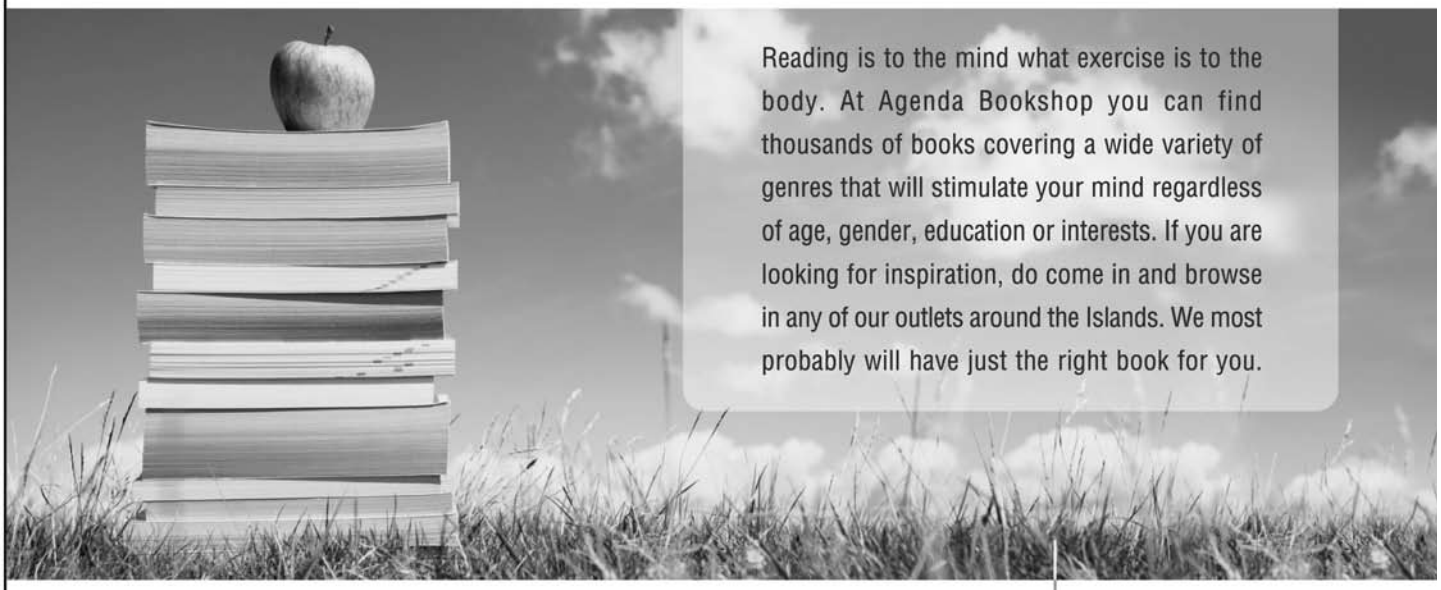

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Cover Design - Engineering sustaining our future
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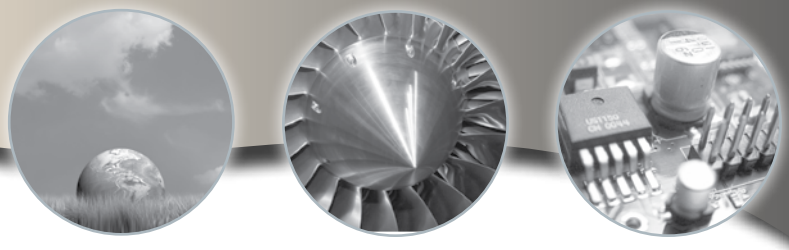


Contents

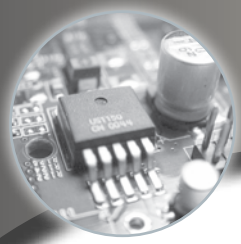
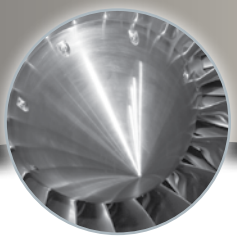
Foreword....14
Faculty Facilities....15
Areas of Research....18
External Funded Projects....19
Collaborating Organistations....20
Acknowledgements....20
Faculty of Engineering - Members of Staff....21

Projects supervised by members of the Department of Mechanical Engineering

Mathematical Model of a Tube-Fin Heat Exchanger - *Agius Robert ME1* 26
A Study on the Mechanics of Creep - *Apap Claire ME2*....27
Design and Construction of an Indoor Blimp - *Camilleri Andrew ME3* 28
Peltier Cooling - *Camilleri Josef ME4*....29
Mitigation of Welding Distortion and Residual Stresses via Cryogenic Cooling - A Numerical Investigation. - *Cutajar Jonathan ME5* 30
Design and Construction of a Free Piston Engine - *Dalli Illan ME6* 31
The Design and Construction of a Human Powered Boat - *Eberjer Clive ME7* 32
Experimental Analysis of a Fixed and Variable-Speed Air Conditioning System - *Fenech Graziella ME8*....33
Design and Construction of a Model Floating Offshore Wind Turbine - *Fenech Lawrence ME9*....34
Investigation of Proper Refrigerant Condenser Design - *Genius Keith ME10*....35
Mathematical Model of a Geothermal Air-Conditioning Unit - *Grima Amanda ME11* 36
Further Work on a Vapour Absorption Refrigeration Test Rig - *Lanzon Kris ME12* 37
Investigation of the Heat Transfer in the End Region of Small Electric Machines - *Saliba Adrian ME13* 38
Numerical Modelling of Welded Structures Subject to Thermal Tensioning - *Scicluna Maxine ME14*.... 39
Stress and Strain Analysis on a Physiological and Pathological Knee Joint - *Seychell Clive ME15* 40
Designing a Disassembly Process for Household Appliances - *Spiteri Andre ME16*....41
Energy Analysis and Efficiency Evalutation of a Pool Complex - *Spiteri Matthew ME17*....42
Design and Construction of a Low-Speed Open-Jet Wind Tunnel - *Vella Ramon ME18*....43

Projects supervised by members of the Department of Metallurgy and Materials Engineering

Plasma Anodizing of Magnesium Alloys - *Azzopardi Damien MME1* 44
Development of an Innovative Air Filter for Removing Particulate Emissions from Diesel Engines - *Borg Christopher MME2* 45
Development of New Methodology for Materials Selection - *Ciliberti Daniel MME3*....46

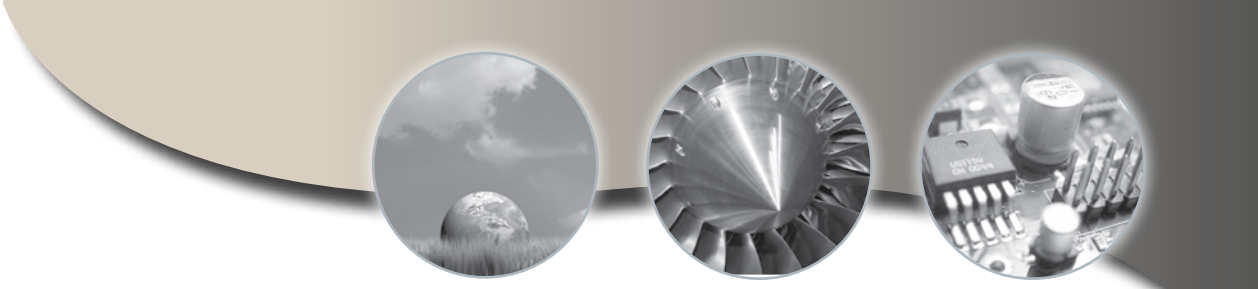
Development of a Modified Slurry Pot Erosion Testing Machine Design - *Consoli Thomas MME4* 47
Laser Process for Welding of AISI 316 Steel Parts - *D'Amato Clayton MME5* 48
Development of Procedures for Using a Modified Slurry Pot Erosion Testing Machine Design - *Farrugia Francelle MME6* 49
Mechanical Testing of Fibre-Reinforced Polymer Matrix Composites - *Zerafa Samuel MME7*...50

Projects supervised by members of the Department of Industrial and Manufacturing Engineering
Studying the Feasibility of Small Hole Drilling using Conventional EDM - *Borg Astrid IME1* ...51
Process Evaluation Towards Lean Production - *Calleja David IME2* 52
Design and Construction of a Machine Vision System for Inspecting Cosmetic Cases - *Desira Luke IME3*....53
Automation Considerations in a Bulk Tablet Packing Process - *Fenech Ian IME4*....54
Machining using CO2 Laser - *Galea Roberta IME5* 55
An Innovative Tool for Global Design and Manufacturing - *Mifsud Darren IME6* 56
Improving Smoothness and Reducing Sound in Lipstick Packaging - *Spiteri Gilbert IME7*....57
Increasing Efficiency in the Laundry Department of Portughes Laundry and Dry Cleaning - *Spiteri Jeremy IME8*....58

Projects supervised by members of the Department of Industrial Electrical Power Conversion
Charging and Discharging of high capacity Lithium ion batteries - *Buttigieg Samuel EPC 1*....60
DC electronic load with energy recovery - *Camilleri James EPC 2*....61
Sensorless control of an AC drive for electric cars - *Sciberras Edward EPC 3* 62
The design and implementation of an electric boat - *Testa Conrad EPC 4* 63
Energy Efficiency in Buildings - *Zammit Karl EPC 5*....64

Projects supervised by members of the Department of Electronics Systems Engineering
Design and construction of flight simulator components (Part 1) - *Abdilla Analiza ESE 1* 65
Indoor Blimp - Electronics - *Apap Edward ESE2*....66
Simulation of a typical Flight Management System - *Bartolo Roderick ESE3*....67
A contract protocol for traffic conflict mitigation in aviation - *Bonnici Graziella ESE4* 68
Design and construction of flight simulator components (Part 3) - *Busuttil Mario ESE5*....69
Design and construction of flight simulator components (Part 2) - *Ellul John ESE6*....70
Inertial measurement in light-weight head mounted display systems - *Fonk Kenneth ESE7*....71
Ensuring safety and stability measures on a crane - *Galea Anna ESE8* 72
Aircraft ground movement modelling - *Muscat David ESE9* 73
A navigation algorithm for airborne platforms - *Parascandalo Daniel ESE10*....74
Image Warping - *Satariano Jean ESE11*....75

Projects supervised by members of the Department of Systems and Control Engineering SCE
Control of a Robotic Finger with Non-Conventional Actuators - *Aquilina Nicholas SCE 1* 76
Signal Processing of Cyclic Voltammetric Measurements to discriminate between Neurotransmitters in vitro Solutions - *Azzopardi Carl SCE 2*....77



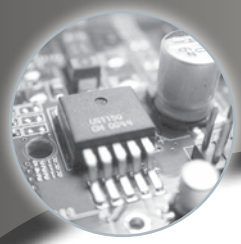
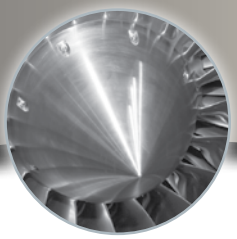
Geo-location by view analysis - *Balzan Emanuel SCE 3* 78
Active Vibration and Noise Control - *Dimech Steve SCE 4* 79
Multiple Model Adaptive Control - *Gauci Melvin SCE 5* 80
Head Motion Tracking - *Sapienza Michael SCE 6* 81
Spatio- Temporal Modelling of the Ozone layer - *Tabone Sarah SCE 7* 82
Identifying globally Salient Line paths from scribbled drawings - *Vella Clifton SCE 8* 83
Control of a Rotational inverted Pendulum - *Zahra Steve SCE 9* 84
Analysis of brain networks during specific mental states - *Zhu Tingting SCE 10* 85

Projects supervised by members of the Department of Communications and Computer Engineering in the Faculty of ICT

Indoor Blimp – Communications - *Bezzina Andrew CCE 1* 86
Corrosion Mapping - *Cremona Daniel CCE 2* 87
Robust Video Transmission using Data Hiding Techniques - *Facciol Robert CCE 3* 88
Remote Processing of an interactive application - *Gauci George CCE 4* 89
Using a Genetic Algorithm to Construct VLEC Codes - *Grima Steven CCE 5* 90
IPv6 Virtual Test bed - *Lia Josef CCE 6* 91
A study on the QoS of Multi-View Video Search Streams Transmitted over Wireless Channels - *Micallef Brian CCE 7* 92
Video and Image Search - *Micallef Jeffrey CCE 8* 93
Adaptive and Distributive Routing using Artificial Intelligence - *Saliba Chris CCE 9* 94
Solar Powered Wireless Networking - *Scicluna Sylvana CCE 10* 95
Long Distance MIMO Links - *Vella Jean CCE 11* 96
A support vector Machine Approach to Location Estimation in Urban 3G Networks - *Xuereb David CCE 12* 97
Multicasting over 802.11a/g/n - *Yang Shuo CCE 13* 98
Implementation of a Wireless Infrastructure for the Management and Control of a Utility Network - *Zammit Tonio CCE 14* 99

Projects supervised by members of the Department of Microelectronics and Nanoelectronics in the Faculty of ICT

Linearity Analysis of CMOS and Bipolar Analogue Building Blocks - *Apap James MNE 1* 100
Implementation of a Radial Basis Function Neural Network - *Balzan David MNE 2* 101
Design of a CMOS/BICMOS Upstream CATV Amplifier - *Caruana Charlene MNE 3* 102
Digital Implementation of Self-Organizing Maps - *Cutajar Michelle MNE 4* 103
Design of integrated switchmode DC-DC converters using an on-chip /SOC inductor - *Gatt Christine MNE 5* 104

FOREWORD

Dear Reader,

This publication documents the final-year projects that students following the BEng(Hons) degree at the Faculty of Engineering at the University of Malta undertook during academic year 2008-2009.

In one page, each student describes his or her project; what it was all about, what s/he set out to do and what was actually achieved. As can be seen, the range of subjects tackled in this work is very vast, spanning various aspects of mechanical and electrical engineering, and includes fields that have now moved to the new Faculty of ICT.

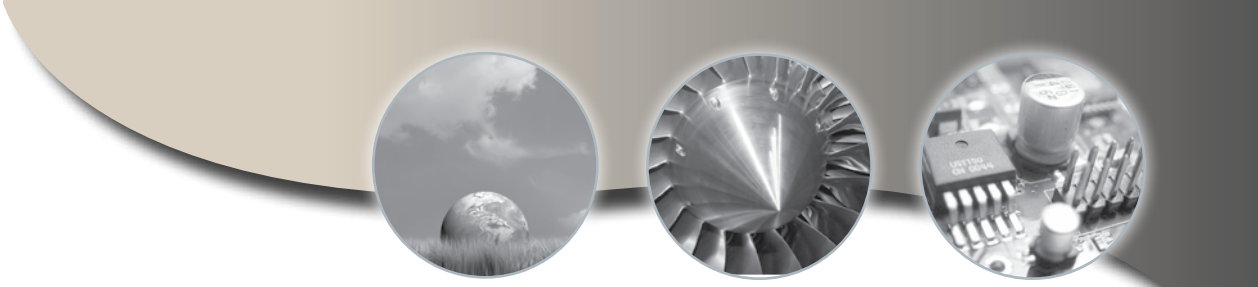
These projects are a very important element of the educational experience that we give our students. The work which culminates in a document of around 100 pages, namely the dissertation, sometimes also referred to as the thesis, is spread over the whole of the final-year, and requires the students to use all the skills that they have acquired during the previous years. These include being able to research a topic, designing and setting up an experiment, carrying out the tests in the correct scientific method, analysing and interpreting the data so obtained and reaching the right conclusions. This they then have to write up, as I have already mentioned, into a dissertation, which must be written not only in good and correct English but also in a structured and logical manner and according to rules and standards that are widely recognised academically.

The academic year that has just come to an end has been an important one for the Faculty. We started the year with a new set of undergraduate courses, with the introduction of a new three-year BEng(Hons) degree in Mechanical Engineering, a new three-year BEng(Hons) in Electrical and Electronics Engineering and a new four year Bachelor (Hons) in Industrial Engineering. The next step is to introduce taught postgraduate courses at Master's level to complement the already existing Masters by research. Some departments are also working on International Masters which are courses run jointly with other European universities and where students spend time in each of the universities taking part in the programme.

We have continued to work on a number of projects funded by the European Regional Development Fund, which will see our laboratories equipped with state-of-the-art equipment and which will enhance the quality of our teaching and research.

I would like to take this opportunity to thank all members of staff, both academic and non-academic for another year of hard work for the good of the Faculty and its students.

Prof Robert Ghirlano
Dean of the Faculty of Engineering



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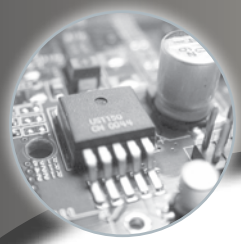
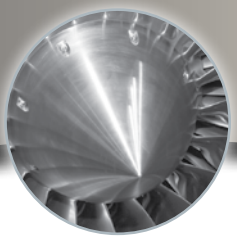



INDUSTRIAL AUTOMATION
PUMA 260 Industrial Robot
DVT SmartImage Sensor and Accessories
Various Actuators and Sensors
PLCs
Automation Training and Prototyping Facilities for Pneumatic and Hydraulic Systems
Interfacing Hardware

INSTRUMENTATION AND CALIBRATION
Electronic Calibration Systems.
High precision electronics measurement equipment.
Metrological Equipment Including CMMs and Surface Texture Measurement.
Calibration of Metrology Equipment in Roundness, Linear and Angular Measurements

POWER ELECTRONICS
Harmonic Voltage and Current Measurement Set-up
Grid Connected PV and Wind Systems
High voltage and current DC supplies
Passive/Active Filters for Power Factor Improvement
Switching Frequency Current Sensing for Power Electronics and Control

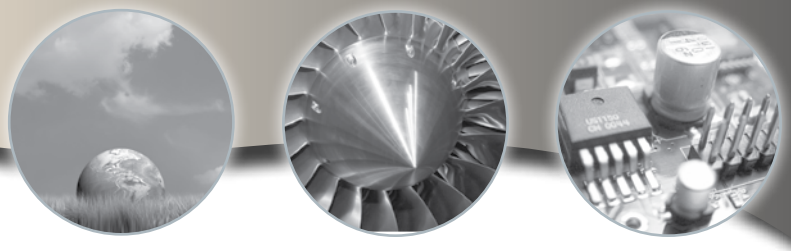
ELECTRONIC CIRCUIT DEVELOPMENT
Digital and Analogue IC Design.
IC Probing Station and Testing Equipment.
PCB Design, Manufacturing and Testing.
FPGA Development.
Electronics bench equipment for electronic system design and analysis.

ELECTRICAL DRIVES
High Performance Machine Control
Vector controlled Induction Motor, Permanent Magnet Synchronous Motor and Switched Reluctance rigs
Medium Power DC Machine Loading Units
Electrical Drives and Control Simulation Software
200V AC 28KVA 3-phase and 200V DC 20KW Supply for Testing Purposes

CONTROL SYSTEMS
Control Systems Design Software
Analogue and Digital Control System Development Tools
Computer Control Interface Boards
Programmable Logic Control (PLC) Systems
Robotic Manipulators
Pneumatic/Hydraulic Control Rigs

COMMUNICATION SYSTEMS
System Design and Analysis Software.
Digital and Analogue Satellite Receivers.
Video Encoding Systems.
HF, VHF and UHF Transceivers.
Communications Test Equipment.
Microwave Equipment.

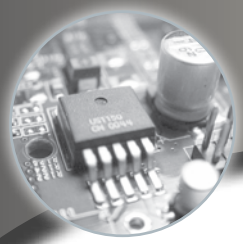
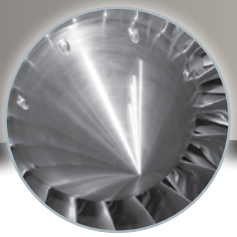
COMPUTER SYSTEMS
In-Circuit Emulators.
Microcontroller systems.
Computer Network Modelling Software.



SIGNAL PROCESSING SYSTEMS
Speech and Vision Software and Hardware.
Motion Control DSPs.
Other DSP Hardware.
Acoustic Measurement Software and Hardware.

IMAGE PROCESSING
Solid-State Cameras.
Frame Grabber.
Digital Image and Video Capture and Recording Equipment.
Machine Vision Lighting Equipment.
Thermal Imager.

GENERAL
Networked Computer Laboratories.
Mail and Web Servers.
100Mbits Switched Network in all offices and laboratories.
MATLAB and Simulink Simulation Software.
C, C++ and Fortran Programming Language Development.

AREAS OF RESEARCH

Mechanical Engineering
Wind Turbines; Welding Residual Stresses and Distortion; Biomechanics; Pressure Vessels; Structural Integrity; Energy; Sound and Vibration; Refrigeration; Thermodynamics/Fluids; Internal Combustion Engines; Aerodynamics; Solar Cooling; Marine Engineering

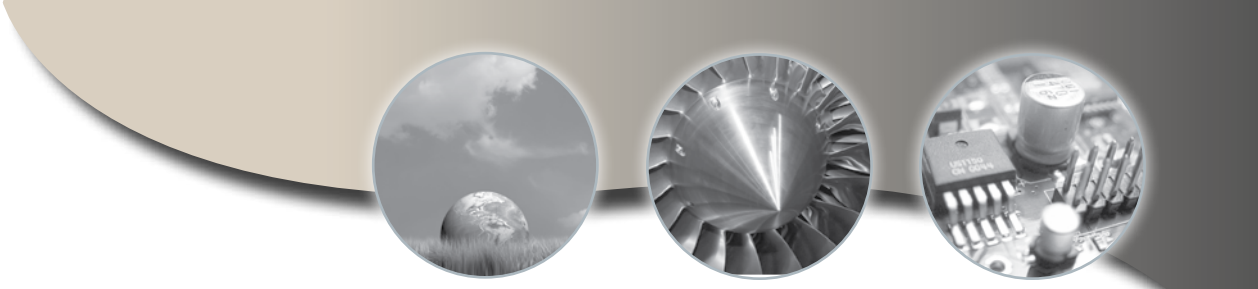
Metallurgy and Materials
Ion-beam Assisted Deposition; Laser Surface Engineering and Material Deposition; Plasma Assisted Physical Vapour; Plasma Anodizing of light metals; Laser Rapid Fabrication; Thermochemical Processing of medical grade stainless steel; Thermal Treatments of Shape Memory Alloys; Solar Desalination (collaboration with MEC); Surface coating for conservation of metallic artefacts; Development of Nano Coatings For High Efficiency Solar Energy Absorption; Degradation of Composite Materials.

Industrial and manufacturing Engineering
Concurrent Engineering; Intelligent Systems in Design and Manufacturing; Computer Aided Engineering Design; Product Development Technologies and Methodology; Rapid Prototyping; Industrial Sustainable Development; Industrial Robotics and Mechatronics; Robotic Grasping and Handling; Industrial Automation; Quality Engineering; Micro Manufacturing.

Industrial Electrical Power Conversion
Sensorless Control of A.C. Machines; Control of Electrical Machine Drives; Electromagnetic Design of Electric Machines; Direct AC-AC Converters; Switching Power Converters; EMC of Power Converters; Electric Transportation Technology (Electric Cars, Electric Boats); Wind and P.V. Grid Connected Systems; Analysis of Renewable Energy Systems for Grid Integration; Microgrids and Smart Grids; Quality of Electrical Supply; Domestic and Industrial Electrical Energy Efficiency; Energy Efficiency in Buildings.

Electronic Systems Engineering
Electronic System Design; Aviation Safety; Avionics Sytems; Air Traffic Management; Trajectory Optimisation; Flight Control and Guidance; Traffic Collision Avoidance; Surveillance; Cockpit Display and Instrumentation Design; Flight Simulation and Modelling.

Systems and Control Engineering
Computational Intelligence; Signal and Image Processing; Biomedical Signal Processing; Neural Networks; Machine and Computer Vision; Automatic Control Systems; Automatic Control Systems; Adaptive and Intelligent Control; Robot Control Systems; Spatio-temporal System Modelling; Bayesian Estimation.



EXTERNALLY FUNDED PROJECTS

CCOPPS – Certification of Competences in the Power and Pressure Systems Industry
Department of Mechanical Engineering in a consortium with other European partners
Funding Source: EU Leonardo Programme

Solar Desalination – Production of portable water in a completely sustainable manner
Department of Mechanical Engineering and Department of Metallurgy and Materials
Funding Source: MCST Programme

FastAhead – Strengthening Asian Higher Education on Advanced Design and Manufacture
Department of Industrial & Manufacturing Engineering in a consortium with other universities
Funding Source: EU Asia-Link programme

IDeLap - ICT based design tool from the Development of Micro-parts for a Laparoscopic Surgery tool
Department of Industrial & Manufacturing Engineering in a consortium with other universities
Funding Source: National RTDI-2006

AUTOMATE – Investigating and improving the use of manufacturing automation in the Maltese Islands
Department of Industrial & Manufacturing Engineering
Funding Source: National RTDI-2006

ECON2 - Marie Curie Fellowships for Early Stage Research Training in Electrical Energy Conversion and Conditioning Technology
Department of Industrial Electrical Power Conversion in a consortium of European universities
Funding Source: EU Marie Curie Programme

FLYSAFE
Department of Electronic Systems Engineering in a consortium with 33 other European partners Funding: EC Framework Programme 6

Clean Sky
Department of Electronic Systems Engineering, in collaboration with the Department of Computer Science, Faculty of ICT, in a consortium with 33 other European partners
Funding: EC Framework Programme 7

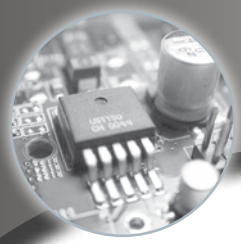
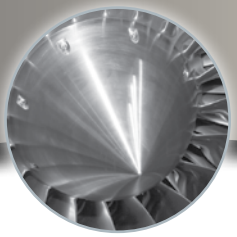
ODICIS
Department of Electronic Systems Engineering, in a consortium with 8 other European partners Funding: EC Framework Programme 7

ALICIA
Department of Electronic Systems Engineering, in a consortium with 8 other European partners
Funding: EC Framework Programme 7

3D-Head
Department of Systems and Control in collaboration with Megabyte Ltd
Funding Source: National RTDI-2004

Biopattern
Department of Systems and Control in an FP6 consortium of 32 EU institutions
Funding Source: EU FP6 ICT for Health

Computational Intelligence Techniques for Control of Complex Systems
Department of Systems and Control Engineering
Funding Source: National RTDI-2004

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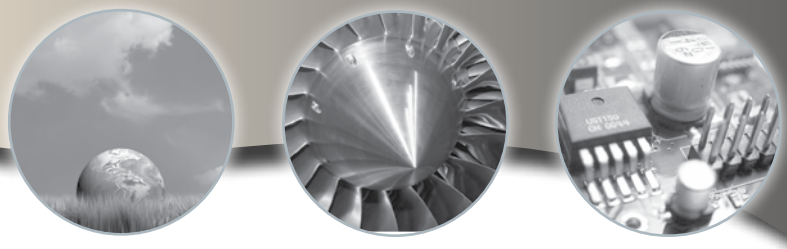
The following firms worked conjointly with the Faculty on some of this year's engineering projects by providing essential expertise or financial and technical resources:

Abertax Quality Ltd, Actavis Ltd, Delta (Malta), Buccaneer, CMT Laboratories, BVT Surface Fleet Ltd, Ecological Ltd, Engenuity Ltd, Ministry for Resources and Rural Affairs, Malta Tourism Authority, Middlesea Valletta Life Assurance Company Ltd, Portughes Laundry and Dry Cleaning, Prominent Fluids Controls Ltd, Scicluna & Associates Engineering Consultants, Seifert mtm Systems (Malta) Ltd, Solid Base, Surface Engineering Ltd, Toly Products Malta.

ACKNOWLEDGEMENTS

The Faculty gratefully acknowledges the following firms and organisations for financially supporting this year's Engineering Projects Exhibition:
Abertax Quality Ltd, Deeco Ltd, Dedicated Micros Malta Ltd, Enemalta, Fabian Enterprises, Farsons Ltd, FGP Ltd, Megabyte Ltd, MCST, Methode Electronics Ltd, RS Components, Tektraco, Wurth Ltd

The Faculty also gratefully acknowledges the following organisations for kindly offering prizes to students who have shown commendable performance in some specific aspect of their B.Eng.(Hons) course of studies:
Chamber of Engineers, Group of Professional Engineering Institutions, RS Components, Tektraco, The Institution of Engineering Designers



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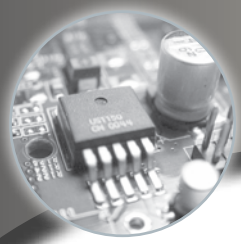
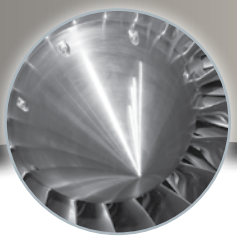

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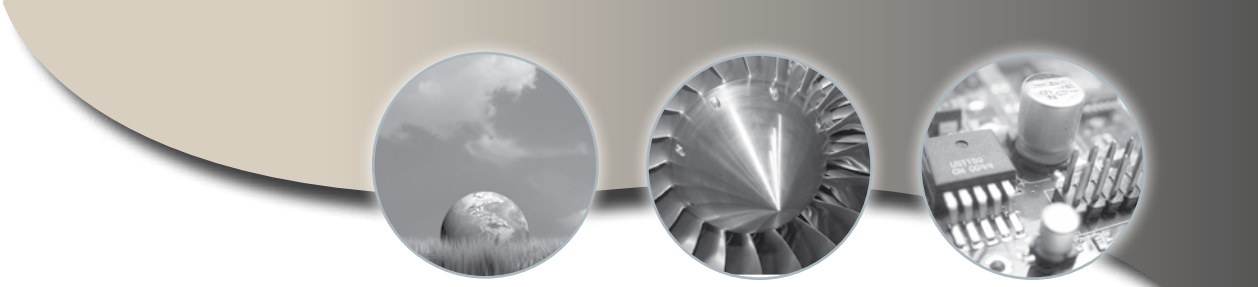

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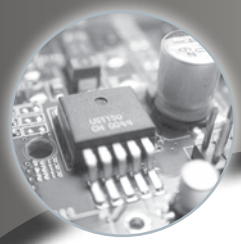
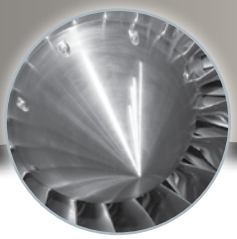

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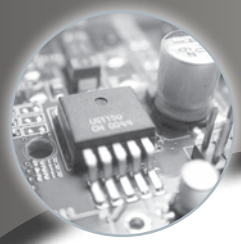
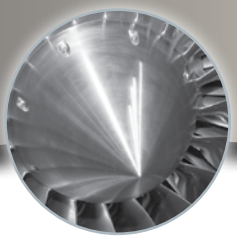
Mechanical Engineering Stream

MATHEMATICAL MODEL OF A TUBE FIN HEAT EXCHANGER

Student: Agius Robert **Supervisor: Dr. Ing. Christopher Micallef**

Introduction

Most common material used for heat exchanger is copper due to its high thermal conductivity. But there is the negative side of using this material, the cost of copper for production is typically three times the cost of an equivalent size of aluminum this cost increase is based on many factors.

Project objectives

The main objectives of this dissertation are:

- To build a thermal model of a tube fin heat exchanger and validate it.
- To determine the operating characteristics of two similar heat exchangers, one using copper tubes and the other using aluminium tubes.
- To vary the configuration of the aluminium heat exchanger to increase its performance.

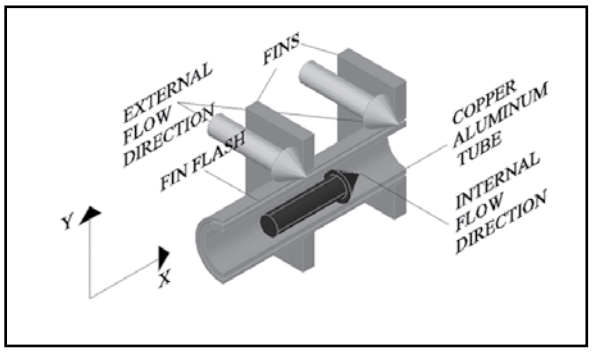


Figure 1: Representation of the different fluids directions of the heat exchanger system between the fins and around the tubes and the internal flow

Project methodologies

One major use of compact heat exchanger in today's technology is in electronic cooling systems. An effective thermal design is required to sustain the trend of smaller power electronic devices.

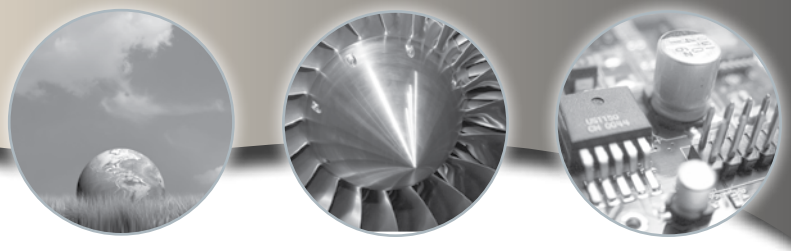
A mathematical model was built in order to investigate the heat transfer of a compact tube fin heat exchanger. In investigating the heat transfer of the system, the heat transfer through the heat exchanger was simplified to be in two-dimensions of figure 1 above. The x direction was the heat transferred along the tube of the heat exchanger and the internal flow while the other direction was the heat transferred between the internal and external flow over the heat exchanger.

In heat transfer between the two fluids, which in this case was water in the tubes and air flowing around the tubes, negligible heat transfer losses to the surrounding atmosphere was considered also negligible potential and kinetic energy changes. Since there is no phase change in the heat exchanger and for constant specific heat capacity equation 1was applied to the heat exchanger:

$$\dot{m}_W c\left(T_{out_W} - T_{in_W}\right) = \dot{m}_{air} c_p \left(T_{out_{air}} - T_{in_{air}}\right) \ldots EQN\ 1$$

Experimental and thermal model results

Given two heat exchangers with same design same configuration same tube diameters but one with aluminium tube and the other with copper tubes, various tests were carried out on both of them on the test rig and as well on the mathematical model. It is well clear that both of these metals have high thermal conductivity with copper having a thermal conductivity higher than that of aluminium and more commonly used for heat exchangers until now. But there is a minor difference in the heat transfer between the two heat exchangers which can be due to various reasons as explained in the dissertation write up.



A STUDY ON THE MECHANICS OF CREEP

Student: Claire Apap **Supervisor: Dr. Ing. Martin Muscat**

Introduction

Creep is a phenomenon which happens after a very long time in various materials; this is defined as a deformation occurring on any material due to the submission to load and temperature exposure for a long period of time. Creep becomes a problem when failure could occur due to the large deformations in the structure or component. The effect of creep is different for each material since creep deformation is a function of the melting temperature.

Creep can be seen in many mechanical components; a turbine blade of an aircraft which experiences different stresses and temperatures along the flight cycle is one such example. The electronic industry is also affected by creep as for example during the soldering of electronic components. Power generation is another sector where creep is present, here many components are exposed to high temperatures and therefore are susceptible to creep. These components could range from bolted flanges to pressure vessels.

Project Objectives

- To study the mechanics of creep in metals.
- Select and study a relevant code of standard.
- Use the code standards and learn how to design for creep.
- Find examples and work them out using the standards while trying to relate them to industrial examples.
- Use finite element software to help in creep design.

Project Methodologies

- A sound background on creep was studied, mainly creep in metals
- The background and theory were written down in the form of the literature review
- Code standards were studied regarding industrial components
- A calculation against creep was done to determine the thickness of a boiler tube using BS 1113:1999
- Further studies of creep in pressure vessels were done using BS EN 13445-2:2006
- Creep checks are being done using ANSYS®

Results and Achievements

The results achieved at this stage are calculations which were done to determine the sufficient thickness of boiler tubes. Code standards were also used to enhance the study of creep in pressure vessels. Finite Element modeling is being done as an alternative to design by formula. Moreover, this thesis was the first step to further studies on creep, since this is currently a new subject being studied in our Faculty.

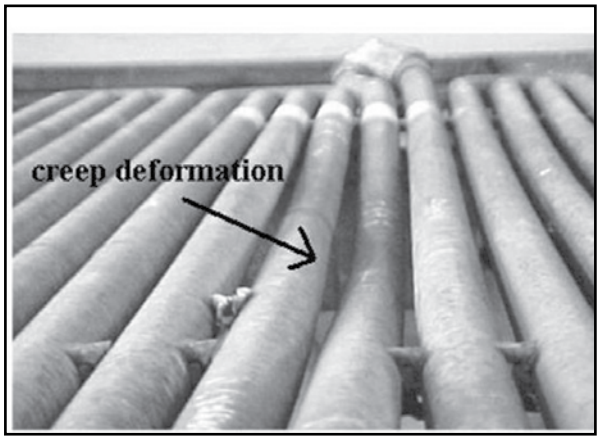


Figure 1: Creep Deformation in Superheater Tubes

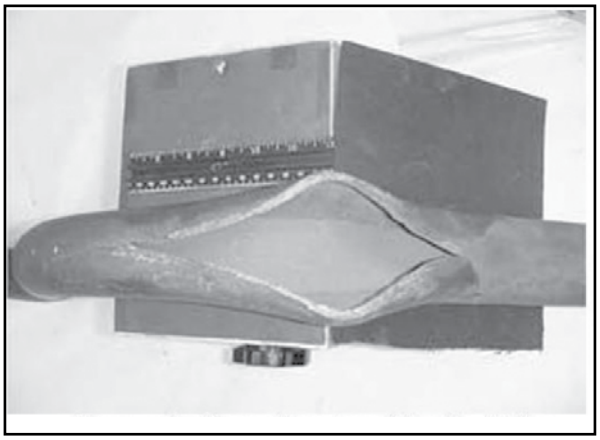
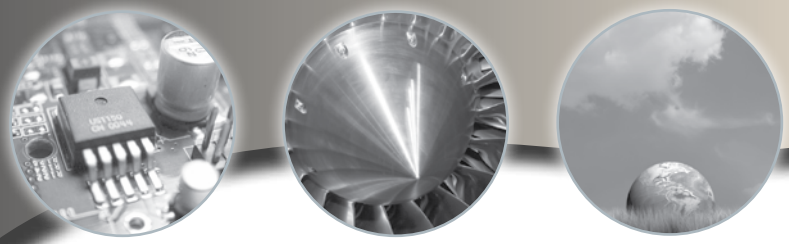


Figure 2: Creep Ruptured Boiler Tube



DESIGN AND CONSTRUCTION OF AN INDOOR BLIMP

Student : Andrew Camilleri

Supervisor: Dr. Ing. Martin Muscat
Co-Supervisor: Ing. P.P. Debono

Introduction

The blimp structure resulting from this project is aimed to be used for indoor surveillance. The blimp shall be controlled via remote control and its various motors shall control its direction of flight within the indoor space. It shall be able to perform various surveillance functions through the electronic equipment attached to it.

Project Objectives

The aim of this project was to design and construct an indoor blimp structure capable of carrying a 1kg payload. The blimp structure had to be as lightweight as possible. Also, the minimum dimensions had to be considered for the blimp in order for effective maneuvering to be achieved via the propellers.

Project Methodologies

Research was carried out to aid in making certain crucial decisions, such as:

- The material to use for the envelope (the component which contains the helium gas),
- The shape of the blimp,
- The overall dimensions of the blimp.

Experiments were carried out to test the loading capabilities of various materials considered to be used for the envelope of the blimp. From the results of these experiments, the circumferential or hoop stresses that developed were calculated.
A further experiment was carried out to test the permeability of the material, which concluded positively from the previous experiments mentioned. A downsized model of this project's blimp was constructed from this material and filled with air to verify the time for the majority of the gas to escape.

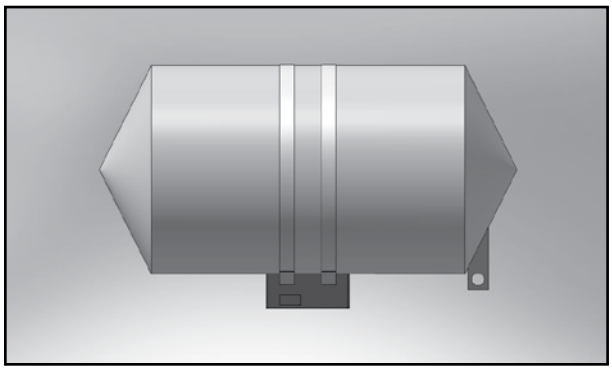


Figure 1: Side view of the blimp

Results and Achievements

From the experiments carried out poly vinyl chloride (PVC) resulted in being the best alternative for the envelope material. Unfortunately, with the PVC found locally the blimp had to be constructed with relatively large dimensions (due to its high density), which are not suitable for indoor use. An alternative material was found from an overseas company, called Mylar A.
An air valve (instead of a helium valve), that is normally used for inflatable boats and dinghies, was used for the construction of the downsized model as well as for this project's blimp.

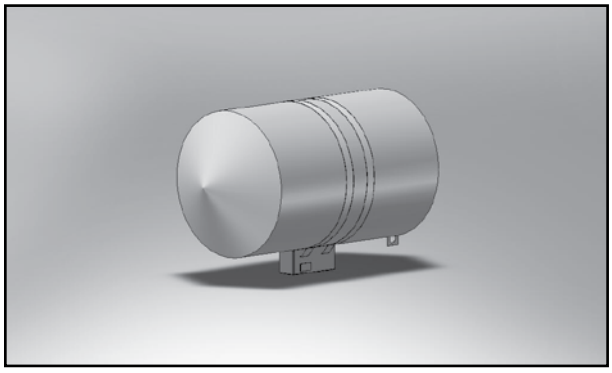
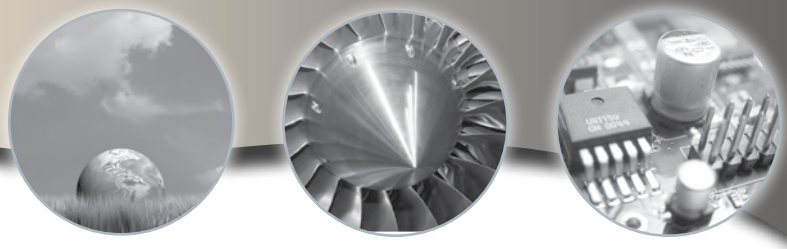


Figure 2: Concept drawing of the blimp



PELTIER COOLING

Student: Josef Camilleri **Supervisor: Dr.Ing.Mario Farrugia**

Introduction

Thermal management of electronics is required in order to reduce the risk of component failure and work more efficiently. Thermoelectric refrigerators are ideal for this application since they perform the given cooling task with the minimum power required. Unlike other cooling solutions, thermoelectrics are silent, compact, and require minimal maintenance.

Project Objectives

The projects' objective is to investigate the use a thermoelectric unit made of a number of Peltier coolers assembled in a sandwich between heat sinks, and optimize its performance.

Project Methodologies

The project deals with the understanding of thermoelectrics and calculations to obtain the best performance of the system through a thermoelectric software and finite difference analysis method. The following steps were carried out during the implementation of the project:

- Literature review on thermoelectric theory and heat transfer through heat sinks.
- Develop a software to investigate the effect of various parameters on the thermal performance, and optimize the operating parameters of a thermoelectric in view of the optimum coefficient of performance, maximum heat pumping capacity, and maximum temperature differential.
- Construct and test thermoelectric samples to validate the software.
- Develop a finite difference model of the heat sink to simulate the heat rejected by the thermoelectrics and model the temperature distribution along the heat sink.
- Perform tests on the heat sink to validate the software.
- Identify the optimum dimensions of the heat sink leading to improve the thermal performance, maximize the effectiveness of the thermoelectric together with the heat sink, and minimize the size, weight, power consumption, and costs of the system.

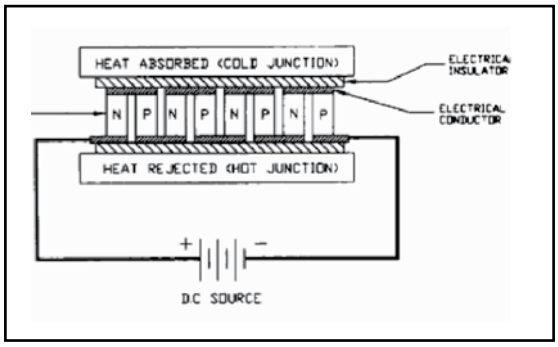


Figure 1: Thermoelectric cooler.

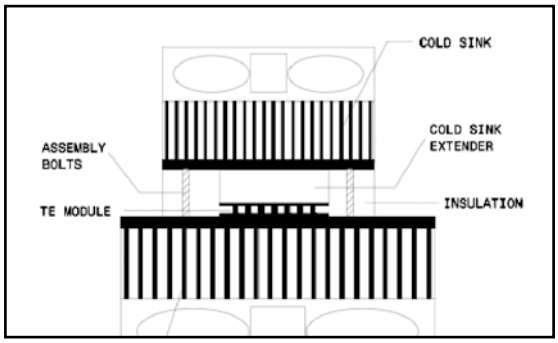
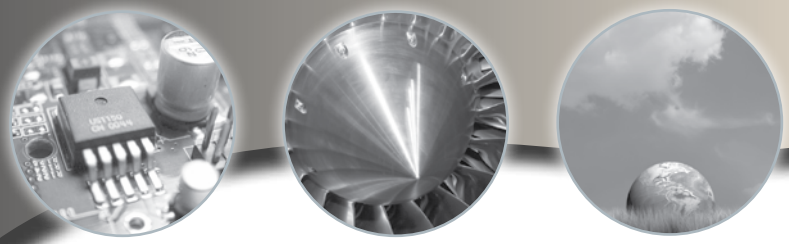


Figure 2: Thermoelectric unit.

Results and Achievements

From power input considerations, it is reasonable to keep the operation of the coolers to values less than the current yielding maximum heat pump. Low temperature differentials aid to achieve higher heat absorptions at the cold junction and better coefficient of performance. Since the hot side temperature of the module is dependent on the heat sink resistance, the temperature differential and the heat pump will decay with an increase in the heat sink resistance. To improve the coefficient of performance of the unit, more Peltier coolers must be applied than the minimum number required to pump 100W. For any heat sink, an optimum fin density exists for every fin thickness. Beyond this optimum number of fins, the heat transfer rate will decay. Also there exists a single case of fin thickness and fin density that represents an optimum of the optima. The thermal resistance of the un-finned area and of the fins are the most critical, and any attempt to improve the thermal performance should focus on these two factors, while the thermal resistance of the base is not trivial, and for a given heat sink height, the base thickness should be made as small as possible, only limited by the manufacturing process



MITIGATION OF WELDING DISTORTION AND RESIDUAL STRESSES VIA CRYOGENIC COOLING - A NUMERICAL INVESTIGATION

Student: Jonathan Cutajar **Supervisor: Dr. Ing. Duncan Camilleri**

Introduction

Fusion welding is one of the most common and convenient fabrication methods for large, thin-plate structures. However, the tendency to out-of-plane distortion frequently results in severe design and fabrication penalties and the requirements for expensive rework. A feasible and efficient weld distortion mitigation technique is to cool the weld at a rate that is higher than if it were cooled by convection. This can be done by the application of cryogenic CO_2. Cryogenic cooling reduces welding distortion mainly by decreasing the heat dissipation into the structure, consequently diminishing the size of the regions undergoing yielding and permanent plastic strain.

Project Objectives

This study focuses on the use of cryogenic CO_2 to reduce distortion and residual stresses in butt-welded C-Mn BS4360 Grade 50 D plates. Several combinations of weld preparations and cooling parameters were considered and an optimisation process was undertaken. The resulting deformations, stresses and temperature profiles were predicted using numerical techniques.

Project Methodologies

The project identifies feasible modelling techniques for predicting the inherent residual stresses and distortion through finite element analysis. The following steps were carried out during the implementation of this project:

- Literature review of current computational models of welding fabrication and mitigation techniques
- Prediction of thermal transients developed during fusion welding
- Development of an elasto-plastic numerical model to predict inherent residual stresses and deformation due to fusion welding with and without the inclusion of cryogenic cooling.
- Identifying the optimum parameters leading to minimisation of welding distortion.

Results and Achievements

Full transient thermo-elastic-plastic models require considerable computational time, making them inapplicable to predict welding distortions in multiple welded structures. Thus a more computationally efficient model was used for optimisation purposes. The achieved results show that with the inclusion of cryogenic cooling, the maximum temperatures reached in welded models are significantly lower than for non-cooled welds. Moreover, with the application of cooling, the models experienced more than 6% decrease in out-of-plane deformation.

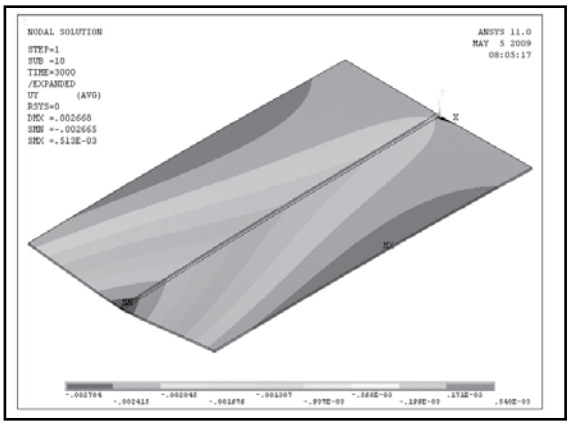
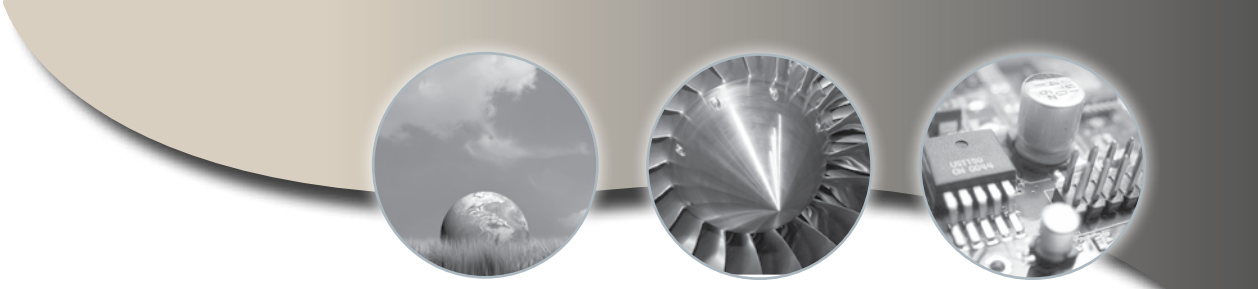


Figure 1 – Predicted out-of-plane deformation



DESIGN AND CONSTRUCTION OF A FREE-PISTON ENGINE

Student: Ilan Dalli **Supervisor: Prof. Ing. Robert Ghirlando**

Introduction

Internal combustion engines have a good power to weight ratio, and good portability. However IC engines are a good source of pollution, this project was carried out to design and built an engine for the study of more efficient systems.

Project Objectives

To design and build a free-piston engine for the possibility of study HCCI combustion processes

Project Methodologies

The engine was built from scratch, a good mathematical model was required to obtain a functional engine. The engine had to be as simple as possible, can be easily modified for future work and further experiments and should have a means of measuring the power and efficiency

- Literature review of existing free-piston engines, the combustion processes and the parameters related to engine(i.e. compressors and two-stroke processes)
- Mathematical model to determine the engine dimensions and load
- Design and source parts as per mathematical model
- Fabricate the engine and source parts according to design.

Results and Achievements

Engine was completed and assembled, study is going on to achieve reliable running easy starting.

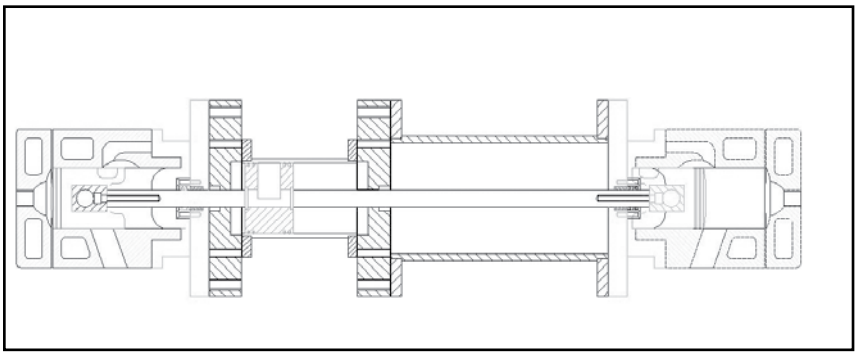
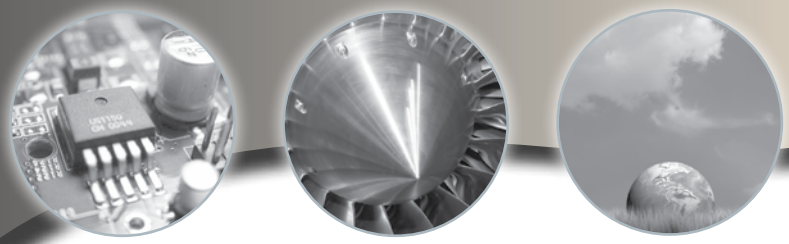


Figure 1: Section elevation of engine



THE DESIGN AND CONSTRUCTION OF A HUMAN POWERED BOAT

Student: Clive Ebejer **Supervisor: Dr. Ing. Christopher Micallef**

Introduction

Today the human being relies almost totally on engine driven means to travel and/or perform leisure activities. Throughout the years technology has offered more comfortable and energy efficient fuel powered media, hence facilitating their use. However this progress may lead to laziness and maybe health problems related with lack of physical exercise. Therefore it is the aim of this project to promote the idea of using human power at least for leisure activities associated with water sports i.e. one should have fun while doing physical exercise.

Project Objectives

- Produce a literature review about naval architecture and SWATH technology
- Design and build the various parts of the human powered boat (HPB)
- Test the prototype built through a number of variables
- Evaluate the strengths and limitations of the HPB developed

Project Methodologies

The design of this HPB is based on Small Water plane Area Twin Hull (SWATH) technology. The advantage of this design is that a significant proportion of the hull which offers the majority of the buoyancy force is situated below the sea surface. The interface of the hull with the surface of the sea is very small and in this case is limited to four vertical pipes which emerge out of the surface. This reduces greatly the wave making resistance hence leading to a more efficient hull thus requiring less power for propulsion which is very limited in a human. Additionally the boat would be more stable and is less susceptible to the waves of the sea resulting in a much smoother ride. The reason for this is that the majority of the submerged part of the hull i.e. the horizontal pipes would be situated a small distance below the surface where the sea would be less choppy. The designing of the boat was followed by the actual construction of the various components i.e. the hull, the platform, the driving mechanism and the rudder system. In the end the boat was tested in the sea for stability, speed and manoeuvrability.

Results and Achievements

The hull was constructed from PVC pipes which make it easy and relatively cheap to build. These are joined together using standard fittings and then glued at half the joints such that the hull can be disassembled for easier transportation. On the top a wooden platform is constructed which would hold the rider, the propulsion mechanism and the rudder system. When the boat is fully loaded, the two horizontal tubes would be completely submerged while the four vertical tubes would be only half submerged. The main concern for the design of the boat was the stability due to the small water plane area. However the hull resulted to be very stable and gives a pleasant ride for the rider even when the sea surface has small wavelets. Initially the rider may experience a sense of fear from tipping over the boat since the boat trims and heels considerably when the rider is at the edge of the platform. However after some time the rider acquires a sense of security on the boat. The cruising speed and the manoeuvrability of the boat were both satisfactory. The rudder can be easily and effortlessly operated.

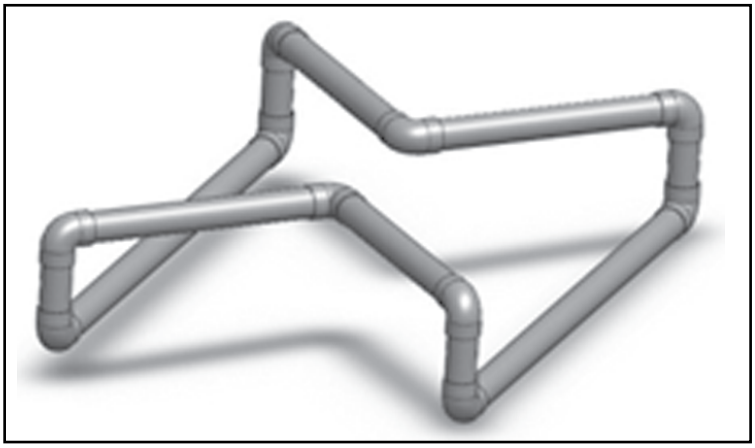
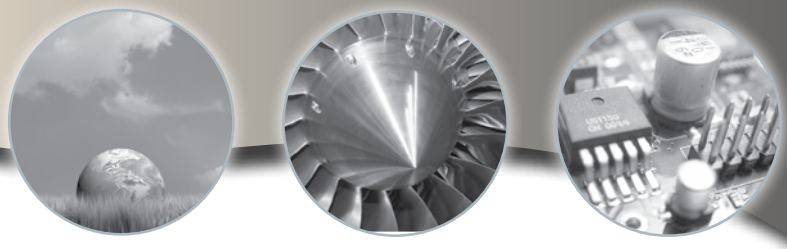


Figure 1: Hull of the boat



EXPERIMENTAL ANALYSIS OF A FIXED AND VARIABLE-SPEED AIR CONDITIONING SYSTEM

Student: Graziella Fenech **Supervisor: Dr. Ing. Mario Farrugia**

Introduction

Variable-Speed air conditioning also known as inverter driven air conditioning systems are designed with the main target of saving energy. In fact they are advertised as typically consuming 30 per cent less energy than fixed-speed systems. This low energy is achieved by the use of variable-frequency drive (VFD) which continuously changes the speed of the motor and thus of the compressor according to the cooling demand.

Project Objectives

- System circuit design and building up the experimental test rig, including specific hardware such as the condenser and evaporator heat exchangers and small T-type thermocouples.
- Perform a series of experiments on the fixed -speed system.
- Replace the fixed-speed compressor with the variable-speed compressor and carry out the same set of experiments.
- Experimental analysis and comparison of both systems

Project Methodologies

In this dissertation the first task was to conduct a literature search and review on variable-speed air conditioning technology in order to acquire and extend knowledge on such systems. Two units; one fixed-speed and the other d.c inverter air conditioning unit were supplied from Engenuity Ltd. CAD design of the system's circuit was drawn and following this the test rig was implemented. The fixed-speed system was tested by varying the refrigerant condenser out temperature in the range of 30°C - 55°C in increments of 5°C. The compressor was then replaced by the variable-speed compressor and the system was modified by heating the water at the evaporator inlet. This was achieved by making a tank with three heating elements installed to it. Similarly, the inverter driven system was tested by varying the refrigerant condenser out temperature for the same range of temperatures. The COPs of both systems together with the electrical energy consumption amongst other parameters were computed and compared.

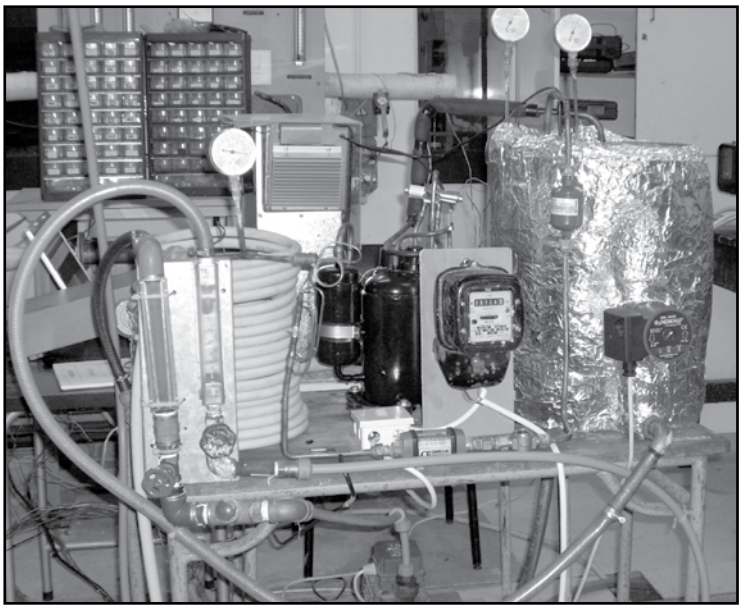
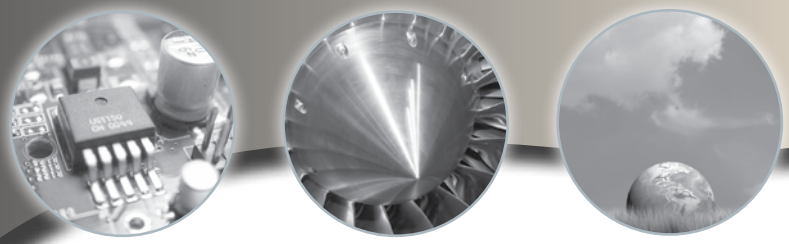


Figure 1: The Test Rig

Results and Achievements

From results' analysis, it was concluded that an inverter driven system indeed performs better and consumes less energy than a fixed-speed system. The average electrical COP (water cooling effect divided by the electrical power consumed by the system) for the fixed-speed system over the range of tested temperatures was 1.83 when the average cooling capacity was 2.4 kW, whilst the average electrical COP for a variable-speed system over the same range of temperatures and with 2.0 kW load, was 3.46, meaning that the inverter driven system is more efficient electrical-wise.



DESIGN AND CONSTRUCTION OF A MODEL FLOATING OFFSHORE WIND TURBINE

Student: Lawrence Fenech **Supervisor: Dr.Ing. Tonio Sant**

Introduction

Wind turbines mounted onto floating structures are currently being analysed and tested to be later employed in deep waters. Such a wind turbine would be less rigid than a fixed bottom turbine which makes it behave in a different manner. Such a situation can be studied by model testing.

Project Objectives

The objectives were to design and construct a model floating wind turbine with a tension leg foundation and test it in the wave tank. In this way the aerodynamics of a floating wind turbine could be studied and any aerodynamic damping effects analysed.

Project Methodologies

The project aimed at analysing the aerodynamics of a floating wind turbine. The following steps were carried out during the implementation of the project:

- Literature review of current developments in the wind energy industry with particular emphasis on the offshore and floating offshore wind industries.
- Theoretical analysis of a wind turbine with a moving foundation using the blade element theory to analyse aerodynamic damping.
- Theoretical analysis of the tension leg platform when subject to wave loading and prediction of the resulting motions.
- Design of the model floating wind turbine.
- Construction of the model and assembly in the wave tank.
- Testing of the model with wave and wind loading and analysis of the resulting motions and forces.

The design of the model has different constraints and objectives from a commercial wind turbine. The model is intended for experimental purposes for assembly only in the wave tank for short periods of time. On the other hand various parameters need to be varied like the height of the tower and the length of the mooring lines. The model must also allow the reading of various parameters like the turbine thrust, the mooring line tensions and the structure motions so that the system can be analysed. Therefore the model that was constructed differs from a real wind turbine in various aspects but it enables the study of the motions and aerodynamics of a floating wind turbine.

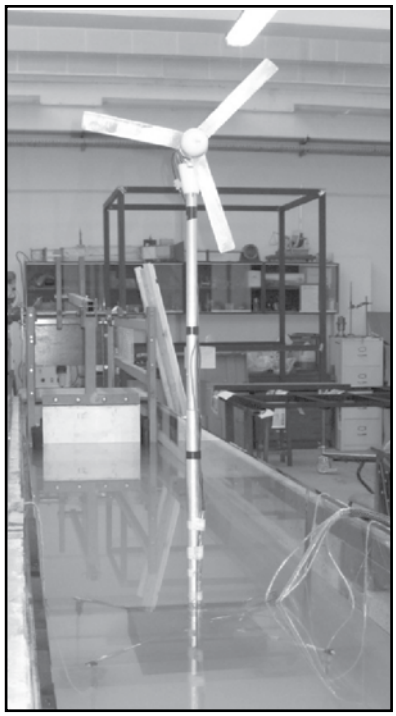
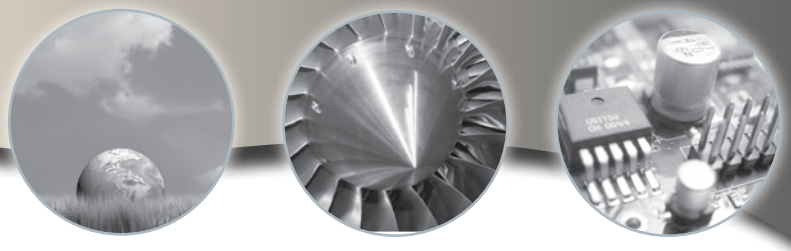


Figure 1: The model floating wind turbine that was constructed. and assembled in the wave tank.

Results and Achievements

The theoretical analysis of aerodynamic damping showed that the thrust force produced by a moving wind turbine varied in such a way as to reduce these motions. This would be very beneficial if it could be employed realistically as the support structures required would be smaller. The motions of the model floating wind turbine were found to be only in surge (backward and forward) because of the geometry of the mooring system. Aerodynamic damping could not be observed as the resulting motions were too slow – this means that to utilise aerodynamic damping a floating wind turbine must be designed with particular emphasis placed on its motions so that they can be damped.The effects of the waves and wind on the structure were analysed and patterns could be found regarding the variation of the motions with the wind and waves. These showed the limitations of linear wave theory which must be supported with other theories for a structure moving with the waves.



INVESTIGATION OF PROPER REFRIGERANT CONDENSER DESIGN

Student: Keith Genuis **Supervisor: Dr.Ing. Mario Farrugia**

Introduction

A very important parameter in condenser design is the flow of the refrigerant in the condenser piping. While condensation is taking place, the refrigerant undergoes various types of flow. The type of flow depends on many factors mainly on the vapour quality and the mass flow rate of the refrigerant. Vapour quality is defined as the amount of vapour available in the tube. The direction of flow of the refrigerant inside the condenser tubes is also very important. The flow can favour gravity and thus flow downwards inside the tubes. It can also flow counter-gravity, that is, upwards inside the tubes. The difference between these is very important since it affects the rate of heat transfer and thus would affect the performance of the heat exchanger.

Project Objectives

The aim of the project was to first built a vapour-compression system with downward flowing pipes in the condenser so that the different flows inside the condenser can be identified and investigated. The system must then be able to vary the direction of flow, first having upward flowing pipes and than having downward flowing pipes. The difference between these two must be investigated and compared.

Project Methodologies

The project identifies the various types of flow that exist in the condenser by having a transparent test section between the two condensers so that the flow can be visualized and compared. The following steps were taken in the project:

- An intensive literature review was performed on the condensation process and the different types of flow that exist in refrigeration. Also a literature review was performed on the condenser characteristic whether having upward flowing pipes negatively affects the heat transfer coefficient in refrigeration systems.
- A vapour-compression system that had downward flowing pipes was designed and built so that different flows could be visualized and identified by varying the vapour quality in the condenser
- The vapour-compression system was then modified to cater for both downward flowing pipes and upward flowing pipes. The flow was visualized and various tests were made so that refrigeration parameters could be found and compared.

Results and Achievements

The different types of flow were clearly visualized and interpreted. It was found that for upward flowing pipes stratified flow could not be visualized. Slug flow and plug flow could not be visualized in upward flowing pipes due to less condensation being achieved with this type of flow. Slug flow and plug flow could be achieved in downward flow when the flow rate of cooling water was increased ad the vapour quality decreased. The parameters for upward flowing pipes and downward flowing pipes were compared and it was found that the head pressure decreased by 2 bar when the system was working with upward flowing pipes in the condenser. Also, it was found that the heat transfer coefficient decreases drastically when the flow was flowing upwards and thus less condensation occurred in the test section.

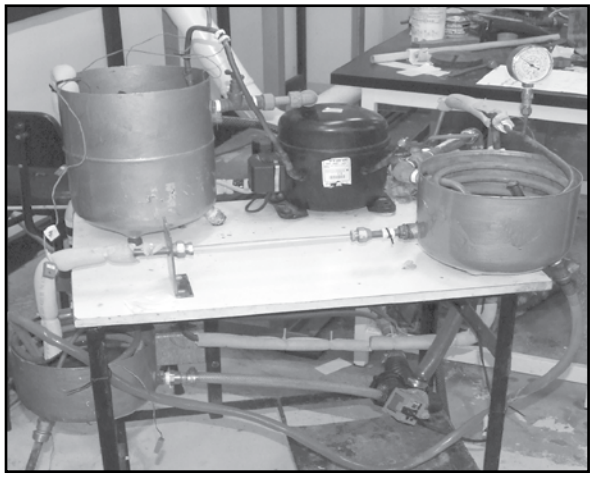
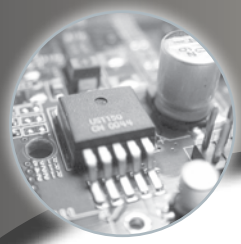
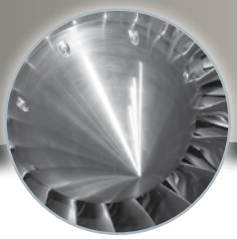


Figure 1: Test Rig Completed

MATHEMATICAL MODEL OF A GEOTHERMAL AIR-CONDITIOING UNIT

Student: Amanda Grima **Supervisor: Dr. Ing. Christopher Micallef**

Introduction

Malta has to produce 10% of its final energy consumption from renewable resources by 2020 [1]. This project targets geothermal low grade energy, an important type of renewable energy which could be applied in Malta to heat and cool buildings.

Project Objectives

The main aim of this project is to create a mathematical model that sizes the earth connection of a heat pump system; the ground heat exchanger in the case of ground-coupled heat pumps and ground water flow rate in the case of ground water heat pump units.

Project Methodologies

The following steps were carried out during the implementation of the project:

- An extensive literature review in order to be aware of the different types of ground source heat pumps together with different mathematical equations that size such systems; focusing primarily on the ground heat exchanger part
- Understand the theory behind ground source heat pumps
- Create a mathematical model that will size the earth connection
- Test the mathematical model and verify that it is operating correctly
- Compare the results obtained by the different types of models

Results and Achievements

This project is based solely on theoretical principles and when the system is actually sized, cost plays an important role. Sometimes the cheapest solution does not rely on choosing the shortest ground heat exchanger or the smallest well flow rate. A compromise needs to be found between initial and operating costs.

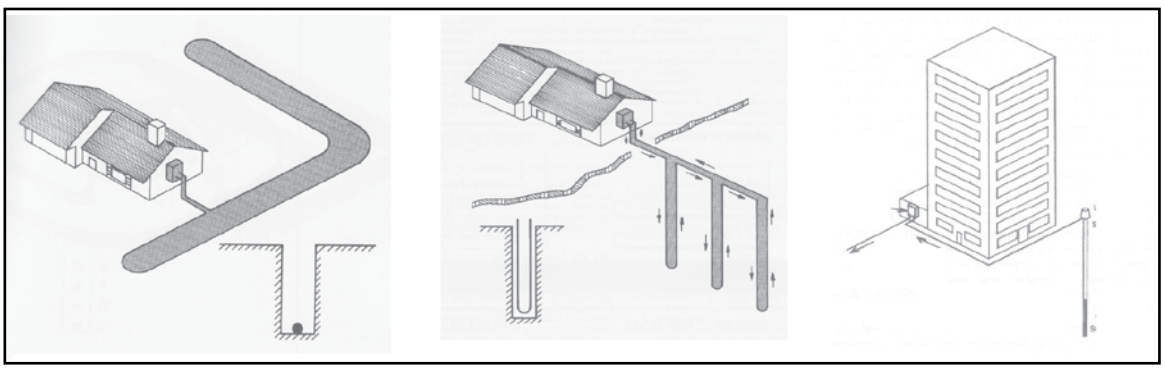


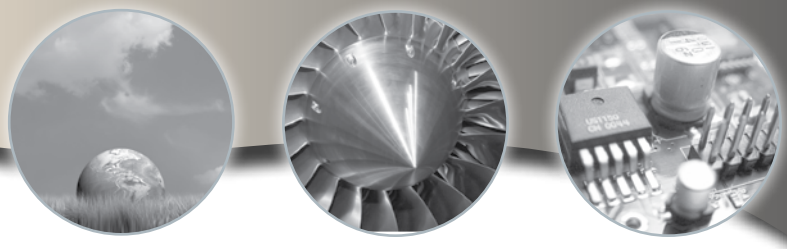
Figure 1: The three types of heat exchanger configurations considered in this project:
Left – Horizontal ground-coupled heat exchanger, [2]
Centre – Vertical ground-coupled heat exchanger, [2]
Right – Ground water heat exchanger

References

[1] House of Lords, European Union Committee. The EU's Target for Renewable Energy: 20% by 2020, Volume I: Report, London, 2008

[2] Oklahoma State University, Closed-loop/Ground-source heat Pump Systems: Installation Guide, ISBN: 0-929974-01-8, Stillwater, Oklahoma, 1988

[3] S. Kavanaugh and K. Rafferty, Ground-Source Heat Pumps – Design of geothermal systems for commercial and institutional buildings, ISBN 978-1-883413-52-1, American Society of Heating, Refrigeration and Air-conditioning Engineers, United States of America, 1997



FURTHER WORK ON A VAPOUR ABSORPTION REFRIGERATION TEST RIG

Student: Kris Lanzon **Supervisor: Prof. Ing. Robert Ghirlando**

Introduction

It is well-known that air-conditioning systems powered by electricity consume a lot of energy which is getting more expensive every day. To reduce the existing dependency on electricity and fuel consumption, systems utilising renewable energy sources to drive cooling systems are being investigated and developed.
Vapour absorption refrigeration cycles have a potential when it comes to the above; the energy input required to drive such systems is in the form of thermal energy, or in simpler words, heat. Various studies were carried out in the University of Malta which showed that it is possible to create a cooling effect using solar heat energy or even heat energy extracted from the exhaust gases of a car engine. For these studies, a commercial vapour absorption refrigerating unit was used which proved to be very inflexible making further studies on these systems very limited.

Project Objectives

In 2007, a project to design and build a vapour absorption refrigeration test rig from scratch at the University of Malta for further investigation into these systems was initiated. The system was designed to use water as the refrigerant and lithium bromide as the absorbent. The construction was finished in 2008, however due to the lack of time and experience in the practical aspects of absorption systems, it did not work.
The aim of this project was therefore to continue developing this test rig, make modifications to the initial design and work on them.

Project Methodologies

Numerous difficulties were encountered to make the test rig work. One of the main difficulties was that many of the appropriate components required by this system are not readily available on the market so many had to be custom-made. The following are the most important changes done on the system:

- A proper solution pump capable of delivering the required pressure difference was found and its flange was redesigned.
- The levels of the components in the system were raised to the right height such that the flow would be aided by gravity at each point before reaching the pump.
- Transparent plastic tubes made of plastic, with the required pipe wall thickness to withstand vacuum pressures, were added to the piping circuit to better understand the cycle of the refrigerant and the solution.
- Proper means of throttling the refrigerant between the high pressure side and the low pressure side were investigated and worked upon.

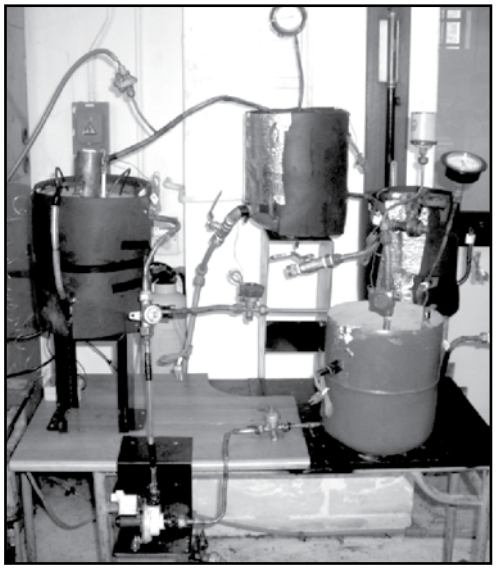
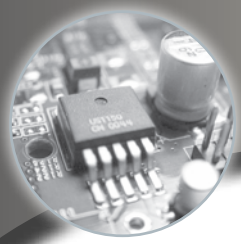
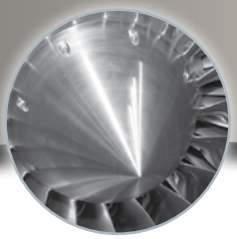


Figure 1: The Modified Vapour Absorption Test Rig (April 2009)

Results and Achievements

During this project, a lot of experience on vapour absorption systems was obtained when it comes to their practical aspect. Some of the results obtained also indicated that the system could be made functional with some further tweaking. This would make it possible to perform further studies on absorption systems, including driving the system with alternative sources of energy rather than just electrical energy.

INVESTIGATION OF THE HEAT TRANSFER IN THE END REGION OF SMALL ELECTRIC MACHINES

Student: Adrian Saliba **Supervisor: Dr. Ing. Christopher Micallef**

Introduction

The temperature levels reached in certain areas such as the end winding region, limit the capacity of electric motors whilst excess temperatures seriously affect the life expectancy of the machine. At present, the insulation material has reached a state where no further considerable improvement can be made and thus one would emphasis on the importance of increasing the heat transfer performance.

Project Objectives

The main objectives of this project are (a) to investigate heat transfer at different locations in the end region of a small electric machine at different operating motor speeds and (b) to analyse the effect of a different wafter configuration on the cooling performance.

Project Methodologies

The following steps were carried out during the implementation of the project:

- Literature review regarding heat transfer in the end region of Totally Enclosed Fan Cooled (TEFC) induction motors;
- Construction of a test rig;
- Determining a suitable fixing method for heat flux sensors and thermocouples;
- Carrying out test in order to determine heat transfer coefficient values at different locations in the end region and at different motor speeds;
- Constructing and testing a different wafter configuration (Figure 1).

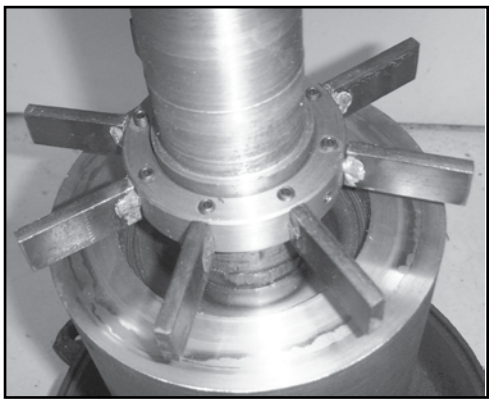
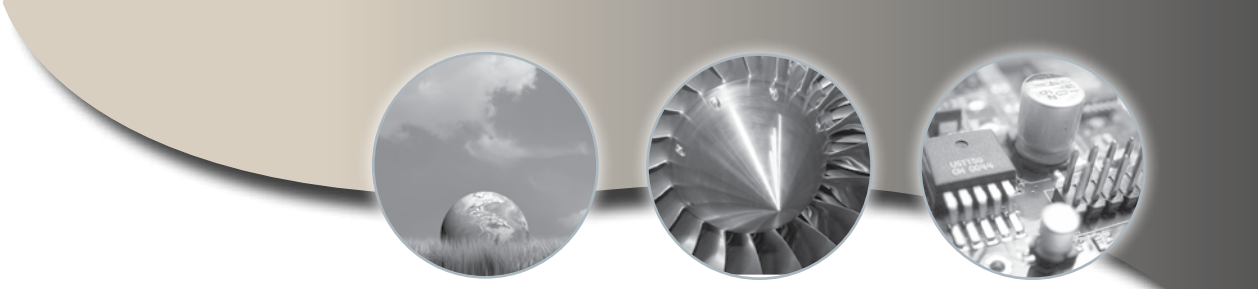


Figure 1: Modified wafter configuration

Results and Achievements

From these experimental investigations, it was found that the rotor cooling effect is directly related to the motor speed and thus also directly related to the fundamental frequency of the voltage supply. Results show that for the present wafter configuration, the overall heat transfer coefficient on the end windings varies according to the relationship: $\alpha \sim (\text{motor speed})^{0.60}$ whilst on the end shield varies according to the relationship: $\alpha \sim (\text{motor speed})^{0.75}$.

The wafter modification resulted in a considerable increase in the overall heat transfer coefficient values at the end shield. Additionally an increase of about 60 percent in the local heat transfer coefficient values (compared to the present wafter design) were obtained at the tips of the end windings, the region which is normally associated with the highest temperatures.



NUMERICAL MODELLING OF WELDED STRUCTURES SUBJECT TO THERMAL TENSIONING

Student: Maxine Scicluna **Supervisor: Dr Ing. Duncan Camilleri**

Introduction

Ship designers are faced by challenges to design lighter structures in order to reduce weight and enhance fuel economy. One solution sought is the reduction in the thickness of plates used to build ship structures, but severe distortion problems have emerged with the use of plates as thin as 4mm. Shipyards apply flame straightening to correct distorted structures, but the cost incurred to correct distortion reaches millions of dollars. A more cost effective method to reduce distortion involves applying additional heat simultaneously during welding. This is more commonly known as thermal tensioning.

Project Objectives

The objectives of this project are:

- To model welding processes with and without transient thermal tensioning (TTT).
- To determine the optimum parameters in regard to the amount of heat input from the heaters, the orientation, and the longitudinal and transverse distances away from the weld.
- To determine the mechanism by which thermal tensioning reduces out-of-plane distortion.

Project Methodologies

The project uses finite element analysis (FEA) to predict thermal gradients, residual stresses and distortion. The following steps were carried out during the implementation of the project:

- Literature review of current state-of-the-art computational models of welding fabrication and distortion mitigation techniques.
- Prediction of thermal gradients developed during fusion welding.
- Development of elasto-plastic numerical models to predict residual stresses and deformation due to fusion welding.
- Identification of the optimum TTT parameters leading to minimisation of welding distortion.

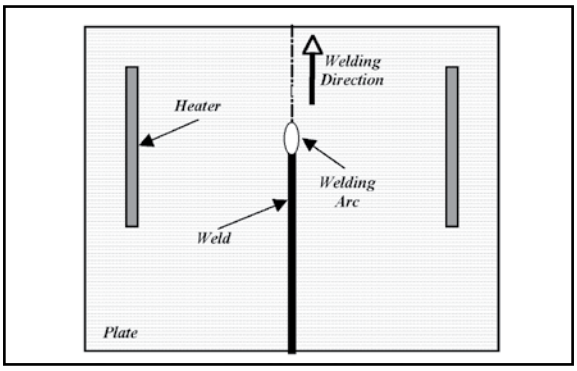


Figure 1: Set-up for welding with thermal tensioning

Results and Achievements

This study shows that thermal tensioning is an effective solution in reducing out-of-plane distortion in 4mm DH36 steel plates. For optimum results, the heater for TTT should be positioned parallel to the welding direction, centre aligned with the arc and at a distance of 210mm from the weld line (for plates of section 250x4mm). This is shown in Figure 1. The optimum heat input is 2MW/m^2, equivalent to a maximum plate temperature of approximately 800^{0}C in the TTT region.

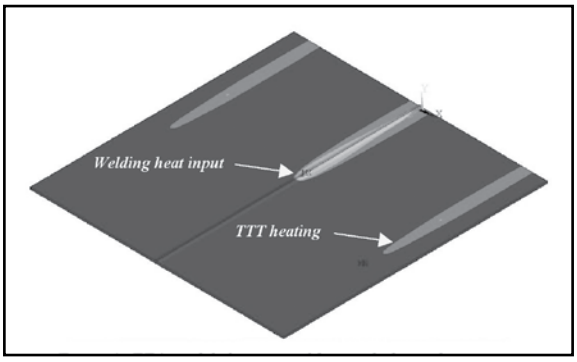
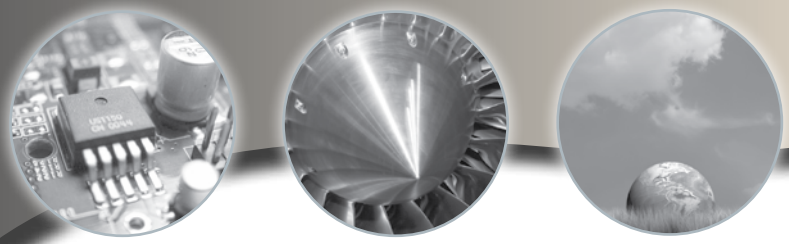


Figure 2: FEA model showing welding with thermal tensioning



STRESS AND STRAIN ANALYSIS OF A PHYSIOLOGICAL KNEE JOINT

Student: Clive Seychell **Supervisor: Dr. Ing. Zdenka Sant**

Introduction

The study of the knee joint is very important due to the knee's complex structure and functionality. The clear understanding of its behavior also forms the basis in the manufacture of knee prosthesis and in the treatment of patients who have suffered knee injuries.

Project Objectives

The aim of this project is to study the behavior of the knee joint under different body weights. This analysis will help us understand where and how excessive body weights can badly affect a physiological knee joint, such as stress and strain.

Project Methodologies

The following steps were carried out during the implementation of this project:

- Studying the knee physiological anatomy and biomechanics. All the segments which make up the knee joint were studied and their principal functions were noted.
- Force analysis of a physiological knee joint was carried out to identify the forces acting on the joint and in which position these forces act.
- MRI's acquired from Mater Dei's Hospital, opened from Dicom Works and converted to JPEG's.
- These JPEG's were imported to Rhinoceros 3D Software and a 3D model was created.

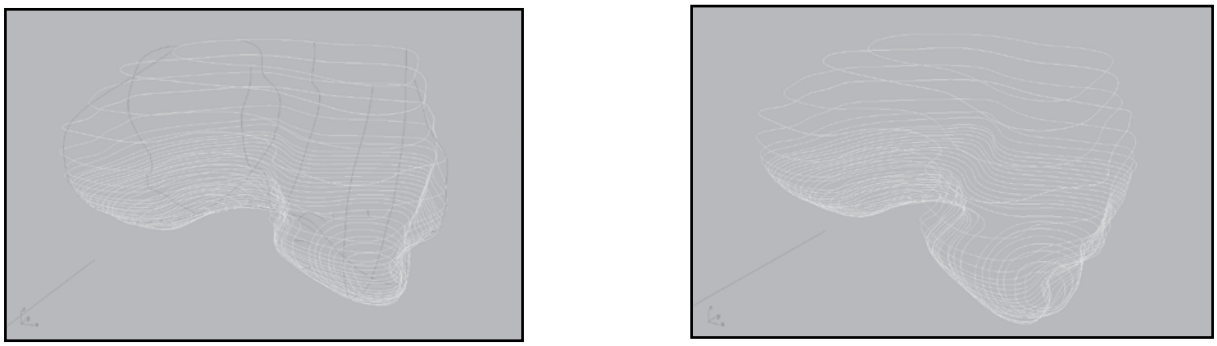


Figure 1: The modeling procedure in 'Rhinoceros 3D software' – a) initially creating the splines. b) followed by the areas

- The areas were exported from Rhinoceros 3D and the volumes of the tibia, menisci and femur were created after imported into ANSYS.

- All the necessary material properties, element types, boundary conditions and forces were defined. Consequently segments were meshed and computed in ANSYS.

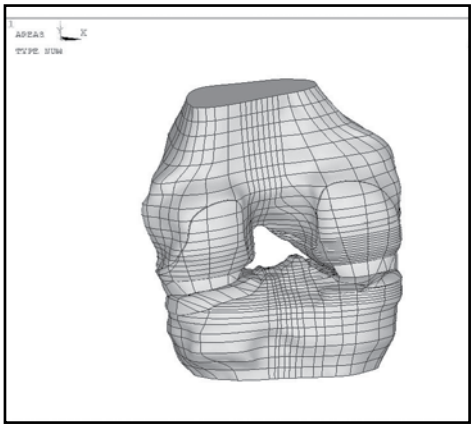
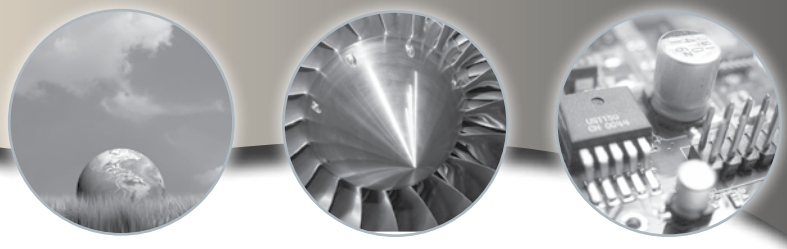


Figure 2: illustrates the assembly of the tibia, menisci and femur volumes

Results and Achievements

Computations and results are still being carried out. The stress and strain results versus the body weight will be noted and analyzed. Special attention will be given to the difference between the knee joint reactions to the different body weights and how different body weights can damage or affect the knee joint segments so as to pin-point what are the major damages caused by overweight and obesity.



DESIGNING A DISASSEMBLY PROCESS FOR HOUSEHOLD APPLIANCES

Student: André Spiteri **Supervisor: Prof. Ing. Robert Ghirlando**

Introduction

In the past decades, the generation of waste from the disposal of electrical and electronic equipment (EEE) has increased exponentially.Due to tougher environmental legislation together with pressure from customers to improve environmental performance, producers and importers of electrical and electronic goods must contribute towards national targets in the recovery and recycling of waste from electrical and electronic equipment (WEEE). The national target for WEEE set by the EU is 4kg per capita per year. WEEE is subdivided in ten categories, each focusing on particular electrical or electronic equipment. This study will focus on the disassembly process of large household appliances.

Project Objectives

The overall goal of this study is to propose a disassembly process together with a conceptual design of a work station to be able to achieve the optimal disassembly of household appliances. This should include the building of a sound understanding of the construction and composition of household appliances together with the challenges to be faced during disassembly vis-à-vis the Maltese scenario.

Project Methodologies

The study encompasses the understanding of the composition of household appliances, prediction of quantities of WEEE generated in Malta, selection of a feasible disassembly process together with the optimization of the selected process and the designing of a workstation. In order to obtain results to sustain the study the following work was conducted:

- A literature review and statistical analysis of current waste flows.
- Various experiments to identify difficulties in manual disassembly encountered and possible methods to overcome such difficulties.
- Time study to record the disassembly time of particular appliances.
- Development of a mathematical model of the disassembly sequence to conduct an optimization process to achieve the minimum disassembly time.
- Propose a conceptual design of the disassembly workstation

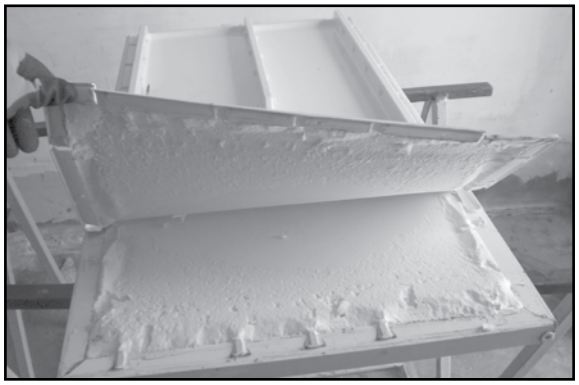


Figure 1. Exposed insulation foam of a refrigerator door.

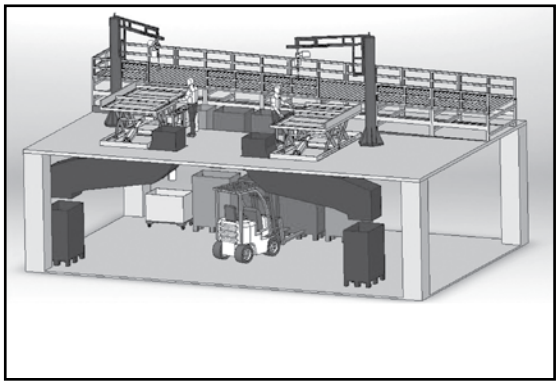
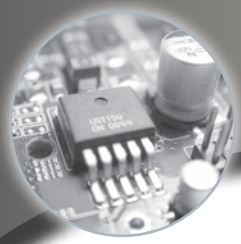
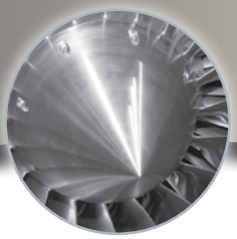


Figure 2. 3D model of the conceptual design.

Results and Achievements

The difficulties encountered during disassembly experiments showed that insulation foam is the most problematic material in the disassembly of refrigerators. The foam limits the extent of material separation. Following analysis it has been established that, due to economies of scale, a fully automated processing station would not be feasible for Malta and consideration to implement a manual disassembly process would therefore be more appropriate locally. The study achieved an optimised model to achieve the shortest disassembly time.

ENERGY ANALYSIS AND EFFICIENCY EVALUATION OF A POOL COMPLEX

Student: Matthew Spiteri **Supervisor: Prof. Ing. Robert Ghirlando**

Introduction

Energy is the mainstay of an industrial society. When discussing such a matter, it is fundamental to consider the three key concepts that form the basis of thermodynamics: Energy, Entropy, and Exergy. Whilst classical First Law Analysis is concerned only with the quantity of energy used, Exergy (together with Entropy) provides an alternative means of efficiency measure by considering the quality and usefulness of the energy.

Project Objectives

The Razzett tal-Hbiberija plant will be used as a case study to perform a holistic energy analysis of the system components, including both the qualitative and quantitative aspects of energy. The final goal of the thesis is to research the theory behind, and perform, a comprehensive Energy Audit for all the system components at the plant. The objective is that the micro case of Razzett tal-Hbiberija can act as a yardstick for the methodology in analyzing energy efficiency on the macro scale.

Project Methodologies

The procedure for achieving the above objective was done following the guidelines described by Krarti in his Energy Audit description[1], and applying them for the case under study.

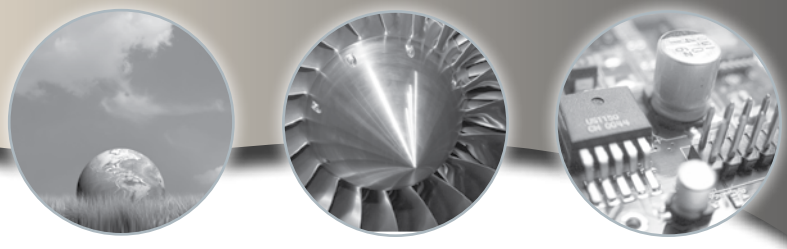
- Facility and Utility Analysis
  - o Evaluate energy systems, characteristics and drawings
- Theoretical Model
  - o Acquire all the necessary theoretical background on each component through an extensive Theoretical Review
  - o Perform Energy and Exergy Efficiency analysis (Thermodynamic analysis) and list factors to be measured
  - o Digitally model the pool hall for simulation using Hevacomp Building-Utility software
- Walk Through Survey
  - o Measure factors described in the previous step
  - o Acquire necessary utility bills, occupancy density, etc.
  - o Identify fuels and wastes, and their pattern of use through the system
- Baseline for Building Energy-Use
  - o Set up a Base Case Model by using the data acquired from the previous stage, for comparison in future changes.
- Evaluation of Energy Saving Measures
  - o Identify main losses and propose measures versus economic cost
  - o Consider the proposed Wasteserve steam energy supply to the plant
  - o Analyze where the Pinch-Off method can financially feasible to apply

Results and Achievements

From the initial analysis of the system, losses in efficiency include thermal losses (such as at the heat exchanger surfaces), and flue gas losses, where the high-energy quality water vapour is lost to the environment. For the recovery of the enthalpy of vaporization of water, a heat exchanger can be fitted at the flue gas chimney. This would improve the efficiency considerably yet economic and engineering constraints (due to high corrosion) can restricted the application of such a measure. It is immediately evident that the crux of such an analysis is to find sustainable measures that are both feasible and economically attractive[2].

References

[1] Kreith, F., & Goswami, Y. D. (Eds.). (2007). Handbook of Energy Efficiency and Renewable Energy. USA: CRC Press.
[2] Osborn, P. D. (1985). Handbook of Energy Data and Calculations. Cornwall, UK: Butterworths.



DESIGN AND CONSTRUCTION OF A LOW-SPEED OPEN-JET WIND TUNNEL

Student: Ramon Vella **Supervisor: Dr. Ing. Tonio Sant**

Introduction

Wind tunnels are nowadays seen as a much more important tool in the engineering sector since the testing of the particular objects such as cars, ships and aircrafts is seen to be of great importance due to safety and aerodynamics factors. It is regarded as an important tool both for engineering education and also for research. Their main purpose is to replicate the airflow as close as possible to reality and thus helping the engineer to produce a much more efficient product to be able to identify the behavior of the object under certain conditions. By testing the particular product in the wind tunnel, it is made sure that the requirements requested in the design stage have been satisfied and thus satisfying the customer's needs. Moreover it must be ascertained that certain non-uniformities due to slight differences in the airflow which might consequently change the behavior of the tested objects are avoided, since they can lead to wrong information resulting in wrong decisions.

Project Objectives

- Carry out research work to get a better know how on wind tunnels and outlining the important features.
- Design the open-jet wind tunnel on the dimensions required and construct it
- Test the wind tunnel by taking detailed measurements of the flow distribution at the exit jet.

Project Methodologies

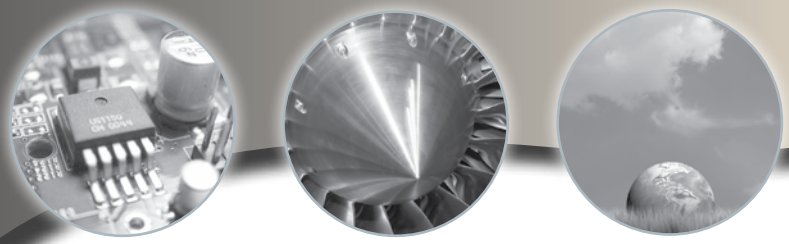
In the preliminary design stage, the requirements (such as the dimensions and type of the tunnel) were established. Various sketches were drawn and were discussed with the tutor to figure out the best layout. A support frame was built up of steel hollow sections. This can be easily dis-/assembled as its middle part is fixed to its sides using stainless steel bolts. This support frame was built on height adjustable caster wheels that will allow the flexibility to move the wind tunnel from one place to another and adjust the tunnel height.

Figure1: Low speed open jet wind tunnel

Steel sheets 10 ft x 4 ft x 1mm thickness were used for the construction of the duct sections. These sheet sections were first cut to the required width and then rolled in the roller at the University of Malta (UOM) workshop to obtain a circular profile. The ends of these steel sheets were joined using the spot welding. The duct sections where then placed in the marine plywood flanges and formed the four duct sections that can be seen in the figure below. The duct sections were then mounted on the support frame using rubber mountings to eliminate any vibration that will be induced by the fan during operation. The fan was assembled to the final section at the entry of the tunnel and measures were taken to align the fan properly in the duct. An inverter was connected to the fan to be able to vary the rotational speed and thus vary the airflow speed. In fact the testing carried out on this tunnel as part of this dissertation was to measure the flow velocity at different speeds and at different locations across the vertical and horizontal axis of the tunnel with the Pitot-static tube situated at various distances away from the tunnel.

Results and Achievements

From the measurement of the flow velocity it was noted that the velocity at the centre of the tunnel is less than at the outer sides. This is due to the interference generated by the hub of the fan. This effect could be reduced by applying a contraction section that concentrate the flow in the central areas and thus producing a more uniform flow.



PLASMA ANODIZING OF MAGNESIUM ALLOYS

Student: Damien Azzopardi **Supervisor: Dr. Ing. Stephen Abela**

Introduction

Global warming is bringing adverse effects on the world's natural balance. This is coming from the increase of carbon dioxide in the atmosphere which is causing the green-house effect. A significant percentage of the carbon-dioxide in air is coming from road vehicles. A sector where vehicles can be highly improved is by reducing the weight so that smaller engines can be used.[1] A person is only 7% the weight of an average vehicle, so 93% of the fuel is wasted in moving the vehicle's weight. A perfect metal to reduce the weight is magnesium as it is 75% lighter than steel and 33% lighter than aluminium. However magnesium needs to be surface engineered to make it less reactive. Automotive and aircraft industries can hugely benefit from this process.

Project Objectives

The first objective of this dissertation is to conduct a preliminary study of developing an anodizing coating onto the magnesium alloy AM50 at low pressures and room temperature. The process is completely innovative and must be highly environmental friendly. This is important because if by improving the magnesium alloy to reduce global emissions, the environment is being heavily polluted by the process itself, then there is no scope. The process takes place below 100°C reducing heating energy requirements and must increase the corrosion resistance of the magnesium alloy. Since paints do not adhere well with alkali metal such as magnesium and aluminium, another objective is to improve the adhesion of protective paints with magnesium alloys, in a way that the coating will act as the base primer.

Figure 1: Crank-shaft pulley

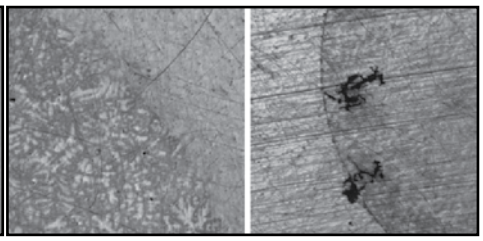


Figure 2: Mag.(25x) - (a) Treated AM50 corrosion tested, (b) Untreated AM50 corrosion tested showing heavy pits.

Project Methodologies

Research was carried out on all the types of anodizing treatments that reached industrial level [2] and to find all the surface engineering treatments that are available for magnesium alloys. [3] These are all discussed in the literature review of the dissertation. The process for this anodizing treatment consisted of 100mins sputtering and 9hrs process time in a PVD furnace. Gases used were argon, helium and oxygen which are all environmental friendly. The mixture consisted of 30% argon and 70% oxygen + helium. Process runs were conducted varying the (oxygen : helium) gases ratios and keeping the argon constant. First runs were conducted on 60mm diameter magnesium alloy AM50 discs. Samples were tested for improved corrosion resistance and for paint adhesion. Characterization was conducted using a high definition optical microscope, an SEM with EDS and an XRD. After identifying the best parameters, an actual automotive component, the crankshaft pulley was manufactured from the AM50 billet. Sixteen pulleys were manufactured and treated and sixteen crankshaft representations were also manufactured from mild steel. The assembly will be tested for corrosion resistance using a salt-spray machine to simulate the real environment.

Results and Achievements

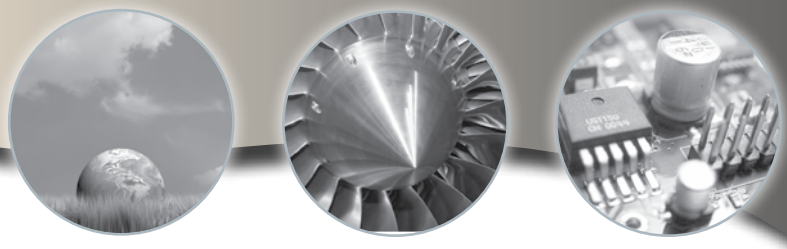
The objectives of this dissertation were accomplished as the anodizing coating was developed and protected the magnesium alloy as shown in figure 2 and figure 3. Paint adhesion was also improved. The best anodizing coating obtained was using (75% Oxygen : 25% Helium). Sealing the anodizing coating will further improve the corrosion resistance.

References

[1] S. Abela, "The Development of Wear and Corrosion Protective Coatings for Light Alloys", degree of Doctor of Philosophy, University of Malta, Malta, 2007.

[2] A. Kuhn, "Plasma Anodizing of Magnesium Alloys", Metal Finishing Information Services Ltd., United Kingdom, (2003) 44 – 50.

[3] C. Blowet, W. Dietzel, E. Ghali and G. Song, "Anodizing Treatments for Magnesium Alloys" 8 (2006) 6: 511 – 533.



DEVELOPMENT OF AN INNOVATIVE AIR FILTER FOR REMOVING PARTICULATE EMISSIONS FROM DIESEL ENGINES

Student: Christopher Borg

Supervisor: Dr.Ing. Stephen Abela
Co-Supervisor: Ing. Maurizio Fenech

Introduction

Several decades after the attainment of industrialization, modern day society is finally becoming more conscious of the pollution being emitted into our atmosphere. Considering the air quality, certain improvements in technology have led to polluting the atmosphere with a vast range of impurities, some of which are of high detriment to the people when inhaled for a long period of time.

One group of pollutants that is of detriment to both to the human health and to the environment is particulate matter (PM). In Malta the burning of fossil fuels constitutes to the highest percentage of particulate emission in urban and traffic areas. Energy generation and diesel vehicle engines are the main contributors towards this particulate emission. Particularly the latter source creates quite a hazardous environment for pedestrians and commuters alike.

Project Objectives

The main objective of this final year project is to develop an innovative air filter in order to try and reduce the level of particulate matter being emitted from vehicle diesel engines. For convenience this thesis is subdivided into the following objectives:

- To understand the composition of diesel particulate matter
- With the above in mind choose and design a tail pipe air filter prototype
- Improve the efficiency of the prototype filter
- Minimize the impact of the filter on the engine and fuel consumption through iterative design.
- Conduct a material selection exercise for the filter
- Construct and test the filter

Project Methodologies

- A literature review was compiled to understand better the problem and what measures are being used at present date
- Meetings with Ing. Marco Cremona (since he is the industrial partner of this thesis) were held so to discuss the best way to try and tackle this problem and the Electrostatic Precipitator was chosen as a good innovative option
- A suitable engine that had to be used for testing was found and modified for the testing purposes
- The design, construction and testing of the Electrostatic Precipitator prototype

Results and Achievements

So far the design and construction of all the setup has been made and testing is due to be started on the actual prototype. Until now the electronic circuit has been tested and a suitable high voltage has been obtained. The filter design chosen has minimum effect on fuel consumption since it does not obstruct the exhaust flow. Testing of the filter is to be done by using filter paper to determine the amount of particulates that are exhausted with and without the prototype.

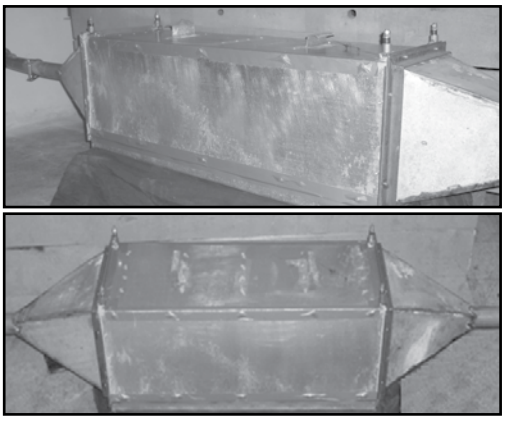
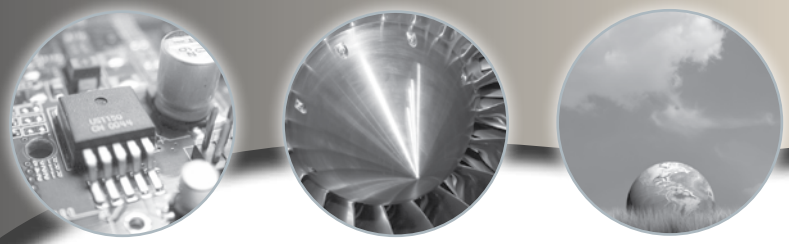


Figure 1: The Electrostatic Precipitator prototype



DEVELOPMENT OF NEW METHODOLOGY FOR MATERIALS SELECTION

Student: Daniel Ciliberti **Supervisor: Dr. Ing. John C. Betts**

Introduction

Material selection is considered as one of the influential parameters together with product design specification, design analysis and market investigation, as stated in the total design model [1]. The selection of materials involves decision-making processes in order to balance different functional and economical criteria reflecting the function of the part/product, the manufacturing process, and the final cost. A growing inter-disciplinary community of material engineers and designers think that a standard, simple and systematic scientific method or mathematical tool [2] is yet to be presented. This demanding problem has created the roots for this dissertation, which resulted in putting to test a new concept in the name of Game Theory. When dealing with situations where multiple decisions makers will interact strategically, Game Theory can foresee what outcomes will result in order to yield good results [3].

Project Aim and Objectives

The aim of this project is to develop a user-friendly methodology that assists designers to select the most suitable material for their application. Its more specific objective is to possibly utilise Game Theory as a framework for material selection by providing a systematic and simple methodology for designers to make use of.

Project Methodologies

The project identifies the main concepts that are found within Game Theory and utilise its elements and principles in order to be possibly utilised as a methodology for material selection. The following steps were carried out during the implementation of the project:

- Literature review of Game Theory in order to familiarise it to the readers due to the fact that this concept is unknown to many in the engineering profession and literature review of the philosophy surrounding material selection.
- Identify the elements of Game Theory which were then uses as a framework for material selection.
- Analyse the main concepts, Nash Equilibrium, Mixed Strategies Nash Equilibrium and Backward Induction, which are found within Game Theory by putting to test its applicability.
- Further analyse the main concepts by carrying out case studies.
- Verify the analyses carried out by summing up the conclusions.

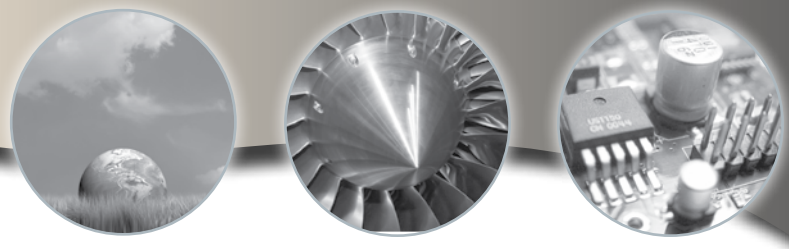
Results and Achievements

The main conclusions derived so far for developing a methodology by using Game Theory are:

- The elements of game theory can be utilised for a material selection methodology.
- Both the strategic format and extensive format are useful and helpful for comparing the materials' compatibility results to its coupled material, such as for galvanic corrosion, wear resistances and friction effects. So far there are no methodologies presenting detailed analyses for components compatibility, and thus Game Theory as a framework can be utilised to further aid the designer in selecting the optimal material.
- This framework is ideal to be utilised in the detail stage of the design process, when designers are comparing the last few materials that would be possible for the application.
- The three concepts analysed can sometimes provide the required predictions but however in each concept, it fails to be consistent with the material selection requirements.

References

[1] Pugh S. Total design: integrated methods for successful product engineering. Wokingham, UK: Addison Wesley Ltd.
[2] Rao, 2008. "A decision making methodology for material selection using improved compromise ranking method". Elsevier
[3] Dixit, Avinash K. and Skeath Susan, 1999. "Games of Strategy". WW Norton & Company.



Development of a Modified Slurry Pot Erosion Testing Machine

Student: Thomas Consoli **Supervisor: Dr. Ing. John C. Betts**

Introduction

Using materials and coatings with an increased erosion resistance for wear protection in materials processing, handling, and transport by hydraulic means can lead to remarkable economic benefits. These benefits are derived from the fact that use of more erosion resistant materials will lead to less frequent failure of critical components which will in turn lead to reduced maintenance costs and plant downtime [1]. However, there is a lack of experimental data which can be considered to be consistent and reliable due to the existence of numerous parameters affecting the erosion phenomena which are difficult to control, and due to the fact that the results obtained heavily depend on the flow configuration and on the design of the erosion tester. Hence, there is a need of an erosion tester which experiences the lowest number as possible of unwanted and uncontrolled parameter variations during the tests and which offers enough flexibility to vary parameters and study the effect of such variations.

Project Objectives

The main aim of this final year project is to make improvements over an existing modified Slurry Pot erosion testing machine by designing and constructing an erosion tester which is easy to use and which exercises control over all the variables affecting the experiment; hence producing an efficient way of ranking materials in order of resistance to erosion.

Project Methodologies

In the project, critical parameters upon which control is necessary when carrying out a slurry erosion test were identified and consequently an erosion tester which exercises the required control over these parameters was designed and constructed. The following steps were carried out during the project:

- Literature review of already existing slurry erosion testers and their development throughout the years.
- Literature review of the effect of uncertainties and variation of experimental parameters on the flow configuration and on the erosion of the specimens being tested.

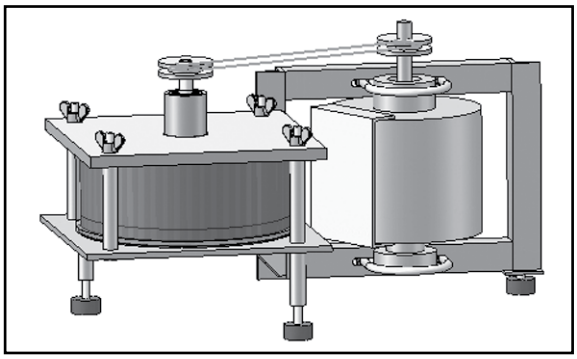


Figure 1: Computer Assisted Drawing of Final Assembly

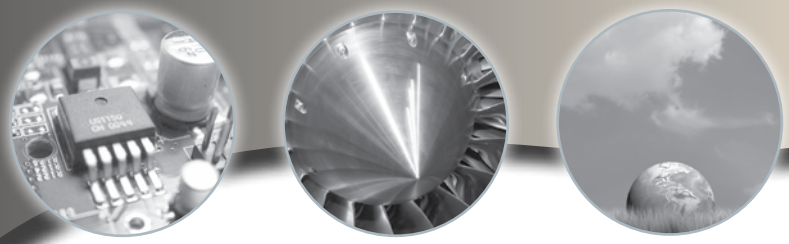
- A design procedure including functional analysis, association methods, brainstorming, DFX, constructional domain analysis and a material selection procedure.
- Construction and assembly of the components making up the Slurry Pot erosion tester.
- Test to determine the best impeller for particle suspension at a certain set of parameters.
- Test of the erosion testing machine with specimens having different erosion-resistant properties.

Results and Achievements

The erosion tester designed and constructed in this final year project offers flexibility in changing most of the test parameters which have an effect on the erosive wear of specimens under test; hence allowing further experimental investigations to be made in the future with the aim of defining standard parameter values and consequently define a standard test for assessing the erosion resistance of materials.

References

[1] H. Mcl. Clark, R.J. Llewellyn, 'Assessment of the erosion resistance of steels used for slurry handling and transport in mineral processing applications', Wear 250, 2001, pp. 32-44



LASER PROCESS FOR WELDING OF AISI 316 STEEL PARTS

Student: Clayton D'Amato **Supervisor: Dr. Joseph Buhagiar**

Introduction

Austenitic stainless steel components are currently being produced by Adpro instruments by welding stainless steels bars to a casting using the manual metal arc welding process. Improvements to the outcome of such a process can be achieved by welding the parts using a CO_2 laser. This process is capable to produce welds having deeper penetration, faster welding speeds and much narrower weld beads; thus a higher weld quality [1].

Project Objectives

The aim of the project is to identify the laser parameters suitable to fully weld the parts by making a single sided weld and using no filler material. The welds should not include any major voids and they should satisfy the aesthetic requirements of the company. Repeatability of the process is an essential requirement.

Project Methodologies

Review of the literature was carried out to understand the techniques currently used in laser welding. The researched techniques and parameters were then applied to weld samples cut from the austenitic stainless steel bars. A technique known as keyhole welding was used to weld the material without using any filler material. Optimization of the parameters was then carried out by a suitable deign of experiment. Parameters investigated included laser power, traversing speed, focus position, shielding gas type and flow, and also plasma suppression by means of a side jet.

The welded samples were then sectioned and analyzed under a microscope to study their microstructure and determine the presence of any defects. Once the optimum parameters suitable to achieve the desired weld quality were discovered, welding of the actual parts was carried out and further improvements on the process were made.

Results and Achievements

One of the first achievements was to obtain a weld penetrated from side to side (fully penetrated). Relatively high laser powers were used to achieve such a weld and the welds were not repeatable. An improvement was obtained when plasma suppression was utilized, this reduced the power needed and improved repeatability. The weld achieved had still a problem of slight under-fill (fall in level of the material), still this was solved by introducing a slight clamping force. Optimization of the parameters of the laser and plasma suppression system together with this final addition of clamping resulted in a fully penetrated, repeatable weld, having a good weld profile. The cross section of such a weld is shown in figure 1.

The parameters obtained were then used to weld the actual parts. A good weld was achieved; still the end of the weld was not being welded uniformly. This was solved by varying the laser path to control the input of energy at the end of the weld. This resulted in a fairly uniform weld along the part. The top side of the weld performed is shown in figure 2.

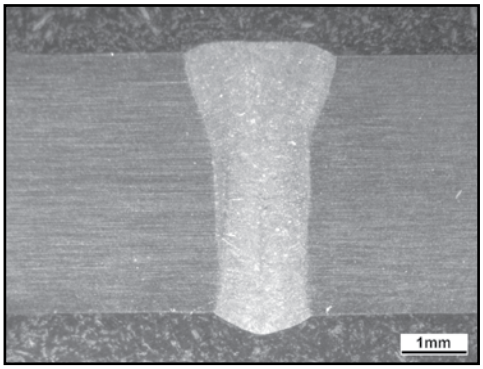


Figure 1: Weld cross section.

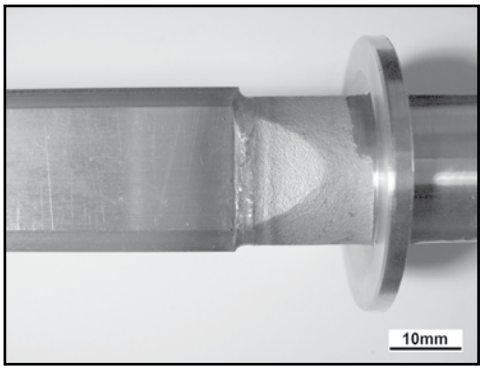
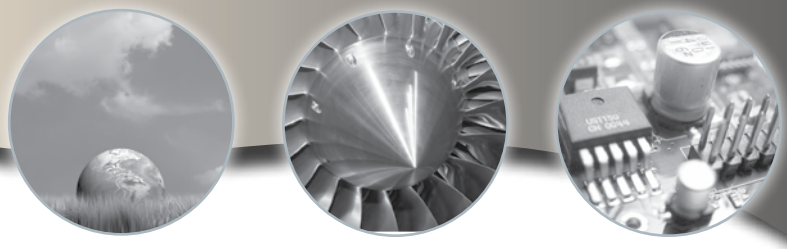


Figure 2: Top side of weld on actual parts.

References

[1] Sindo Kou. "Welding Metallurgy". Canada, New Jersey: John Wiley and Sons, Inc., 2003.



DEVELOPMENT OF PROCEDURES FOR USING A MODIFIED SLURRY POT EROSION TESTING DESIGN

Student: Francelle Farrugia **Supervisor: Dr. Ing. John C. Betts**

Introduction

Slurry erosion is the progressive loss of material from a solid surface. This takes place by the action of a mixture of solid particles in a liquid in motion with respect to the solid surface [1]. In a number of applications, flow of fluid with particles in it is required therefore there should be standard tests that clearly differentiate between the erosion performances of different materials.

Project Objectives

The aim of this dissertation was that of attempting to produce a standard test for measuring erosion, using a modified slurry pot erosion tester. The main objectives were:

- To vary test parameters and analyse the effect o on the erosion mechanism.
- To develop a methodology for the application of the modified pot, as well as for presenting the data obtained from it.

Project Methodologies

The following steps were carried out during the implementation of the project:

- Literature review of parameters effecting erosion, and of various tests that enable the analyses of effect of such parameters.
- Refurbishment of the modified slurry pot erosion tester and carrying out tests using this pot to vary the following parameters: time of test, concentration and size of eroding particles, speed of impeller and specimen material.
- Development of a methodology of evaluating erosive wear as well as a standard test for measuring erosion using a modified slurry pot erosion tester.

Results and Achievements

Erosion rates were measured using mass loss and image analysis of the specimens. The first method of erosion measurement, although straightforward, does not give information on the distribution of erosion material loss and was found to be ineffective for short tests on materials such as stainless steel AISI 316L. On the other hand, it was effective when used on friable materials such as limestone, even for very short test duration of one minute. The second method gave detailed information on the nature, distribution and extent of erosive wear. This led to the development of a standard procedure for using the modified pot as well as a methodology for presenting the data obtained from it.

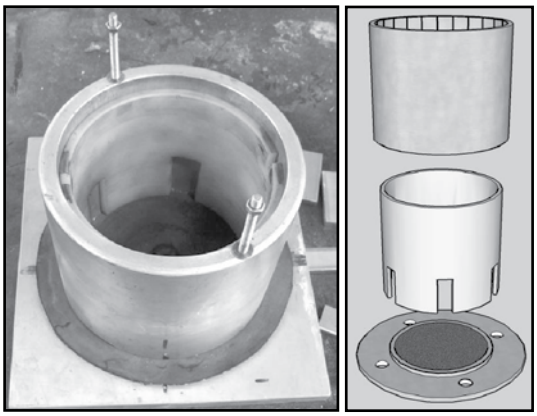
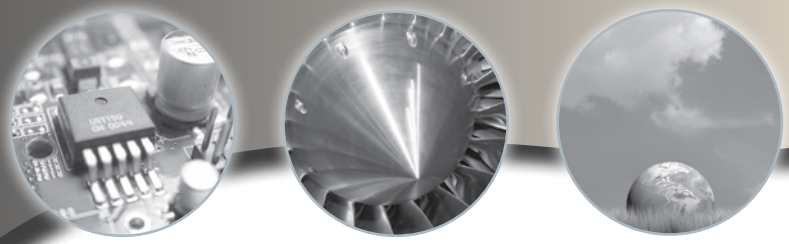


Figure 1. (left) Diagram of modified slurry pot tester: outer cover (top); inner sleeve with five recesses (middle); base with rubber seal (bottom). Figure 2. (right) Assembly of parts (in absence of the lid and impeller) [2].

References

[1] Davis J.R., 'Surface Engineering for corrosion and wear resistance,' ASM International, 2001, pg 54-71.

[2] Betts J.C., The laser deposition of stainless steel-matrix composite surfaces, PH.D. Thesis, 2008.



MECHANICAL TESTING OF FIBRE-REINFORCED POLYMER MATRIX COMPOSITES

Student: Samuel Zerafa **Supervisor: Dr. Ing. John C. Betts**

Introduction

Composites are combinations of materials, differing in composition or form, where individual constituents retain their separate identities and do not dissolve or react. These separate constituents act together to give the necessary mechanical strength and stiffness to the composite part.

The major structural applications for fibre-reinforced composites are in the field of aircraft production, for which weight reduction is critical for higher speeds and increased payloads at reduced fuel consumption. Carbon fibres have become the primary material in many wing, fuselage, and empennage components. Glass fibre-reinforced polymers are also widely used for marine applications. Their principle advantage is weight reduction, which translates into higher cruising speeds, acceleration, better manoeuvrability and fuel efficiency.

Project Objectives

In general, fibres are combined with a polymer to produce a unidirectional laminate or in a 0/90° woven fabric composite.

A number of samples with different fibre materials and different orientations were manufactured and tested under tensile and flexure loading according to BS 2782-3 and BS EN ISO 14125:1998 respectively. A scanning electron microscope (SEM) was used to identify the mode of failure, and recommendations to optimise the materials tested were then given.

Project Methodologies

- Background information was compiled in a review of the literature
- Meetings with Buccaneer Boats and Alliance Ltd., were held to identify experimental results useful to the local industry
- Specimens with S-glass, E-glass and Carbon fibre reinforced Epoxy were manufactured using vacuum bagging.
- After testing under a tensile and flexure load, the samples were viewed under an optical microscope and by means of SEM analysis (Figure 1) to investigate the resulting mode of failure.

Results and Achievements

Results for flexure properties indicate that for those specimens with fibres oriented at 45°/45° a large deflection was obtained resulting in low flexural stress and modulus. On the other hand, the strain was larger than that of the 0°/90°. Similarly the elongation at break of the 45°/45° specimen tested under a tensile load was about 30% in comparison to those 0°/90° specimens where the elongation was around 18% resulting in a catastrophic failure mode.

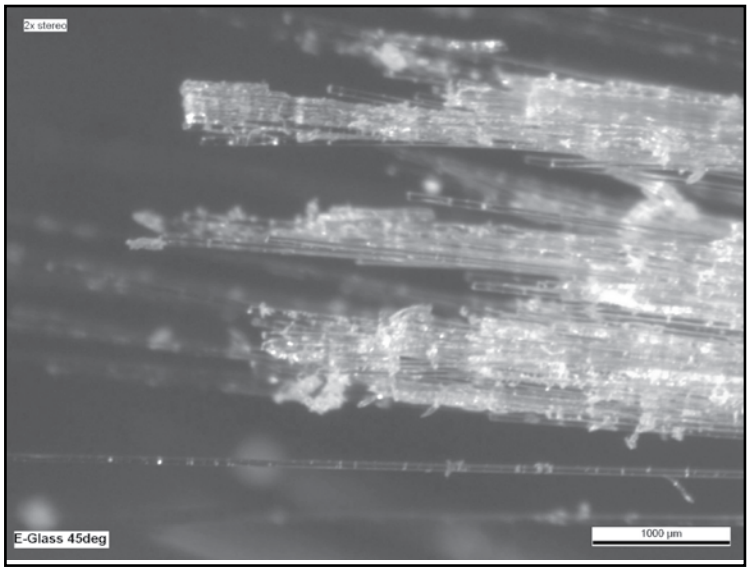
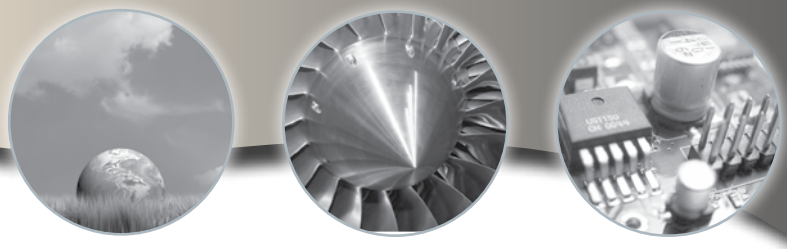


Figure 1: E-Glass composite with fibre orientation 45°/45°after failing under a tensile load and Carbon fibre composite after failing under a 3-point loading test.



STUDYING THE FEASIBILTY OF SMALL HOLE DRILLING USING CONVENTIONAL EDM

Student: Astrid Borg

Supervisor: Ing. Tania Briffa
Co-Supervisor: Ing. Arif Rochman

Introduction

The trend towards micro machining technology has drastically increased in the past years and the emerging roles of small holes is imperative to various sectors including automotive, aerospace, mould, die making industries, optical, medical and dental industry. There are several established manufacturing techniques used for small hole drilling but Electrical Discharge Machining (EDM) drilling is the preferred method due to its high precision, the good surface quality it can produce and the ability to machine conductive hard metals. EDM is a non-traditional thermo electrical process, were material is removed by a series of discrete sparks between the work and tool electrode.

Project Objectives

Small holes are specifically drilled on small hole and micro EDM machines but this research study was conducted on a conventional EDM machine, which is designed for macro machining. The aim is to investigate the feasibility of conventional EDM machine is to drill small quality holes. Quality hole characteristics include form characteristics (taper, straightness and out-of-roundness), surface finish and surface metallurgy. Another objective is to provide guidelines to improve these quality characteristics.

Project Methodologies

- Research study on small hole drilling using the EDM process
- Identify the most influential EDM parameters and perform a set of experiments using these parameters
- Acquiring results of hole quality characteristics
- Analyzing results and identify the best process parameters to drill quality holes

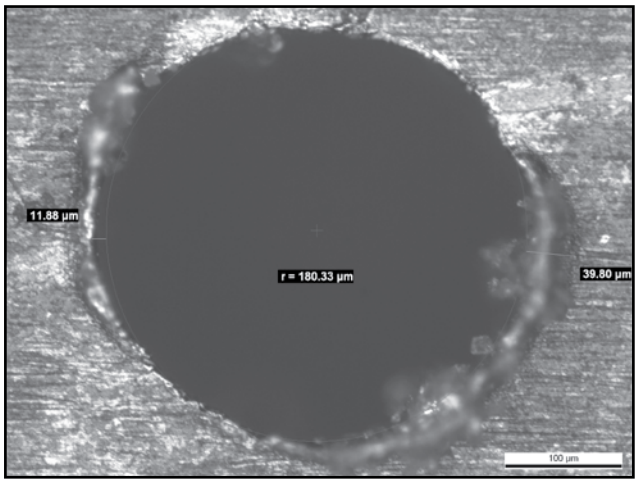


Figure 1: 0.36mm diameter hole containing out-of roundness

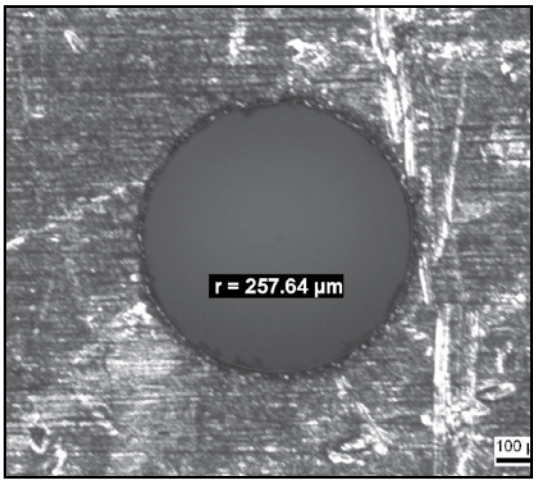
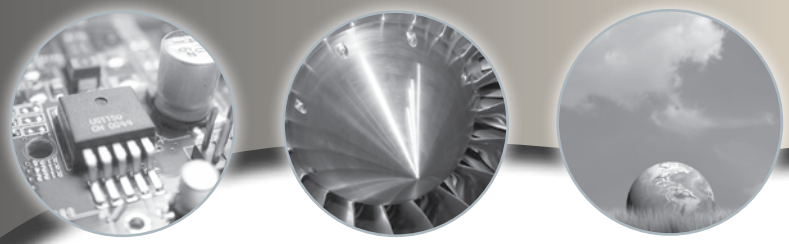


Figure 2. Round hole of 0.5mm diameter

Results and Achievements

Good quality holes have been drilled down to 0.5mm diameter; however the process on a conventional EDM does not provide repeatable results.



PROCESS EVALUATION TOWARDS LEAN PRODUCTION

Student: David Calleja **Supervisor: Dr. Ing. Conrad Pace**

Introduction

It may surprise the average person to find out that only 5% of all the activities performed vis-á-vis the product contribute toward adding value to it[1]. This project, in collaboration with a local manufacturing company, Prominent Fluid Controls ltd., analyzes issues related to the process flow of the production of pH probes and similar measuring products. A strong emphasis on Lean Manufacturing is to be made and any work done throughout this project is based on the principles put forward by it.

Project Objectives

Prominent Fluid Controls ltd., like any other manufacturing industry is faced with everyday pressures which are presented to them by their customers, mainly through the fast response required and changes in demand. The objectives of this project are:

a) To analyse the production flow from a lean perspective
b) To model the existing set-up using computer simulation
c) To propose and evaluate improvements
d) To model the proposed scenarios and compare results to the existing scenario
e) To use these results to pin-point which areas of the production flow can be improved.

Project Methodologies

This project identifies wasteful activities in the production of pH probes at Prominent Fluid Controls ltd. and proposes various options to reduce this waste. Computer simulation is used to simulate the afore mentioned proposals to test their validity. The following steps were carried out during the implementation of the project:

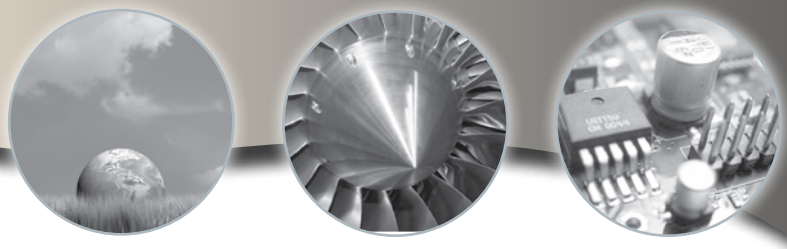
- Literature review of Lean Manufacturing principles, work study and simulation techniques
- Pareto analysis to define where Lean implementation would be most beneficial
- Production flow analysis
- Modeling of current scenario using SIMUL8® simulation software[2]
- Verification and validation of current scenario model
- Solution concept development
- Modeling of concepts using SIMUL8® simulation software[2]
- Verification and validation of concept models
- Comparison of concept models with current scenario model to assess benefits of proposal implementation

Results and Achievements

Several Lean tools were used to formulate solutions to reduce waste from the production of pH probes. Different layouts were proposed for the facility and simulated to given comparable results. The range of proposals range from the minor to the major in terms of investment and re-organization however all serve to make the production in question a Leaner enterprise.

References

[1] Pascal Dennis, 'Lean Production Simplified', Productivity Press, New York, 2002. pp. 13-26
[2] Hauge, JaretW., and Kerrie N. Paige. 'Learning SIMUL8: The complete guide'. 2nd ed. Bellingham,WA: PlainVu, 2004.



DESIGN AND CONSTRUCTION OF MACHINE VISION SYSTEM FOR INSPECTING COSMETIC CASES

Student: Luke Desira **Supervisor: Dr.Ing Philip Farrugia**

Introduction

Machine vision, in short MV, is one of the means through which a manufacturing firm can reduce labour costs and increase the quality of the products produced. MV employs a camera, a lighting device and specialised software to simulate human vision in a manufacturing system. This project, carried out in conjunction with Toly Products Ltd., which is a manufacturing firm producing cosmetic cases, is focused on the automatic inspection of the print on two of their products, the Sephora large and Sephora small lids, depicted in Figure 1. Even though the two parts pass through the same process, they have got different defects. Figure 1 depicts two typical defects in the large and small parts and images of good large and small parts respectively. The various defects on both parts come about due to various reasons, mainly; due to bad positioning when setting up the machine, using dried or a wrong mixture of the paint, printing using a dirty printing pad, or a defective cliché, or because of general wear and tear in the machine.

Project Objectives

- Produce a literature review about MV and various design tools
- Collect information regarding the defects being inspected
- Design an MV system through the use of appropriate design tools
- Construction of selected design for MV system
- Carry out a PFMEA (Process Failure Mode and Effect Analysis)
- Perform an evaluation of the system constructed

Project Methodologies

Figure 1 – Image Showing (a) Typical Defects (b) Good Sephora Parts

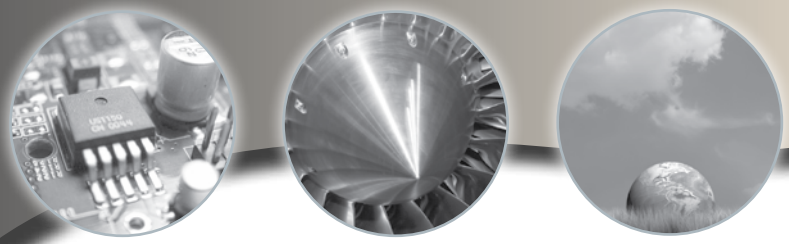
Figure 2 – System Setup

In order to be able to solve this problem, the basic design cycle was followed. This cycle is made up of four sections; problem analysis, synthesis, simulation and evaluation. First, through problem analysis, a very good understanding of the problem at hand is obtained. Tools such as product design specifications (PDS) and quality function deployment (QFD) have been used. Step two involves the generation and integration of solutions to sub processes, such as the material handling and the software tools supporting the camera. Appropriate algorithms were used in order to classify an image. Once the integration was complete, the system was constructed, as seen in Figure 2, and through the simulation stage, it was tested. The final stage in the basic design cycle is the evaluation stage, in which a PFMEA was carried out. Finally, the system will be tested on a production line, to see the real capabilities of such a system.

Results and Achievements

The test carried out involved the system identifying fifty good compacts and seventy defective compacts, a test in which the system performed very well. The engineers at Toly needed a proof of concept, something which they refer to when designing a system to inspect these parts, instead, a system which through minor alterations can be placed in the harsh environment of a production line has been supplied. Through this project, one third of a large project at Toly, that is, the full automation of the manufacturing of these compacts has been completed.

Another important conclusion drawn from this thesis is the huge importance that the amount of light falling on the camera and on the part has. Lighting can make or break a system.



AUTOMATION CONSIDERATIONS IN A BULK TABLET PACKAGING PROCESS

Student: Ian Fenech

Supervisor: Dr. Ing. Conrad Pace
Co-Supervisor: Ing. Donald Camilleri

Introduction
It is a fact that today's customers are continuously requesting lower volumes of products, thus manufacturing companies are continuously running shorter and shorter batches. As a direct consequence to this, manufactures are resorting to automation since less running costs, faster changeovers and thus more production could be achieved.
This is an industrial project sponsored by Actavis Ltd., which is presently one of the leading pharmaceutical companies in the global generic market. One of the areas with a significant labour content at Actavis Ltd., is the bulk packaging of tablets. Actavis Ltd. saw a potential growth in the demand for bottle packaging thus the need for a more efficient and viable process to the present layout arises.

Project Objectives

The aim of the project is to revise the bottling operations through the application of automation such that the bulk packaging line would only necessitate the human interaction of two operators in order to be fully functional. This will enable Actavis Ltd. to re-locate the third operator to a higher demand area of production according to any uprising needs.

Project Methodologies

The design project identifies the process stages were automation should be ideally implemented and offers solutions to all the process functions in those particular stages. The following steps were carried out during the implementation of the project:

- Literature review on the different types of automation, the different types of part escapements and a possible manual to automation migration strategy.
- Process time study.
- Identify the possible stages in the process which should be ideally automated.
- Analyse all the process inputs, outputs, variants and the constraints of these two process stages.
- Generate various concepts which can perform the required automated function.
- Develop the best/most feasible concepts.
- Generate CAED models for these concepts.
- Test some of the designed concepts.

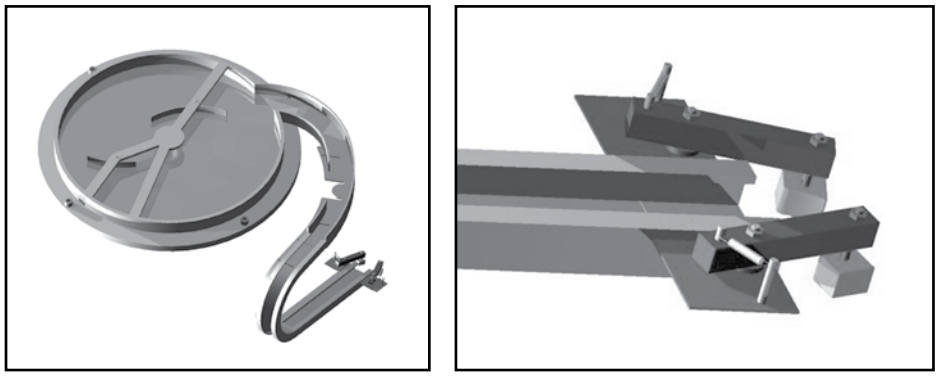
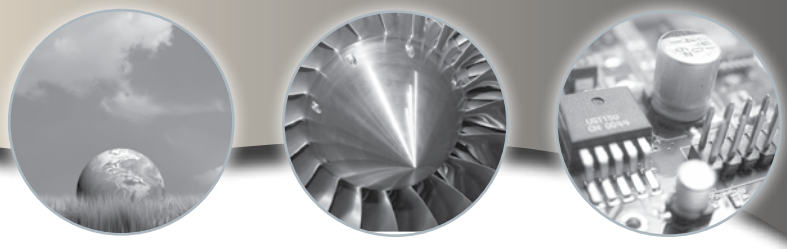


Figure 1: a) The Orienting and Insertion of the Bottle Caps b) Detail of the Cap Insertion Mechanism

Results and Achievements

From the tests carried out, the designed concepts successfully manage to perform the desired functions whilst meeting the production standards of Actavis Ltd with a good level of confidence. In this project two stages of the bulk tablet packaging process were managed to be automated. Particular care was taken in order to purposely design the components to be as portable and as flexible as possible in order to enhance component interchange ability.



MACHINING USING THE CO_2 LASER

Student: Roberta Galea

Supervisor: Ing. Pierre Vella
Co-Supervisor: Dr. Ing. J.C. Betts

Introduction

Along the years, the possibility that a laser could be used for machining and welding was pondered. With regards to machining, the fact that there is no contact between tool and material seemed perfect. The CO_2 laser proved to be successful in the cutting, welding, and heat treatment of metals. [1] In fact, it is considered as the most energy efficient laser capable of providing the necessary beam power densities among lasers with material processing capabilities. Performances are stable and the machines are easy and safe to operate if regulations are observed. [2] Thus nowadays, great interest in machining using the laser has been shown.

Project Objectives

The main objectives for this project are to:

- Define a set of specifically designed experiments whose results will be used to assess the capability of the CO_2 laser for machining a small selection of features in a range if materials.
- Analyse and evaluate test results.
- Establish a small range of materials and features which can be satisfactorily machined using the CO_2 laser.
- Evaluate the strength and limitations of the CO_2 laser in machining selected features in the materials tested.
- Identify areas which require further study.

Project Methodologies

The project identifies different materials and features which can be machined using the Rofin Sinar Triagon 9000 9kW CO_2 fast-axial-flow laser in the laboratories of the Dept. of Metallurgy and Materials Engineering. The following steps were carried out during the implementation of the project:

- Literature review on current processing techniques for ceramics and polymers, glass and PMMA in particular, on laser beam machining and on DOE
- Identify the minimum and maximum parameters to use on both materials
- Use of DOE to determine the optimal runs

Results and Achievements

From the results obtained in PMMA, it can be shown that an increase in spot size leads to a narrower width of cut. It is also evident that as the spot size is increased, the width of cut increases. Results also show that using a higher feedrate will produce a smaller width of cut. A reason for this is that the slower the speed, the longer is the time for the laser beam to diffuse sideways. When it comes to comparing continuous wave mode and pulsed mode, results obtained show that side burning is more evident in continuous wave mode than in pulsed wave mode. The pulse keeps the power intensity constant, thus controlling side burning.

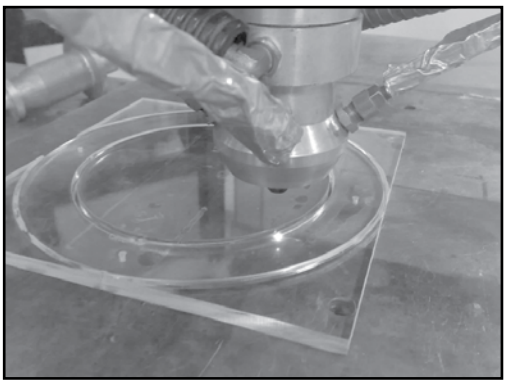
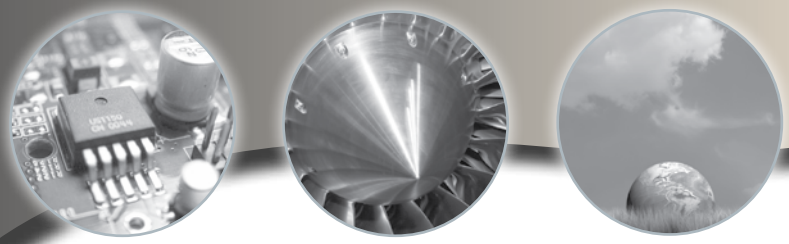


Figure 1: Laser Beam Machining of PMMA

References

[1] G. Eberhardt, "Why CO_2 Lasers – Why Gas Transport Lasers", Industrial Applications of Lasers, Wiley-Interscience Publication, 1984

[2] H. Koebner, "Overview", Industrial Applications of Lasers, Wiley-Interscience Publication, 1984, pp. 69-78



AN INNOVATIVE TOOL FOR GLOBAL DESIGN AND MANUFACTURING

Student: Daren Mifsud **Supervisor: Dr. Ing. Philip Farrugia**

Introduction

Sketching using pen and paper is a natural and comfortable method to express and to store ideas indifferently of the location [1]. Sketching is fundamental during conceptual design but it has its limitations, especially for visualisation purposes. In contrast physical models illustrate the designer's intent more correctly [2].

Project Objectives

This project aims to support mobile designers working in a global design environment by remotely producing a physical model directly from a paper-based sketch in any location around the world.

Project Methodologies

The following methodology was adopted:

- Literature review on computer-based tools supporting global design and manufacturing
- Identification of the technical requirements required to develop an asynchronous collaborative tool with the above-mentioned functionality
- An implementation of a proof-of-concept tool
- An evaluation of the tool with case studies
- An investigation regarding the effectiveness of the tool.

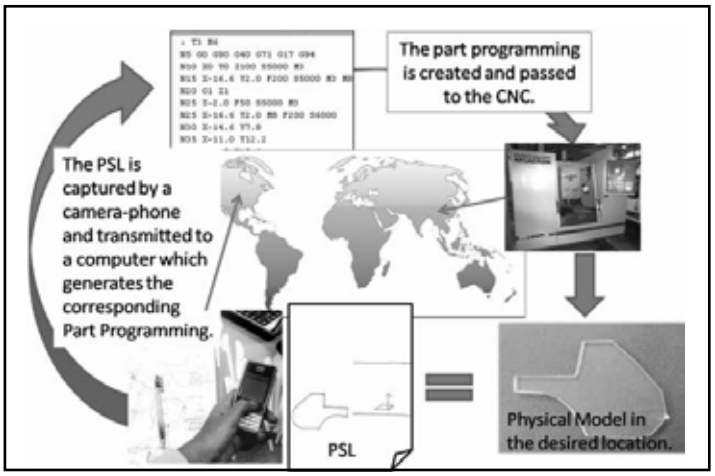


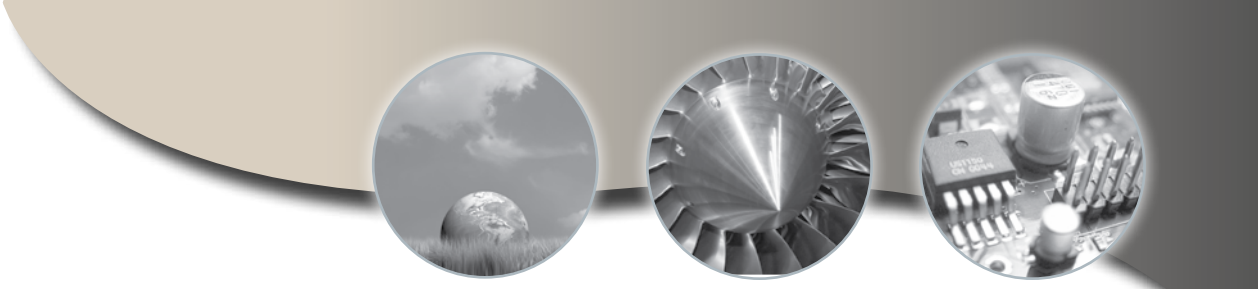
Figure 1 : Application of the tool in a global design and manufacturing environment

Results and Achievements

The prototype tool developed during this project enables the designer to initialise the process to create a physical model from anywhere around the world independently from distance and time zones. The designer sketches the geometry required on a paper, a camera-phone is used to transmit the image to a computer, which in turn will create the part programming necessary to machine the physical model on a vertical milling CNC machine.

References

[1] Beryl Plimmer, Mark Apperley, Computer-Aided Sketching to Capture Preliminary Design
[2] Jack Breen, Robert Nottrot, Martijn Stellingwerff, Tangible virtuality—perceptions of computer-aided and physical modeling, Automation in Construction 12, year 2003, pages 649– 65.3



IMPROVING SMOOTHNESS AND REDUCING SOUND IN LIPSTICK PACKAGING

Student: Gilbert Spiteri **Supervisor: Prof. Ing. Jonathan C. Borg**

Introduction

This project focuses on the mechanisms with which lipstick packaging function and was carried out in collaboration with Toly Products Ltd. For this company, functionality and usability of lipstick packaging are no longer sufficient in order to attract customers from different market segments. Stakeholders are searching for other product attributes with which they can elicit positive and pleasurable emotions in customers. The aim of this project is to elicit positive emotions in customers by improving smoothness and reducing sound in lipstick packaging. This project is a continuation of the thesis entitled 'Design for Emotion of Cosmetic Packaging', which saw the development of a number of innovate concepts. Concepts A and C were chosen by Toly Products Ltd in order to be improved in the fields of smoothness and sound. Two solutions for each concept were developed and the overall most promising ones were chosen following evaluation from both Toly Products Ltd and the end customer.

Project Objectives

Academic goals

- Perform a comprehensive literature review on design for emotion, smoothness and sound
- Utilize appropriate design tools to develop and evaluate a number of alternative design concepts
- Model and manufacture a number of functional prototypes
- Critically evaluate the strengths and weaknesses of the proposed solutions with the end users

Industrial goals

- Assess the manufacturing feasibility of the concepts

Project Methodologies

The layout of this project follows the design methodology of a Basic Design Cycle:

- Problem analysis: an intensive literature review was conducted regarding design for emotions and how these positive emotions can be elicited in the end customer. Two crucial factors for eliciting positive emotions in lipstick packaging are smoothness and sound. A theoretical background on smoothness and sound was carried out, highlighting the factors which provide a smooth movement with less sound produced
- Solution synthesis: a critical review of concepts A and C was conducted, highlighting the major limitations of each concept, and proposing improvements. Four different concepts were generated
- Solution analysis: analysis in further detail was carried out for each solution. Rapid prototyping was a key factor in analyzing these solutions better. Prototypes were manufactured in order to be evaluated
- Solution evaluation: the four solutions were evaluated both by Toly Products Ltd (stakeholders) and by the end customer. A solution cost impact assessment was carried out together with Toly Products Ltd and includes mould costs for each solution. The end customers evaluated the functional prototypes and gave their opinion regarding smoothness and sound

Results and Achievements

From the customer evaluations, it emerged that the solutions with the smoothest movement and which produce the less sound were solutions 1 and 4. Theoretically speaking, these two concepts were designed to provide a smoother movement with the minimum sound generated compared to solutions 2 and 3 respectively. The results of this survey proved this statement even further. From the cost impact assessment, it emerged that the manufacturing costs of moulding solutions 1 and 2 is less than that of moulding solutions 3 and 4. A decision matrix was drawn, comparing the four solutions against eight different criteria. From this matrix, it was concluded that the best overall solution to replace concept A would be solution 2 while that to replace concept C would be solution 4.

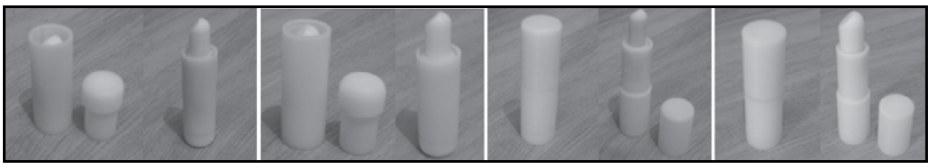
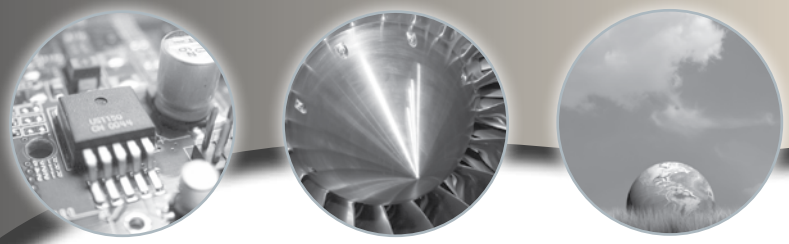


Figure 1: Solutions 1, 2, 3 and 4 respectively



INCREASING EFFICIENCY IN THE LAUNDRY DEPARTMENT OF PORTUGHES LAUNDRY AND DRY CLEANING

Student: Jeremy Spiteri **Supervisor: Dr. Ing. Michael A. Saliba**

Introduction

Introducing automation in the laundry sector of Portughes Laundry and Dry Cleaning is not an easy task, because laundry that is washed belongs to the general public, and thus, unlike laundry from hotels, they vary in sizes, colours and material substantially. Even though other laundries around the world work in a different way, knowledge of their methods is still very useful to design an efficient automation for the Portughes Laundry. Therefore this thesis goes into automation for flexible objects by researching automation used in industrial laundry, and applying innovative ideas to deal with the general laundry found in the Portughes plant.

Project Objectives

The aim of this project was to increase efficiency and productivity in the Laundry section of this esteemed company, to give it that extra weapon to compete and survive throughout its future.
This was achieved by:

1. Re-organising the shop-floor to have a more efficient material flow.
2. Introduce automation concepts to the current processes to cut down Work in Process times and costs.

Project Methodologies

The first objective was achieved by analysing the laundry flow from one section to the other. The laundry flowed from the Lift to Tagging to Washing to Drying to Sorting to the Lift again. Given the current shop-floor, the laundry goes back on its movement many times and this all adds up to wasted time, and chaos on the shop-floor, thus this was eliminated by assigning strong connecting points and weak connecting points to each section of the shop floor to come up with the ideal shop floor layout.

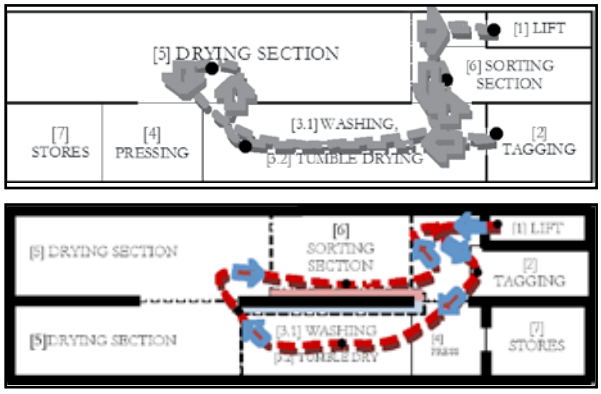


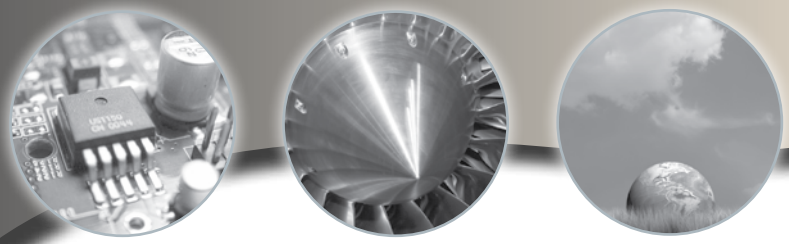
Figure 1: (Top) current shop floor layout. (Bottom) proposed shop floor layout

The second objective was met by introducing a simulation of the current process, so that one can compare how the current process is working, before a new process can be tried and tested. Thus a simulation compiled with the aid of Visual Studio, using C#, was created where the main affecting processes, mainly tagging, washing and sorting were compiled with their respective times in order to have a clear indication when each laundry would be finished. The simulation was run with the amount of laundry that was present each day at the Portughes plant, and the working hours were also inputted. After this simulation was compiled, all ideas that came to mind would then be studied for differences in Work in Process times by using the simulation software.

Results and Achievements

The results aimed for where achieved by implementing many ideas for the processes of this esteemed company. But the main effecting two ideas were the following.
The first main result that was achieved was the more organised and efficient shop-floor. The change in material flow from current shop-floor, to proposed shop-floor can be seen in Figures 1 and 2 respectively.
The second main result was achieved with the proposal of an innovative automation system that sorts laundry whilst they are drying. This was achieved by designing a flexible conveyor system to cope with the relative changes in quilt sizes from the general public. Therefore with the implementation of this innovative system, the Sorting section would be eliminated, reducing the working hours, thus making the process more efficient.
Automating for flexible and deformable objects is a difficult task, but having said that, it is not impossible.

Electrical Engineering Stream



CHARGING AND DISCHARGING OF HIGH CAPCITY LITIUM H-ION BATTERIES

Student: Samuel Buttigieg **Supervisor: Dr. Joseph Cilia**

Introduction

Lithium-ion batteries are a relatively new and promising electrochemical storage technology. Whilst lead acid battery management techniques are quite widespread and well know, the same cannot be said for lithium-ion batteries. The aim of this project is to gain experience in lithium-ion battery management.

Project Objectives

- Automatically charge and discharge a set of lithium-ion batteries
- Discharge the cells into the grid
- Implement a lithium-ion battery state of charge algorithm

Project Methodologies

- Literature review of lithium ion battery management techniques
- Gathering of equipment and assembly of the battery management system
- Performing tests on the charging, discharging and state of charge indication aspects of the system

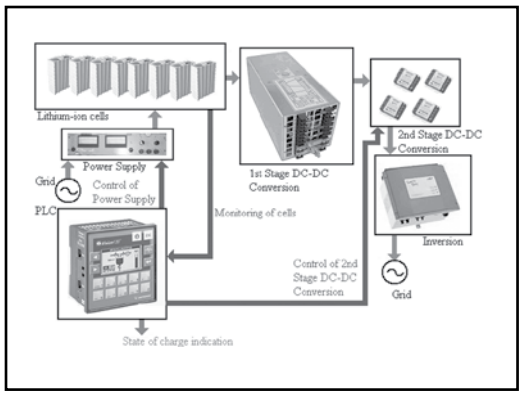
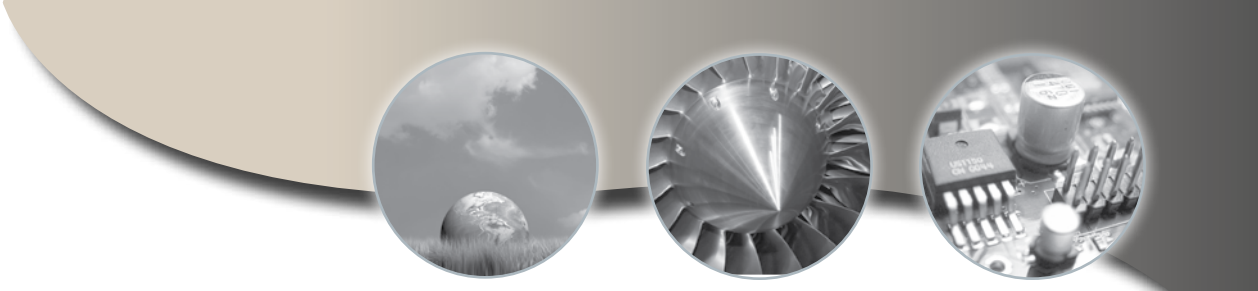


Figure 1: The project layout

Results and Achievements

At the time of writing the cells were automatically charged and discharged in a correct and safe manner. The discharging was done trough a bank of resistors. The discharging into the grid and the state of charge indication aspects will be completed by the end of May.



DC POWER ELECTRONIC LOAD

Student: James Camilleri **Supervisor: Dr. Ing. C. Spiteri Staines**

Introduction

Today we live in a world facing an economic crisis, ever-increasing fuel prices and a growing culture of awareness about the importance of being efficient and environment friendly. As part of the manufacturing process, Delta power supplies are exposed to their maximum loading for a prolonged period of time to test their endurance – a process known as the burn-in test. This consumes energy wastefully, and therefore a more efficient solution was needed to ensure that the test could remain with the same functionality, whilst consuming the least possible energy. This led to the idea of developing an electronic load.

Project Objectives

The aim of this project is to convert 0 – 400V (the output voltages of the range of power supplies manufactured by Delta Malta Ltd) to a suitable voltage that could be connected to a grid-tied inverter so that the energy could be fed back to the mains, resulting in the conservation of the test`s energy rather it being wasted. The end product of this design is then to be used in the testing of switched mode power supplies during the burn in test.

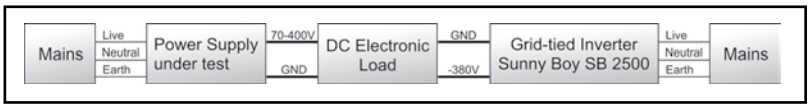


Figure 1: Block Diagram of the Project`s aim.

Project Methodologies

The following steps were carried out during the implementation of the project:

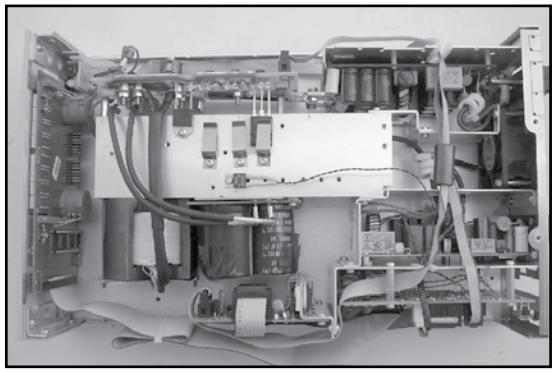
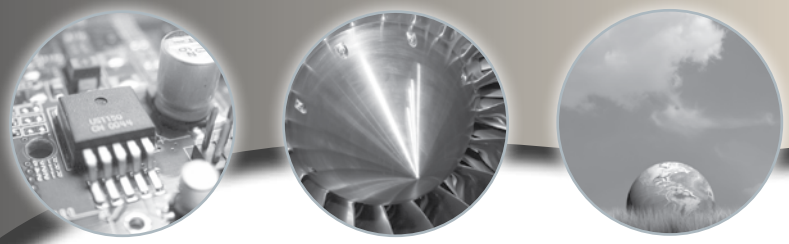


Figure 2: Construction of the DC Electronic Load

- A buck-boost converter with 120 Watt output power was built, proving the concept of the circuit.
- After having proven this concept on a small scale, the 1.6kW Buck Boost converter was designed and built.
- Designed all the circuitry involved, which mainly included two designs: the Control and Power boards.
- Building, Testing, Wiring and Calibrating of all the circuitry.
- The main features of the project include:
  - Automatic input voltage detection, Over- and Under Voltage and Over Temperature Protection;
  - Both the control board and the power board feature extensive easy access test points for both signal measurement and trouble shooting for ease of measurement, fault-finding and calibration
  - DC Current Limit protection together with a Start-up circuit for a smooth power circuit switch on;
  - Roughly 95 per cent of the circuitry was implemented using surface mount devices;
  - Isolation of the control circuit from the power circuitry through the use of an optocoupler;
  - An attractive enclosure with a well organized front panel with 7-segment displays indicating the Output Voltage and Current together with carefully placed LEDs as an aid for trouble shooting.

Results and Achievements

The power board was tested to operate correctly at power levels of 120W and 1600W in open loop. The over- and under voltage protection circuits and over temperature circuit were tested and operated as expected. The current limit circuit is working as designed with the only exception that it oscillates before switching on / off the gate pulses. The start-up circuit needs some minor adjustments on the automatic voltage detection. The control board was tested in open loop and all waveforms were as expected. The final step is to connect all boards together and verify that the entire project is working as planned.



SENSORLESS CONTROL OF AN A.C. DRIVE FOR ELECTRIC CARS

Student: Edward Sciberras **Supervisor: Dr. Joseph Cilia**

Introduction

A.C. drives offer numerous advantages when compared to traditional D.C. drives, namely higher efficiencies, lower cost and lower maintenance requirements. Their control is however more complex, and performance is only equated to D.C. drives with modern power electronics and processors. Vector control replaces the mechanical commutator with a mathematical decomposition performed on software. Performance rivaling that of a D.C. drive can now be achieved. Furthering the drive's robustness, sensorless algorithms attempt to remove the speed encoder from the machine by estimating the rotor speed for use in field orientation as well as speed feedback. A technique known as a Model Reference Adaptive System (M.R.A.S.) is a very popular estimation method which is widely used [1].

Project Objectives

The current setup consists of a 13kW induction machine with a 45kW loading motor to simulate any required load. The motor is controlled under sensored vector control and an F240 processor. This project attempts to implement an M.R.A.S. on the existing setup and update the processing system as follows:

- Build the sensorless algorithms in Simulink and satisfactorily model the drive [2].
- Correctly interface the F28335 processor with the existing setup.
- Implement sensorless vector control on the laboratory's test rig.

Project Methodologies

- Building of new control module between F28335 processor and power module.
- Testing of control module.
- Coding of control algorithms in Simulink
- Verification of code via simulation using PLECS plugin
- Verification of code via implementation on test rig.

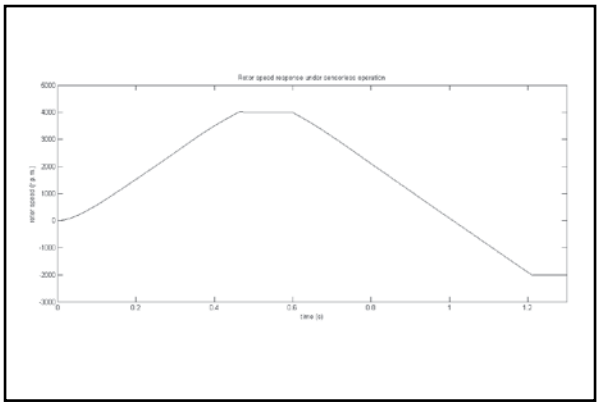


Figure 1: Simulated motor speed response

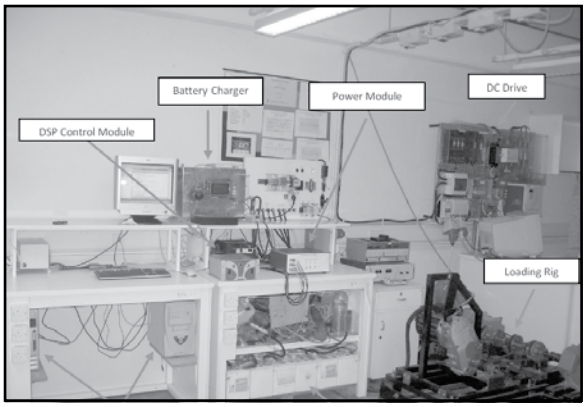


Figure 2: Rig setup.

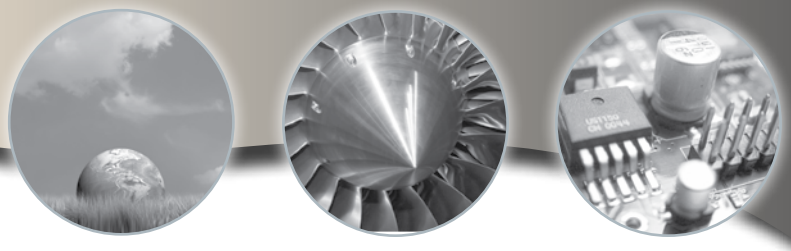
Results and Achievements

The code has been verified by computer modelling of the drive, and implemented in open loop control on the rig. A comprehensive simulated response of the induction motor is seen in figure 1, showing a acceleration to rated speed from rest and speed reversal, all in under 1.2s. Current work aims at correctly obtaining closed-loop M.R.A.S. control of the actual drive.

References

[1] Holtz J., *'Sensorless Control of Induction Motor Drives,'* Proceedings of the IEEEs, 2002, Vol. 90, No. 8, pp. 1359 - 1394

[2] Tabone M., *'Control Optimization of an Induction Motor at Very High Speeds,'* M.Sc. thesis, University of Malta, 2006.



THE DESIGN AND IMPLIMENTATION OF AN ELECTRIC BOAT

Student: Conrad Testa **Supervisor: Dr. Joseph Cilia**

Introduction

In the last few years there has been a great increase in the growing environmental concerns due to noise, water and air pollution caused by fossil fuel driven motors. In fact, most governments are introducing new incentives for drives with a low value of CO_2 emission. Apart from this, the on-going rise in oil prices gave a higher motivation to design and implement an environmentally friendly boat to replace the present boats used for the short trips to the Blue Grotto caves.

Project Objectives

- The first objective was to replace the previous prototype with a new fibreglass boat and electric outboard.
- Secondly design and implementation of all electrical circuitry needed to be made on the new boat.
- A third objective was to find a solution for the motor test rig to be able to fully load the motor.
- A fourth objective was to adjust the previous simulation for the new boat and motor.
- A fifth objective was to design a trailer for the boat so that one person would manage to launch the boat alone.
- A sixth objective was to set up a programmable charging system using prepaid accounts for different users.

Project Methodologies

Being part of a project which consisted of several theses, the first step was to identify and understand the work done on the previous electric boat. Meetings with the Blue Grotto boat owners were held to identify their main expectations from this project. This lead to an in-depth literature review on BLDC motors, type of batteries, type of chargers and boat modelling analysis. After identifying our needs a fiberglass boat similar to those presently used at Blue Grotto, a Torqeedo electric outboard, two Mentzer chargers, a charging pedestal and a trailer were ordered. Charging and discharging cycles on GEL type batteries was constantly applied and monitored using a BMU supplied by Abertax Quality Ltd. The motor test tank was modified and practical test were established until the boat was ready. In the meantime, the previous simulation was modified to suite the new boat and motor. A test rig was designed and built to be used in the wave tank and drag coefficients of the new boat were measured. When the boat and trailer were ready, all designed circuitry was implemented on the boat and it was taken out at sea for practical trials and testing.

Figure 1 Blue Grotto Caves

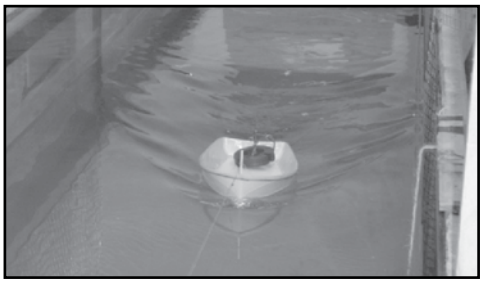


Figure 2 Model Under Test

Results and Achievements

After implementing all the hardware together, several tests were done in order to obtain important practical results. Results shown that Laboratory tests and practical tests were relatively the same were at least a minimum of nine trips can be done without recharging, while limiting the motor to 50A was a must since there was no increase in speed when the motor drawn over 50A. Finally after obtaining these great results and having the right vision to implement these environmental friendly electric boats, this project is ready to be implemented at Blue Grotto.

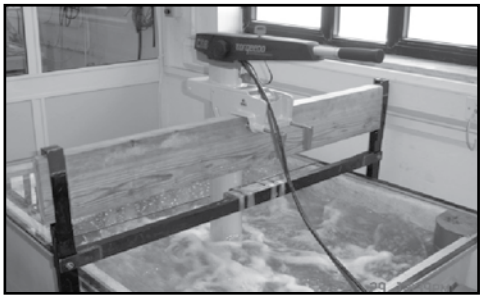
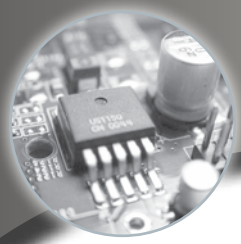
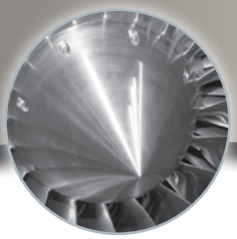


Figure 3 Motor in Test Tank

ENERGY EFFICIENCY IN BUILDINGS

Student: Karl Zammit

Supervisor: Dr. Ing. Cyril Spiteri Stains
Co-Supervisor: Dr. Ing. Cedric Caruana

Background

Energy is the prime mover of life. It is the core of any activity in buildings. Although energy production and building technology have made great achievements in energy efficiency, today we have still come to use more and more energy in buildings than our forefathers. Today's improved quality of life comes at a 'price'.

It follows therefore that energy management and conservation are the keys to using fuel and electrical energy in the most efficient way. Proper energy management can lead to big savings on the operating costs of a building. In addition it will help to conserve valuable natural resources. Any building, being residential, industrial, or commercial can become more energy efficient when proper energy management procedures are applied.

Project Objectives

The aim of this project is to analyse the energy management and conservation in existing buildings, mostly constructed in times when energy conservation was not a problem or a major financial consideration. In doing so it delved into existing systems, namely the Lighting system and the Heating, Ventilating and Air Conditioning systems, being the major systems which consume a high amount of electrical energy inside a building. At the same time it reviews existing systems, which as an alternative to electricity, utilise solar energy.

Project Methodologies

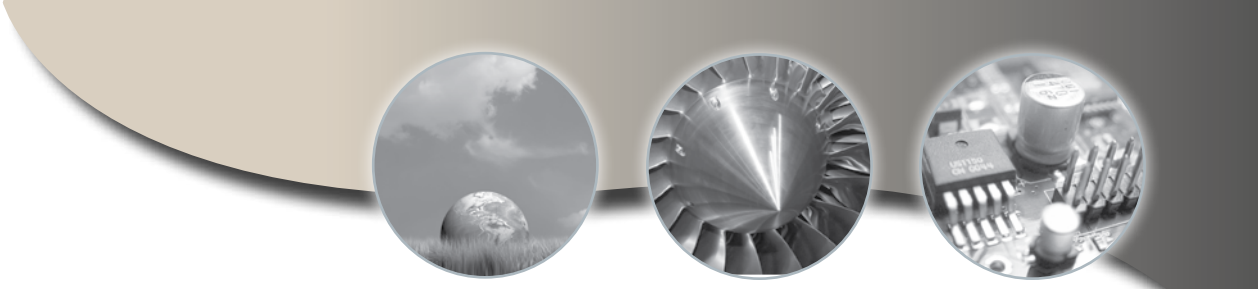
- Literature review on existing systems inside a building.
- Separate energy audit exercises at two particular buildings, one at the premises of one of Malta's telecom provider, GO p.l.c. and the other at the Faculty of Engineering at the University of Malta.

Inside these two buildings:

1. the luminance levels in all the different locations were measured by a Digital *Lux* meter. The *Dialux* software was used to produce better and more energy efficient lighting designs, in instances where the luminance level was not according to the CIBSE standards.
2. the overall Power factor of the entire premises was analysed,
3. the electrical power load on every circuit was monitored by means of a Data Logging Power meter and the results obtained were scrutinized,
4. the different Heating and Cooling technologies at Go p.l.c., chiller system and Variable Refrigerant Flow system, were compared.

Conclusions

The studies revealed that in both cases there is room for improvement in the way energy is consumed. Energy efficient measures, ensuring maximization of energy consumption but without affecting the occupants' comfort, were recommended.



DESIGN AND CONSTRUCTION OF FLIGHT SIMULATOR COMPONENTS (part 1)

Student: Analiza Abdilla **Supervisor: Mr. Brian Zammit**

Introduction

As part of the ongoing research in the field of aeronautics, the Department of Electronic Systems Engineering is currently designing a full flight simulator (FFS) to enable pilot evaluations and preliminary assessment of innovative on-board technologies. Being a distributed system, each component will be dedicated to a specific function and will interact with the simulator using a suitable data bus. This is also true for the cockpit hardware which will interact with the aircraft flight model computer, ideally through the same communication architecture in order to minimize interconnections.

Project Objectives

This project focuses on the interfacing techniques which will be used to interface the overhead panel to the flight computer. This project is required to solve the problem of having large amounts of data lines, replacing them with an effective and robust communication technique to reduce cabling and crosstalk. Three popular buses, namely I^2C, CAN and Ethernet were considered with the latter selected due to the readily available support within the simulator network.

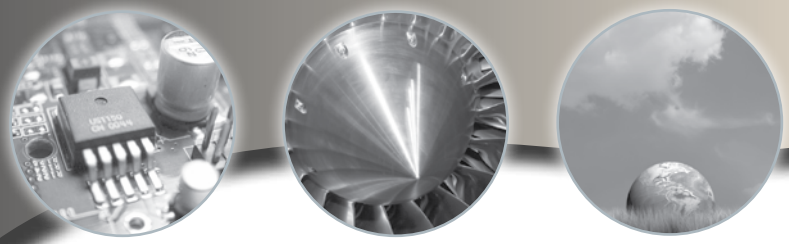
Project Methodologies

The adopted methodology for the implementation of the whole set-up was as follows:

- Review of typical aircraft overhead panels, particularly the A320 model
- Identification of all the input and output devices usually found on such panels
- Review of possible data bus technologies and selection of a suitable architecture to minimize amount of data cables
- Selection of a microcontroller system with TCP/IP support.
- Development of a suitable data structure to transfer digital/analogue information between two parties over Ethernet
- Multiplexing and demultiplexing techniques for the respective overhead panel inputs and outputs to be connected to the limited number of microcontroller GPIO data lines.
- Coding of a mock up flight computer to emulate typical flight data on the Ethernet network.
- Construction of the hardware and interfacing of all panel switches and knobs
- Implementation of the software function to manage the multiplexing and demultiplexing circuitry, decode the network information and relay packets to and from the overhead panel.
- Construction of the hardware and testing of desired operation

Results and Achievements

In view of this, the proposed model is based on Ethernet which conceptually resembles the current AFDX data bus found on new aircraft such as the Airbus A380. In this configuration, all the subsystems communicate over a full duplex Ethernet system. Data is relayed using the User Datagram Protocol, which is able to outperform TCP in speed within local area networks. The current state of the project is that an I/O subset of the overhead panel has been multiplexed and the system was verified to operate as specified. The system is currently being expanded to cater for all the required inputs and outputs.



INDOOR BLIMP – CONTROL MODULE

Student: Edward Apap

Supervisor: Ing. Paul Debono
Co-Supervisor: Dr. Ing. David Zammit Mangion

Introduction

As part of an effort to design and construct an indoor blimp, this project was concerned with the design and implementation of the hardware and software required to control an indoor blimp. The blimp is primarily intended to be used in the faculty for promotional purposes. The construction of the blimp structure and its communication system is being done in other projects.

Project Objectives

The aim was to build a control system capable of navigating the blimp in space. The system has to be operable using either a manual radio remote control (RC) system or by following instructions from the communications board developed in the other project. Data from sensors had to be sent to the communications board when requested. Similarly the system was required to keep itself updated by requesting data from the communications board.

Project Methodologies

- Familiarization with RC systems and programming of AVR microcontrollers in C.
- Research and design of tachometers based on the Hall Effect.
- Implementation of PD controllers used to regulate the speed of the motors.
- Implementation of a hardware interface to set the PID parameters, complete with a four-digit display.
- Design and implementation of a serial full-duplex communications protocol on both the microcontroller and on the PC.
- Development of an application written in C# capable of retrieving real-time results from the control board as well as serving as a simulation platform for the communications module.

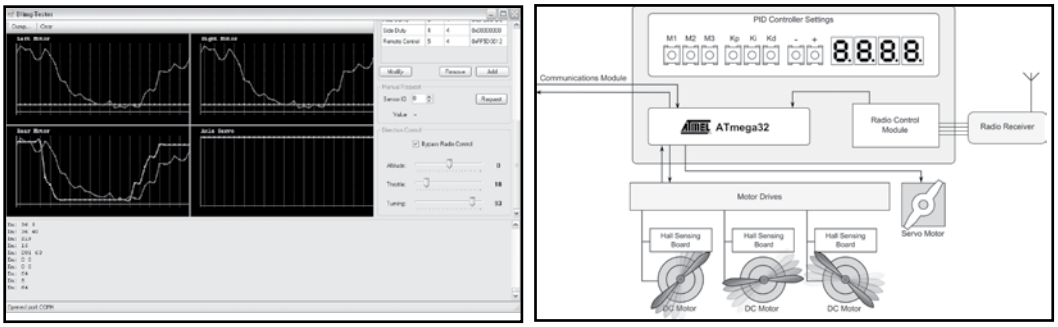
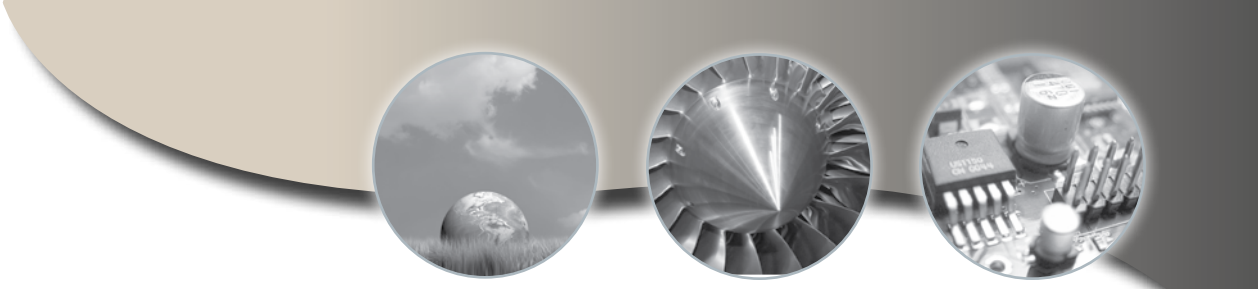


Figure 1: Indoor blimp control module

Results and Achievements

All the results were observed in real-time on the application developed for this purpose. The actual speed of the motors was observed to be very close to the reference value, confirming correct operation of the PD controller. The implemented serial communications protocol was verified to operate correctly and reliably, and in fact was used by the developed application to test the whole system.



SIMULATION OF A TYPICAL FLIGHT MANAGEMENT SYSTEM

Student: Roderick Bartolo **Supervisor: Mr.brian Zammit**

Introduction

Flight simulators are extensively used in the aviation industry for the design and development of conceptual aircraft design, evaluation of avionic mock-up systems, as well as crew training in both civil and military domains. This project looked into innovative ways of replicating and enhancing the function of a Multifunctional Control Display Unit (MCDU) to eventually form part of the ongoing development of an immersive A320 based aircraft simulator which is being constructed by the Department of Electronic Systems Engineering at the University of Malta.

Project Objectives

To study the functionalities of a typical flight management system (FMS), such as that of an Airbus A320 using C# .net framework. To replicate the interface functionalities of the FMS using reconfigurable displays and touch-screen technologies. To validate the interface functionalities.

Figure 1: The developed MCDU simulator has an overlay image implemented on a touch screen, to make it look and feel realistic.

Project Methodologies

1. The system's requirements were evaluated and a wide range of possible implementations and technologies were considered and studied.
2. A highly iterative Agile Extreme Programming (XP) Software Development Methodology was adapted and experimentation with the above technologies immediately started to unveil the strengths, weaknesses and possible applications for each technology. Several prototypes were developed to demonstrate the possible various functionalities of the MCDU.
3. A prototype MCDU and a Development Kit was developed by December 2008 with a Communication Protocol used to talk with external applications. This served as the ground basis of further development; however the MCDU was entirely redesigned by mid March 2009 to cater for more modularity and ease of customisation.
4. Throughout late March and April 2009, X-Plane Flight Simulator SDK in C and C++ was studied in depth and an interface library was developed, exposing the flight's simulation data. X-Plane was then interfaced to the MCDU using this function library. This library can be used in the future by developers to interface with X-Plane.

Results and Achievements

A highly configurable and dynamic MCDU FMS Client was developed capable of communicating with a wide range of devices ranging from microcontrollers to web services and flight simulators.

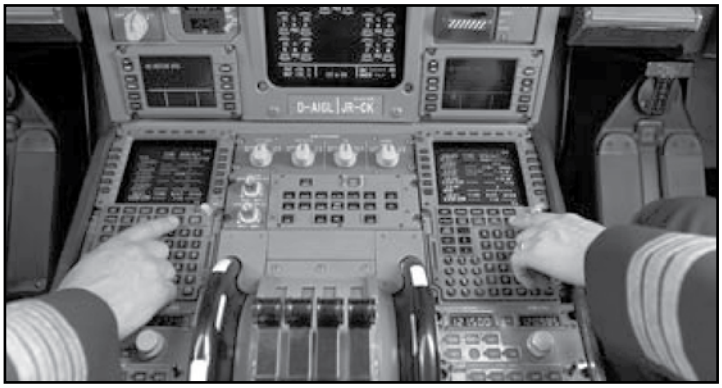
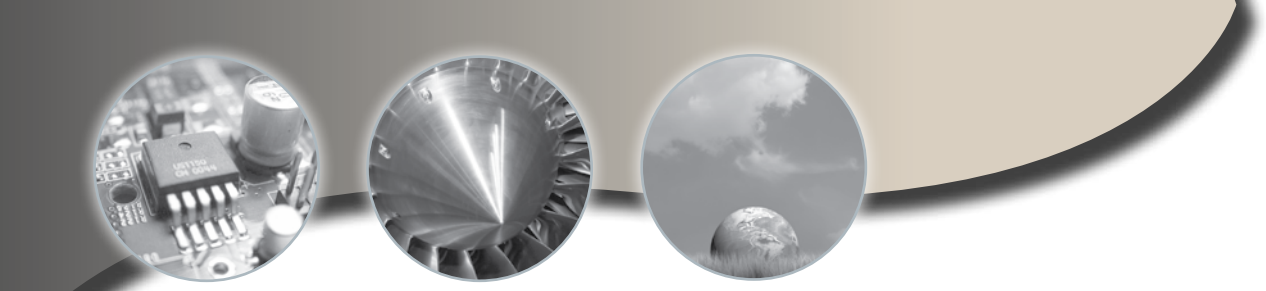


Figure 2: The MCDU is located on the central pedestal. It gives the crew immediate access to the flight handling functionalities.



A CONTRACT PROTOCOL FOR TRAFFIC CONFLICT MITIGATION IN AVIATION

Student: Graziella Bonnici **Supervisor: Ing. Andrew Sammut**

Introduction

The problem of runway incursion (RI) in commercial aviation is of serious concern to the aviation industry. The biggest challenge for aviation safety is traffic growth, which is projected to increase at a 5% rate per annum. Consequently, at current safety levels, an unavoidable increase in the number of RIs is expected. On average one runway incursion occurs in the United States every day and one every two days in the United Kingdom alone. Only a small percentage of these are of serious events but nevertheless this constitutes a major threat to aviation safety since the risk of collision is ever present and when a disaster strikes the result can be catastrophic. Fortunately, the incursion problem has been exhaustively studied by dozens of experts, and mitigations have been devised that can greatly lessen the risk inherent with ground operations today. All runway incursions can be linked to human error and the awareness about the problem has to be increased among all the involved organisations to prevent RIs.

Project Objectives

The aim of this project is to devise a bi-directional protocol between two conflicting parties on the runway, with the scope of liaising together to determine the safest and most efficient mitigation actions required to avoid the conflict. In essence, this study deals with the development of a contract safety-critical protocol capable of being set up between several parties, on which information regarding the type of conflict, each parties possible escape manoeuvres and the preferred solution is transferred, whilst taking into consideration the timing of the scenario.

Project Methodologies

The development of the protocol was based upon the Contract Net Protocol (CNP) which was originally proposed by Reid G. Smith in 1980. It is a fully automated negotiation and has two types of agents, the Initiator and the Contractor. CNP specifies the interaction between these agents for fully automated competitive negotiation through the use of contracts. Within the scope of this study, the agents are the two conflicting parties in a RI.

CNP is mainly composed of a sequence of four main steps:

- Initiator detects RI and sends out a task announcement or a call for proposals (CFP).
- Contractor reviews CFP's and bids on the feasible solution to mitigate the RI.
- Initiator chooses best bid and awards the contract to the contractor. Initiator abides with the bid selected.
- Contractor executes the chosen bid through the award and sends feedback to the initiator.

Results and Achievements

The use and implementation of the CNP in a RI environment which in itself is dynamic and complex was achieved. The message content was implemented as required in the given application and a solution was proposed to negotiate between the conflicting entities.

A bi-directional UDP link between the two conflicting parties was implemented in C# and the message content information between the two console applications can be easily monitored with any network protocol analyser.

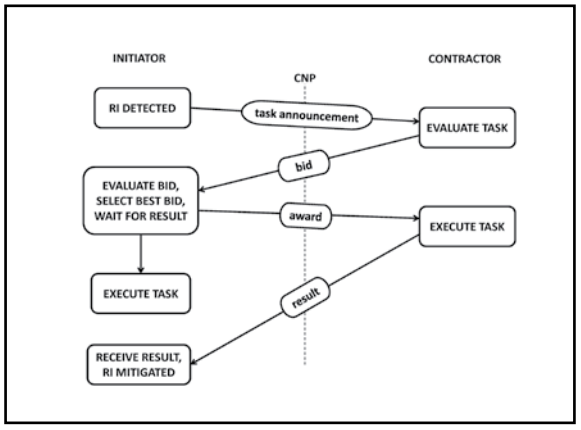
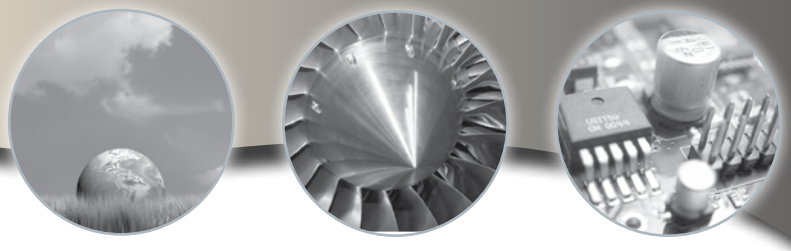


Figure 1. The Contract Net Protocol



DESIGN AND CONSTRUCTION OF FLIGHT SIMULATOR COMPONENTS (part 3)

Student: Mario Busuttil **Supervisor: Dr. Ing. David Zammit Mangion**

Introduction

The Department of Electronic Systems Engineering at the University of Malta is developing its flight simulation facilities. This application requires the development of human machine interface (HMI) components such as switches, knobs, lights, dials, and numeric displays which are typically existent in the cockpit of the aircraft being simulated.

Project Objectives

The aim of this project is to design and construct the interfacing circuitry for the glareshield of the Airbus A320. The glareshield hosts the FCU (Flight Control Unit) and the EFIS (Electronic Flight Instruments). The solution was required to be microcontroller based. It reads and controls the relevant HMI components and consolidates the information to the host PC via Ethernet. The PC running the Flight Simulator Software then replies back with the display information to the HMI.

Project Methodologies

The following steps were carried out during the implementation of the project:

- Literature review for choosing the best microcontroller on which the required TCP/IP stack could be implemented
- Implementation of the TCP/IP stack on the ARM Cortex-M3 Microcontroller
- Design of the necessary electronics to efficiently poll the 512 inputs and outputs present on an A320 glareshield
- Design of the schematics to be put in the A320 glareshield
- Design and manufacturing of the actual PCBs required for glareshield itself
- Implementation of the programming logic on the microcontroller.
- Integration and validation of the design by simulating the Flight Simulator Software using a custom made C# application.

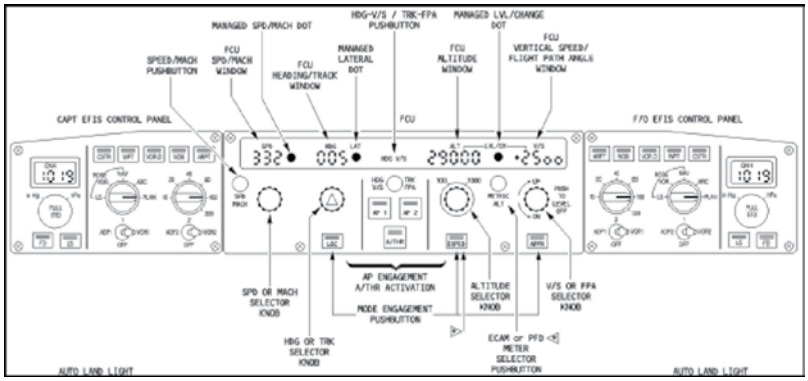


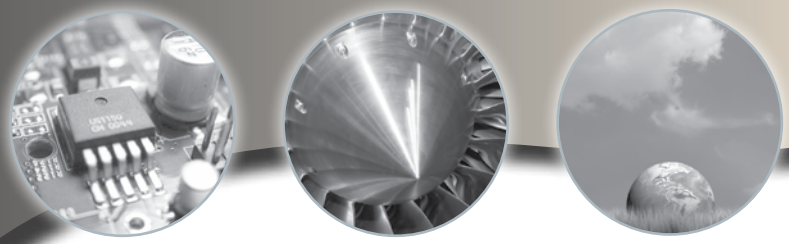
Figure 1: Glareshield of an Airbus A320 [1]

Results and Achievements

The major result of this project is the actual implementation of the necessary electronics to gather all the data from the switches, knobs, lights and dials shown in Figure 1, and relay that information to the Flight Simulator Software. The Flight Simulator Software would then reply with the necessary display data, which is outputted on the displays shown in Figure 1.This project required C and C# programming, digital electronic design and PCB design using CAD software. PCB manufacturing skills were also acquired in the development process.

Reference:

[1] Airbus, "Auto Flight," Airbus Training.



DESIGN AND CONSTRUCTION OF FLIGHT SIMULATOR COMPONENTS (part 2)

Student: John Ellul **Supervisor: Dr. Ing. David Zammit Mangion**

Introduction

Flight simulators have been around for quite some time. These systems have been primarily produced for pilot training affording a cheaper alternative to actual flying. Flight simulators have been refined to closely replicate the response and manoeuvrability of a real aircraft. Indeed, these systems have, today been used by the military, aircraft manufacturers, and operators to test and evaluate new systems. To this effect, the commercially available simulators are usually a replica of some available commercial or fighter aircraft.

Project Objectives

To design and construct all the necessary electronics required to successfully interface flight simulator components to a microcontroller environment and also to design models of the central pedestal for future fabrication.

Project Methodologies

- Literature review of common central pedestals architecture of typical commercial aircraft to identify common on-board functionalities and selection of a data protocol to use for the transmission of data (Ethernet, I^2C, CAN network).
- Test server and client implementation - In the absence of a flight computer, the programming of a test server which emulates the function of the flight computer had to be done.
- Designs for fabrication of the central pedestal using AutoCAD
- Design and implementation of electronics which caters for sufficient inputs and outputs (Approx 450).
- Software design and implementation of the central pedestal hardware with the microcontroller
- Final implementation of the hardware connected to an Ethernet network.

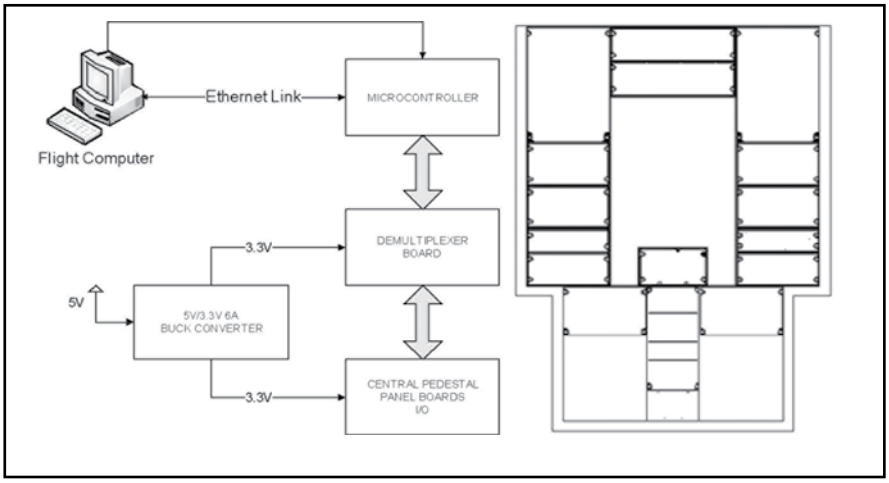
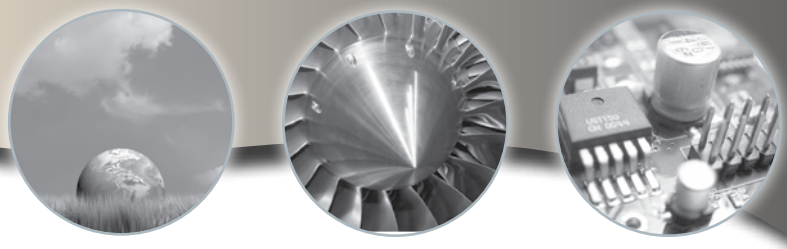


Figure 1: System Architecture and Central Pedestal AutoCAD design

Results and Achievements

Research was conducted on the central pedestal and used as basis for the thesis. Ethernet was chosen as the transmission protocol. The test server was programmed using C# and functions correctly. All hardware has been designed, tested and built onto PCBs. The components and microcontroller were interfaced and function correctly. All models have been designed.



INERTIAL MEASUREMENT IN LIGHT-WEIGHT HEAD-MOUNTED DISPLAY SYSTEMS

Student: Kenneth Fonk **Supervisor: Mr. Marc Azzopardi**

Introduction

Ever since the demand for head-motion tracking came about, engineers and scientists have strived to develop this technology and implement the ultimate head-motion tracker. Several technological improvements such as miniaturization, powerful processing devices and lightweight designs have since been created. Such desirable breakthroughs have allowed for a wave of innovative implementations to be designed thus encouraging technologies such as head-motion tracking to be pushed to its limits.

Project Objectives

Throughout this dissertation, a study on the available methods for measuring the six degrees of freedom required for full head-motion tracking has been carried out, identifying inertial measurement techniques to be the favored method of implementing such trackers due to their light-weight, low-cost, high-accuracy and high data rate features. The main objectives consisted of designing a test setup through adequate hardware selection, whilst researching and applying the necessary algorithms to develop an ideal head-motion tracker. The performance issues relating to the system implementation were explored and evaluated in order to validate the use of inertial measurement techniques throughout head-tracking systems.

Project Methodologies

The project deliverables were modularized into the following steps:

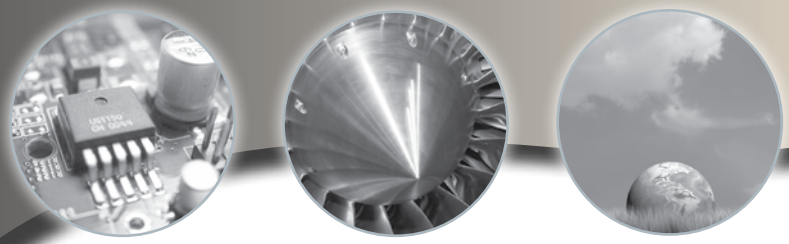
Figure 1: Prototype and Refined product Assembly

- Conducted a literature survey, where possible head-tracking technologies were compared and selected;
- Established and exploited the parameters and limitations which govern the system;
- Researched various inertial measurement techniques whilst exploring the theoretical, mathematical and physical properties required to develop such a system;
- Designed and assembled a prototype for testing and evaluation purposes;
- Tested and validated the overall system design and choice of measurement techniques;
- Designed and constructed a fully functional refined product to demonstrate the design's idealistic nature as a head-tracker due to its sleek, light, wireless and noninvasive layout and structure.

The design implemented made use of two tri-axis accelerometers on either side, a single-axis gyroscope about the pitch axis, as well as a two-axis magnetometer for yaw measurements. Tilt and rotation algorithms were implemented for obtaining orientation parameters, whereas a unique position algorithm was designed and tested to obtain incremental position data. The final design represents a fully functional, wireless head-tracker, which processes and relates data back to the PC via a Bluetooth connection.

Results and Achievements

The overall system delivers accurate and satisfactory results for yaw, pitch and roll orientation parameters. Possible orientation errors are corrected during quasi-static instances through absolute readings. Improved results could be achieved by adding a single-axis gyroscope about the roll axis to further stabilize readings during linear motions as well as swapping the existing magnetometer to a three-axis version to compensate for yaw measurements during tilt sequences. Additionally, positional data was also obtained, however due to the incremental nature of such data acquisition, drift errors inevitably occurred. Thus a secondary system capable of obtaining absolute positional data is being suggested as future work. The encouraging results strongly support the use of inertial measurement techniques as a means for head-tracking for head-mounted display (HMD) systems.



ENSURING SAFETY AND STABILITY MEASURES ON A CRANE

Student: Anna Marie Galea **Supervisor: Prof. Charles Pule'**

Introduction

A crane is a mechanism that can be used to lift objects, transport them from one point to another and lower them down again. They are used in many applications, such as harbours, industries, and on the construction sites. Crane size and capacity vary according to the purpose of their use. It is not uncommon to subject the crane for an overload condition, where it can lead to the capsizing of the crane, twisting or bending of the boom, or destruction of the object itself. The overload condition, which leads to instability of the crane, is a function of the weight that is being lifted, the radius of operation, and also the length of the boom. Stability is also affected by the operating wind conditions, the ground conditions, and the improper use of outriggers. [1]

Project Objectives

The main objective of this thesis is to help the reader to analyze better the stability of a crane. This would include going into deep stability calculations, using simple moment equations. Such calculations would help in analyzing the effect of wind forces on the crane, crane clearances, the resulting loads on the supporting axes, and the ground support reaction due to these loads. Experiments of speed and torque control were also to be expected. Lastly but not least, a simple overload detection system is to be developed. This system should provide the crane operator with useful information regarding the radius of operation, the length of the boom, and the weight of the object that is being lifted. If the crane is subject to an overload condition, the crane operator would neither be allowed to raise the load, nor to lower the boom.

Project Methodologies

The project studies the stability of the crane, when lifting or lowering a load, and also the site of operation parameters, of which the crane operator should be aware of while on the workplace. The following steps were carried out during the implementation of the project:

Figure 1. A typical crane

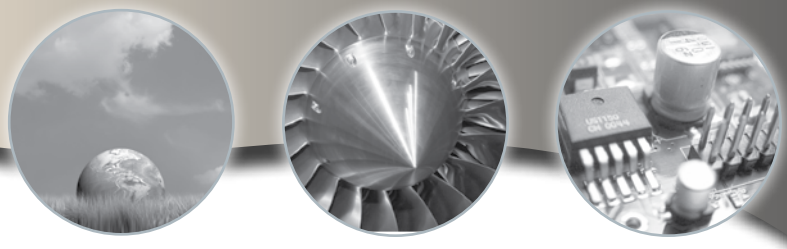
- Stability against overturning of the crane, including the effect of wind forces, using moment equations [1]
- Crane clearances, such as lift and swing clearances, and the supporting loads on the outriggers that will be developed, while lifting a load. This also included a procedure to design the dimensions of the timber material that needs to be placed underneath the outriggers [2]
- Deep analysis of dynamic modeling of the DC motor, and the speed control and torque control of these motors [3]
- Experimental circuit for speed and torque control
- Development of a simple overload device, using PIC microcontroller [4]

Results and Achievements

The study regarding the stability of the crane would help the reader to understand better the crane characteristics, when in operation, in which the picture is seen from the mathematical side. The experimental results helped also to appreciate the physics of what is actually happening when lifting or lowering a load. Also, the overload detection system would help the crane operator to monitor continuously the operation of the crane, without any extra knowledge of how the system is working.

References

[1] Howard I. Shapiro, Jay P. Shapiro, Lawrence K. Shapiro, 'Cranes and Derricks', third edition, pp. 180-195
[2] Howard I. Shapiro, Jay P. Shapiro, Lawrence K. Shapiro, 'Cranes and Derricks', third edition, pp. 244-250, pp. 268-287
[3] Fabri S, "The PI Controller", Course Notes, University of Malta, 2008
[3] Cilia J, "Electro Mechanical Drives", Course Notes, University of Malta, 2008
[4] Martin Bates 'Interfacing Pic Microcontrollers'



AIRCRAFT GROUND MOVEMENT MODELLING

Student: David Muscat **Supervisor: Dr. Ing. David Zammit Mangion**

Introduction

The design of the landing gear is an important aspect of the structural design of an aircraft. This is because during landing, taxiing and takeoff the fuselage and landing gear are subjected to great forces and vibrations. Particularly the landing gear impact has been recognized as one of the main factors which contribute to structural damage, stresses on the airframe and passenger discomfort [1]. Preliminary design and simulation of landing gear dynamics is essential to ensure that the highest technological standards are achieved whilst at the same time ensuring mandatory safety standards.

Project Objectives

The aim of this thesis was to develop a tricycle model of the aircraft which models the vertical dynamics in air and on ground. Also a tyre model was identified which models the horizontal dynamics of the tyre on ground [2]. The landing gear model will then be combined with an aircraft model to obtain a complete air and ground aircraft model as shown in figure 1.

Project Methodology

The project was divided into the following phases:

- Literature review on tyre models, strut and landing gear modelling.
- Coverage of the following topics:
  a. Theoretical overview of airliner landing gear.
  b. Theory involved in tyre dynamics and modelling.
  c. Shock strut dynamics and possible modelling of similar systems such as car suspensions and bouncing balls.
  d. Numerical integration methods.
- Selection of tyre model and familiarizing with mathematical derivation of the model.
- Modelling of single strut on ground and in air with single and multiple wheels.
- Extending model to a double strut and tricycle system.
- Validation of numerical correctness of models.
- Simulating models with realistic aircraft parameters.

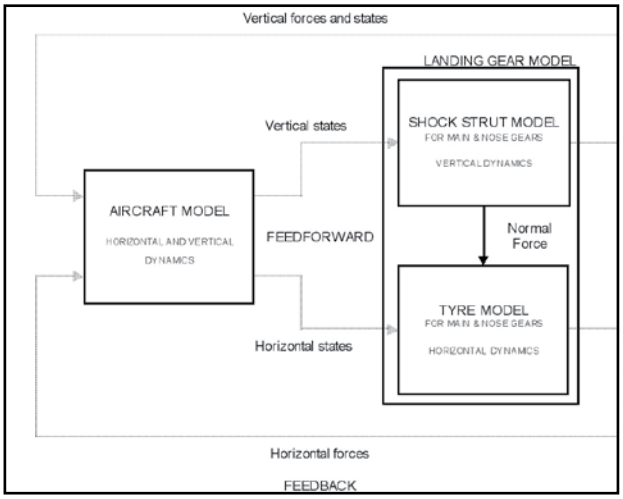


Figure1: Complete air and ground aircraft model

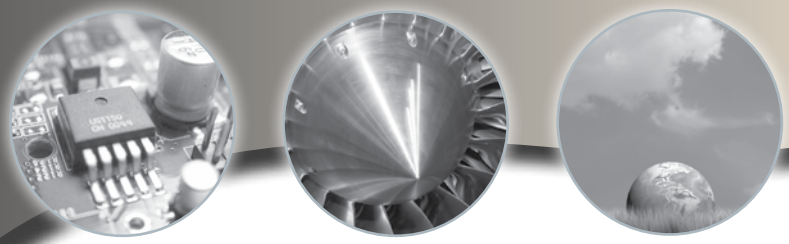
Results and Achievements

The tyre model was simulated under different slip conditions and the relevant forces and moments obtained were analyzed. The tricycle system was subjected to different initial conditions and bounce simulations were obtained. This thesis served to introduce the relevant theory involved and derive the fundamental models. These models will be incorporated with flight models being developed by the Electronics Systems Engineering Department to obtain full flight models and simulations which will implemented in a simulator.

References

[1] R. Lernbeiss and M. Plöchl, "Simulation model of an aircraft landing gear considering elastic properties of the shock absorber", Proc. IMechE Vol. 221 Part K: J. Multi-body Dynamics, 2007

[2] H. B. Pacejka, Tyre and Vehicle Dynamics, 2nd edition. Oxford, Butterworth Heinemann publications, 2006.



A NAVIGATION ALGORITHM FOR AIRBORNE PLATFORMS

Student: Daniel Parascandalo **Supervisor: Mr. Andrew Sammut**

Introduction

The problem of navigation has existed ever since man began travelling. Whereas past techniques in this field relied on human intervention, modern systems are all pushing toward autonomous systems that are capable of travelling from one point to the other independently. Indeed, in the realm of aviation, an Unmanned Aerial Vehicle (UAV) is an aircraft designed with this functionality as its main objective. In order to attain its goal, a UAV uses navigational algorithms for high-level control of the aircraft to determine the high-level manoeuvres required to move from one point to another.

Project Objectives

The aim of this project is to formulate, implement and finally test a robust navigation algorithm that will be capable of navigating a UAV through a set of waypoints in three-dimensional space and time using a set of different navigational techniques.

Project Methodologies

The project was carried out in the following manner:

- Research on navigational techniques: Past, Present and Future.
- Detailed and thorough study of the fundamentals of navigational calculations that make the latter techniques possible, including but not limited to: earth modelling, co-ordinate systems transformations, distance and bearing measurements.
- Determination of the appropriate calculation methods to be used in the context of a microprocessor controlled UAV through method performance tests.
- Design of the navigation algorithm.
- Design, implementation and testing of a robust software test-bench that will provide the required simulation facilities for testing and verification of the algorithm's design and implementation.
- Implementation and testing of all the components that make up the algorithm, as well as testing and verification of the system as a whole.

Results and Achievements

The test-bench was the first task completed by amalgamating the industry standard X-Plane® flight simulator and Google Earth™. This allows for efficient, comprehendible and realistic testing of the navigator. Figure 1 below shows the front-end real time output of the test bench.

On the other hand, the navigator designed is currently capable of two modes of navigation: waypoint-to-waypoint homing and path following. In addition, it also incorporates features such as corner turn smoothening and tolerance to wind disturbance. Figure 2 shows the results obtained for the former two techniques.

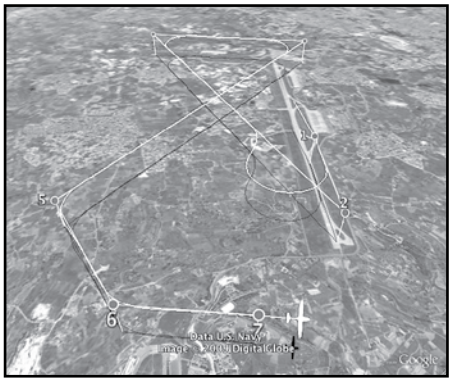


Figure 1: Visual Testing Tools

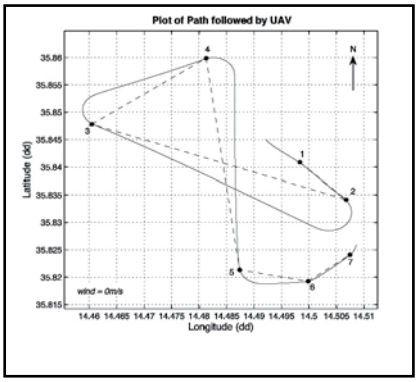


Figure 2: Flight paths achieved using different navigation techniques.

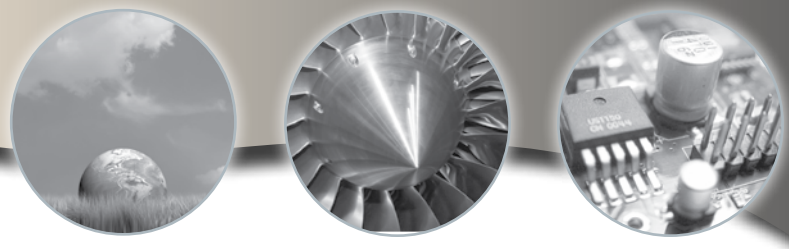


IMAGE WARPING FOR A CYLINDRICAL SCREEN

Student: Jean Paul Satariano **Supervisor: Dr. Ing. David Zammit-Mangion**

Introduction

When projecting an image on a wall perpendicular to the lens assembly of an unmodified projector, the resulting output image that is visible on the screen will be rectangular, having a width-to-height ratios (aspect ratios) depending on the projector specifications (mostly 4:3 or 16:9). However, if the same image is projected onto any other surface, being either a flat surface not perpendicular to the projector lens assembly or any curved surface, the output image will be distorted. The level of distortion depends entirely on the shape of surface and the angular displacement of the projector from the screen.

Project Objectives

The scope of the project is to produce a "correct image" on a curved (cylindrical) screen when using an unmodified projector. For the purposes of this dissertation, "correct image" means that:

- When standing at the centre of curvature of the screen, the correct aspect ratios of the image/video are displayed. This means that if, for example, the source object is a square (aspect ratio 1:1), the output aspect ratio at the screen will still be 1:1. As a result of this, a horizontal line in the source image (or video) will be correctly displayed as horizontal on the screen.

Project Methodologies

The project basically involves the software design and implementation of an algorithm capable of pre-warping a sequence of images (or video) so that it can be viewed, without distortion, onto a cylindrically-curved screen. The hardware version of the project (FPGA) will, in due time, form part (the image processing required) of the flight simulator being designed by the department of Electronic Systems Engineering at the Faculty of Engineering.

The project was divided into 6 phases:

Phase 1:Literature review and research based on:
- Understanding the requirements for successful warping
- Understanding the (external) functioning of a standard video projector
- Discovering detailed functioning of MATLAB

Phase 2:Experimenting and testing of different warping algorithms and analyzing their usefulness for the required tasks

Phase 3:Testing trial algorithms on a makeshift screen (using cardboard)

Phase 4:Designing a larger-scale screen for accurate measurement and testing

Phase 5:Implementing the most efficient algorithm on video samples at a projector offset of zero degrees (projector is perpendicular to centre of screen)

Phase 6:Extending the warping concept for offset angular positions of the projector from the centre of the screen

Phase 7:Detailed testing and statistical analysis of the results by accurate measurements on screen.

Results and Achievements

The testing procedure involved the creation of test images and videos that could eventually be projected on the screen to verify the correct functioning of the designed algorithm. Figure 1 shows how the source images (a) and (d) need to be modified through the software created in order to be correctly visible on the screen. Images (b) and (e) show the images that need to be projected through the video projector when the projector lens assembly is perpendicular to the centre of the screen (offset of 0˚). Images (c) and (f) demonstrate the images that need to be projected when the projector is placed at a horizontal offset of 10˚ to the left of the centre of the screen. Note that this time the images are not symmetrical about the vertical axis. Also, although not clearly visible due to the size of the images, the images are not uniform along the horizontal axis either.

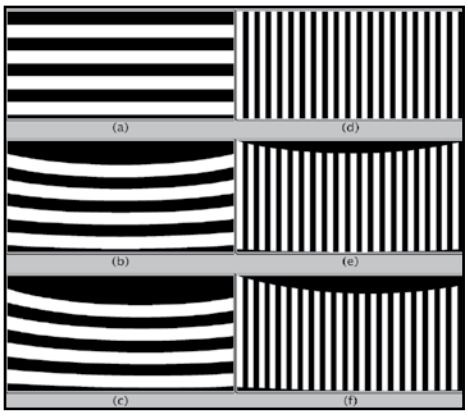
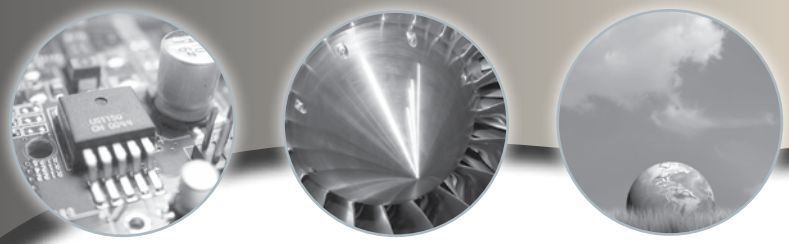


Figure 1: Image warping in a cylindrical screen



CONTROL OF A ROBOTIC FINGER WITH NON-CONVENTIONAL ACTUATORS

Student: Nicholas Aquilina

Supervisor: Dr. Ing. Simon G. Fabri
Co-Supervisor: Dr. Ing. Michael A. Saliba

Introduction

Robotic systemsare widely used in today's world. Due to this, the need of flexible robotic manipulators also arises. Achieving high degree of flexibility implies having more degrees of freedom, which therefore means that more actuators are required. When considering the industrial sector, increasing the number of actuators is not normally a problem since space is usually not limited. However, when considering robotic applications such as prosthesis or teleoperation, the space available for actuators could be rather limited. This problem can be mitigated by using non-conventional actuators which occupy less space. Non-conventional actuators are ideal since they offer a better force to weight ratio when compared to conventional actuators such as electric motors.

Project Objectives

The main objective of this project is to the design an automatic position control system for a robotic finger. The finger will eventually form part of a complete robotic hand able to grasp objects for various applications such as prosthesis or teleoperation. In particular, the project is to investigate the use of non-conventional actuators for effecting finger movement. Hence conventional electric motors should be avoided and alternative solutions should be investigated.

Project Methodologies

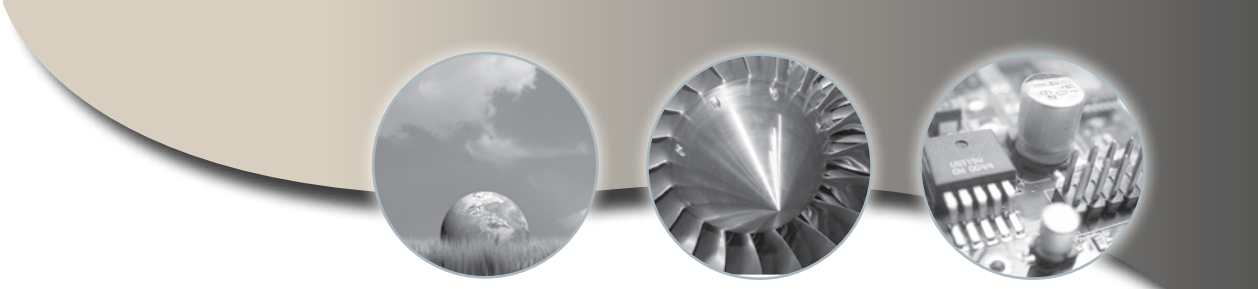
The project makes use of shape memory alloys (SMAs) in order to control the movement of a robotic finger. The following steps were carried out during the implementation of the project

- Literature review and analysis of the available non-conventional actuators and selection of the most suitable one for our application.
- Design and fabrication of the required mechanical setup to complement the type of non-conventional actuator used, shape memory alloy in our case.
- Mathematical modeling of the dynamic response of the selected non-conventional actuator.
- Design, simulation and implementation of automatic position control systems, using gain scheduled optimal control.
- Analysis of testing results.
- Evaluation of results for further improvements.

Results and Achievements

Using an SMA to effect controlled movement of the finger was a challenging task mainly due to the nonlinear dynamic characteristicsof the SMA. Nonetheless the advantages of using non-conventional actuators over other conventional actuators were exploited. Improvements can be obtained by winding the SMA around pulleys to yield a lighter and compact actuator having a high force to weight ratio whilst operating silently. Moreover, implementing other robust controllers, such as sliding mode control, can be considered in order to obtain a better response.

Figure 1: Mechanical setup used



SIGNAL PROCESSING OF PURE AND MIXED NEUROTRANSMITTER VOLTAMMOGRAMS

Student: Carl Azzopardi **Supervisor: Dr. Ing. Kenneth Camilleri**

Introduction

Neurotransmitters are chemicals which transmit signals between one neuron and another in the brain. Three particular ones, called Dopamine, Norepinephrine and Serotonin, are of special interest to scientists since they affect the behaviour of human beings. There have been several studies, where a technique called 'Voltammetry' was used in order to monitor the changes in concentration of single neurotransmitters in the brain. However, there has been very little work which has looked into the problem of estimating the concentrations of more than one neurotransmitter, when these are present at the same time, [1].

Project Objectives

This project had two main objectives. The first was to design and implement a Voltammetric measurement system, in order to collect a set of in vitro readings of pure and mixed neurotransmitter signals. The second objective was to compare the performance of two signal-processing techniques, called Principal Component Analysis and Independent Component Analysis, when these were used to estimate the concentrations of pairs of neurotransmitters present concurrently in the same solution.

Project Methodologies

The project was divided into the following three phases:

- Designing and implementing a Voltammetric system.
- Using the Voltammetric system to collect signals of pure and mixed neurotransmitters.
- Using Principal Component Analysis and Independent Component Analysis to estimate the concentrations of mixtures of neurotransmitters.

Upon completion of the above three steps, a comparison of the results obtained from Principal Component Analysis and Independent Component Analysis will be done, and a simple model of how separate and mixed neurotransmitters interact with each other will also be drawn up.

Results and Achievements

The results obtained so far indicate that changes in concentration of a single pure neurotransmitter are approximately linear, and also that mixtures of neurotransmitters result in the approximate linear addition of their individual signals. The performances of Principal Component Analysis and Independent Component Analysis are apparently similar, but this is still currently being investigated.

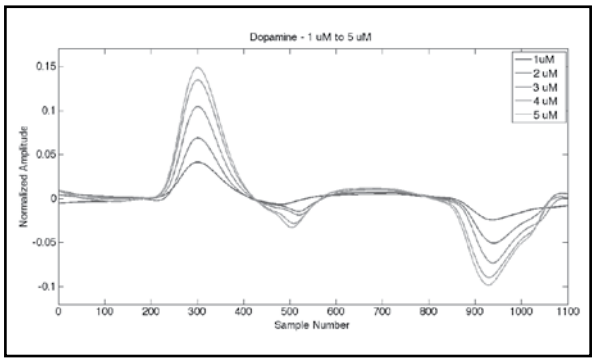


Figure 1 - Dopamine signal at different concentrations

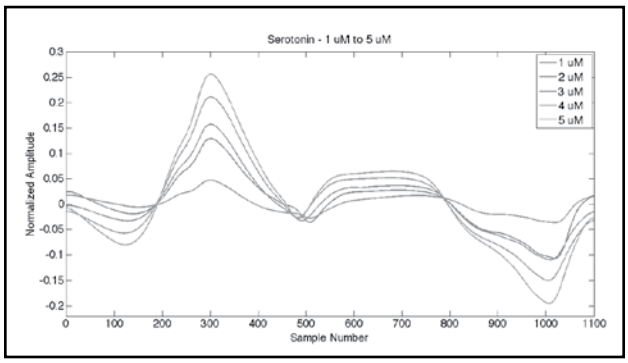
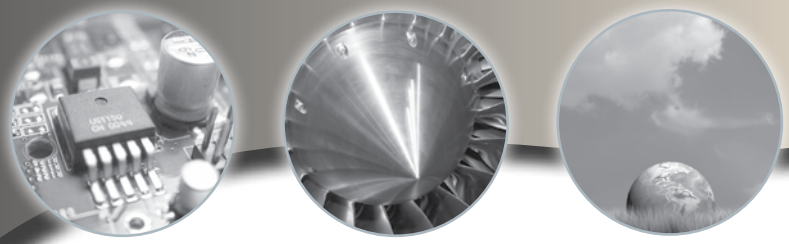


Figure 2 - Serotonin signal at different concentrations

References

[1] C. A. Anastassiou, et. al., "Subsecond Voltammetric Separation between Dopamine and Serotonin in the Presence of Ascorbate", Analytical Chemistry, vol. 78, pp. 6990-6998, 2006.



GEO-LOCATION BY VIEW ANALYSIS

Student: Emanuel Balzan **Supervisor: Dr Ing. Kenneth P. Camilleri**

Introduction

The problem of navigation starts by first wanting to know ones current position. Driven by the urge to make robots function the way humans do, vision sensors such as CCD cameras can be integrated in the robot's structure to aid them to be more autonomous. A Global Positioning System (GPS) might not always be a feasible solution since it does not work when satellite reception is not available (e.g. indoors) or it gives wrong results during bad weather. Computer vision-based positioning is now a possible solution to obtain the geo-graphic location in indoor or outdoor environments.

Project Objectives

The main goal of this project is to achieve vision-based positioning in an outdoor environment based on the appearance of images. An image of the current viewing scene at an unknown location is inputted to the system and by comparing this (query) image with images at known positions stored in a database the geographic location is obtained. Two methods are studied towards localisation of the current image:

- The first approach finds the motion of the camera between the query image and two reference images through epipolar geometry and then calculates the location through triangulation.
- The second approach uses a dimensionality reduction technique, Locality Preserving Projection (LPP), which projects the images in a lower dimensional space.

Project Methodologies

The project analyses two different appearance based techniques which enable vision-based positioning of an image with respect to a database of reference images. The main work during the implementation of the project was conducted as follows:

- Literature review of vision-based positioning techniques, extraction of features from images, epipolar geometry and dimensionality techniques
- Creation of the image database by capturing scene images at known locations in the working environment
- Implementation of the chosen appearance-based self-localisation methods
- Local and global feature extraction, image matching and place recognition
- Camera motion estimation and localisation
- Dimensionality reduction and localisation
- Identification of the most advantageous method to be used in positioning applications.

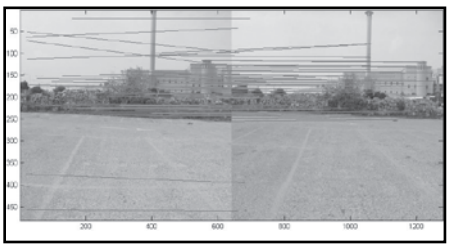


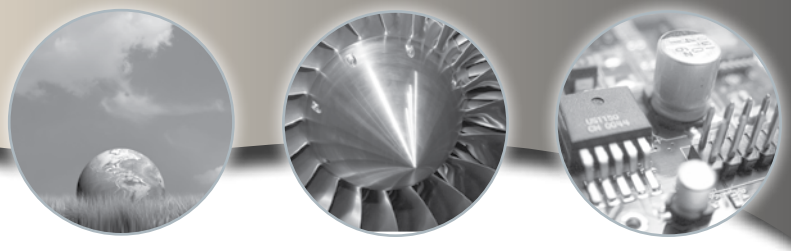
Figure 1: Point to point correspondences between two images viewing the same scene from different viewpoints.

Results and Achievements

Table 1 shows the estimate locations obtained through both methods. Good estimates have been obtained by means of both approaches. Localisation through motion estimation and epipolar geometry is more reliable than LPP because the result of LPP is highly dependable on the appearance of the image. However, LPP performs faster.

	Actual position	Triangulation	Interpolation	LPP
Query image 1	(19.70,14.90) m	(18.73,15.00) m	(22.51,15.00) m	(18.60,10.32) m
Query image 2	(13.85,08.20) m	(10.00,20.28) m	(12.50,16.50) m	(15.80,07.80) m
Query image 3	(4.10,12.80) m	(9.90,10.00) m	(06.73,10.00) m	(31.80,06.00) m
Query image 4	(26.00,16.00) m	(28.08,18.00) m	(23.04,18.00) m	(31.80,06.00) m

Table 1: Results for the geographic location estimation of four query images.



ACTIVE VIBRATION AND NOISE CONTROL

Student: Steve Dimech **Supervisor: Dr. Ing. Simon Fabri**

Introduction

Active control of vibrations and sound is an important multidisciplinary problem in areas ranging from consumer and automotive products to military and aerospace engineering systems. In addition to improving performance, the active control system also aims at reducing the weight and volume of traditional passive damping strategies such as tuned mass dampers [1].

Project Objectives

The objectives of this project are:

- Review of active vibration and noise control systems.
- Design, development and construction of a laboratory-scale pilot plant for implementing, testing and demonstrating active vibration control.
- Design, development and implementation of the interface electronics between the pilot plant and the PC on which the control algorithms will be coded.
- Design, simulation and coding of an active vibration control algorithm.
- Complete system testing and performance evaluation.

Project Methodologies

The project consists of an active vibration control system applied to a flexible aluminium cantilever beam (Fig. 1). It identifies relevant beam theories and uses finite element techniques to develop a precise mathematical model of the flexible cantilever beam. This mathematical model is used to design controllers which are responsible for suppressing vibrations in the beam. The following steps were carried out during the implementation of the project:

- Literature review of Active Vibration and Noise Control systems.
- Accurate mathematical modelling of the flexible aluminium cantilever beam which also incorporates the piezoelectric transducers used in the control system.
- Design, simulation and implementation of a Linear Quadratic Gaussian controller and a Model Predictive Controller with constraint handling
- Performance evaluation between the tested controllers.

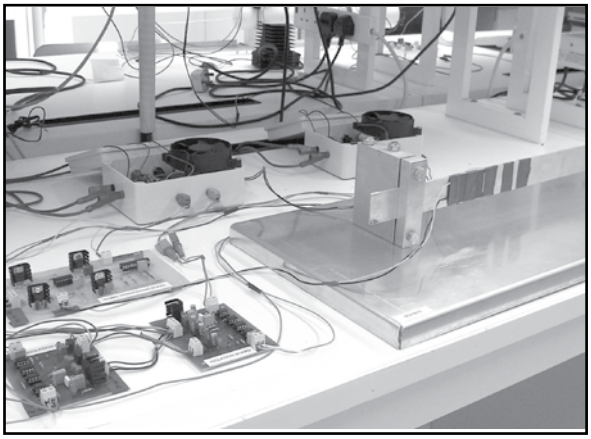


Figure 1: Experimental Apparatus

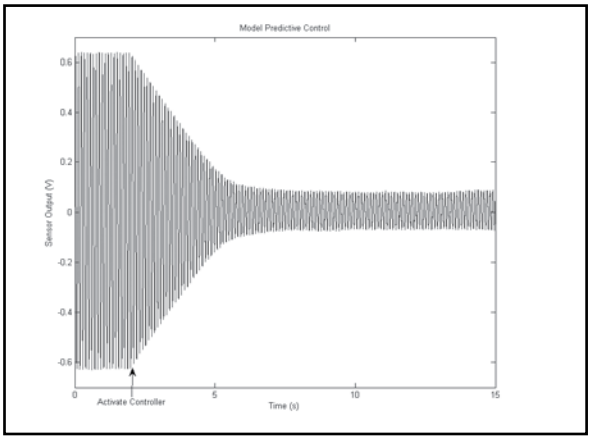


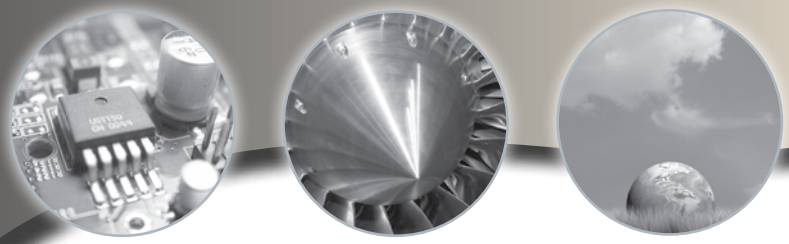
Figure 2: Experimental Results –Suppression of vibrations

Results and Achievements

Results have shown that the designed controllers minimize the amplitude of vibrations induced by an external disturbance. The performance of the control systems is somewhat limited by the actuator limitations [1]. The Model Predictive Control system with constraint handling (Fig. 2) showed superior performance to Linear Quadratic Gaussian control.

References

[1] Wills Adrian G., Bates Dale, Fleming Andrew J., Ninness Brett, Moheimani S. O. Reza, 'Model Predictive Control Applied to Constraint Handling in Active Noise and Vibration Control,' IEEE TRANSACTIONS ON CONTROL SYSTEMS TECHNOLOGY, 2008, Vol. 16, No. 1, pp.3-12



MULTIPLE MODEL ADAPTIVE CONTROL

Student: Melvin Gauci **Supervisor: Dr. Ing. Simon G. Fabri**

Introduction

In control systems engineering, jump systems are ones whose dynamics are prone to change abruptly at any time [1]. Conventional control techniques are restricted to linear time-invariant systems, and are therefore not an option for dealing with jump systems. In the case of a jump system which can operate in a finite number of known modes and which can be modelled a priori, a very elegant solution to the problem is multiple model adaptive control (MMAC) [1]. In MMAC, Bayes' rule or a variation of it, is used to calculate the probability of the process being in each mode at any given time, and this information is used to compute the appropriate control signal to be applied at that time.

Project Objectives

This project is a continuation of three previous undergraduate projects on the control of a thermal airflow process, which is shown in Figure 1. Of these, the third project implemented MMAC, but while basic operation was achieved to a limited extent, this project aims to introduce several enhancements and improvements aimed to make it operate more efficiently and reliably. The main objectives of this project were:

- To design and construct a number of electronic circuits for interfacing the plant to a DS1104© R&D controller board.
- To derive a theoretical model of the plant and use it to gain insight into the plant's physics.
- To obtain empirical models for the dynamics of all modes of operation of the plant to be used in the implementation of MMAC, using a data-driven system identification technique.
- To design a number of MMAC schemes and evaluate their performance through simulation and experimentation, and compare the results.

Project Methodologies

The project objectives were approached using the following methodology:

- Research on various adaptive control schemes.
- Familiarization with the theory behind MMAC and related concepts.
- Theoretical modeling of the plant, and MMAC simulation using this model.
- Design and construction of electronic circuitry.
- Data-driven system identification.
- Simulation and implementation of MMAC schemes using the empirical models.
- Evaluation and comparison of results.

Results and Achievements

While in the previous project only actuator loss of effectiveness and outage were considered as faults, now process faults have been included and succesfully identified. Also, in the previous project considerable delays – on the order of minutes – were observed in mode identification. Through careful tuning of the system, these delays have now been reduced to a few seconds.

Furthermore, the system was shown to exhibit a very satisfactory control performance, with only minor disturbances being observed in the output temperature at the instances when faults occur.

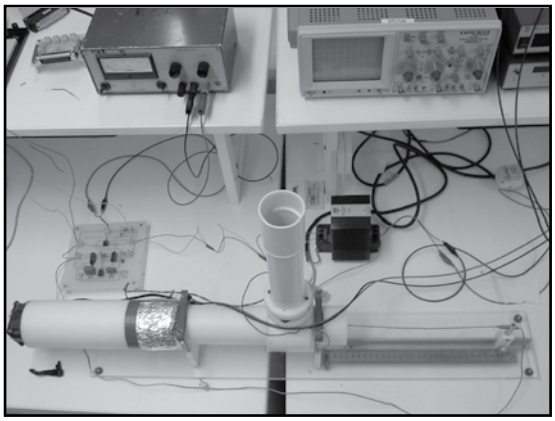
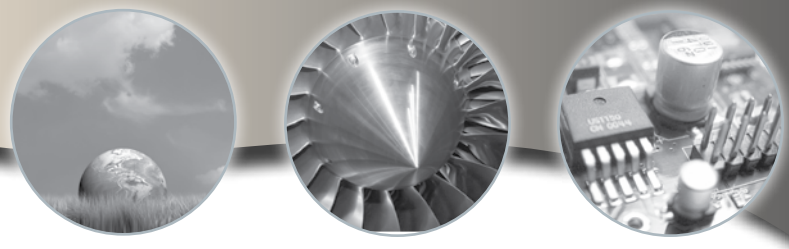


Figure 1: Experimental Apparatus

References

[1] S. G. Fabri and V. Kadirkamanathan, Functional Adaptive Control: An Intelligent Systems Approach, ser. Communications and Control Engineering. London: Springer, 2001.



HEAD MOTION TRACKING AND POSE ESTIMATION IN THE SIX DEGREES OF FREEDOM

Student: Michael Sapienza **Supervisor: Dr. Ing. Kenneth P. Camilleri**

Introduction

Estimating where somebody is looking may be of little difficulty to human beings. In fact, a glance at a person's head is enough to have an immediate indication of where the attention is being directed. Solving this complex problem for computers is an important step for human-computer interaction (HCI), which opens up new ways to control machines and to examine human behaviour. Previous work[1] in the Department of Systems and Control Engineering has focused on single eye gaze tracking under stationary conditions. In order to enable free head movement and enhance the accuracy of the users gaze direction, a head pose tracking algorithm was required.

Project Objectives

This work aims to estimate the human head pose in the six degrees of freedom, shown in Figure 1, and to couple it with an eye pupil tracking framework. These form the two fundamental steps towards estimating a person's gaze direction. Since the only sensor to be used will be a single webcam, the user will be completely free of any devices or wires. Furthermore, there should not be any constraints on the movement of the user, and no need to use cosmetics to provide enhanced facial features. This non-intrusive system would preferably run in real-time, start automatically, and recover from failure automatically, without any previous knowledge of the user appearance or location.

Project Methodologies

The system is designed around a feature based geometrical technique which utilises correspondences between the eyes nose and mouth to estimate the head pose. The following three principal processing steps were carried out during the implementation of the project:

- Face and facial feature detection based on the Viola-Jones algorithm which enables real time object recognition with high detection rates and low false positives[2].
- Tracking of the eye, nose and mouth regions using template matching, based on the Normalised Sum of Squared Difference (NSSD).
- Estimating the 3D vector normal to the facial plane from the position of the features in the face[3].

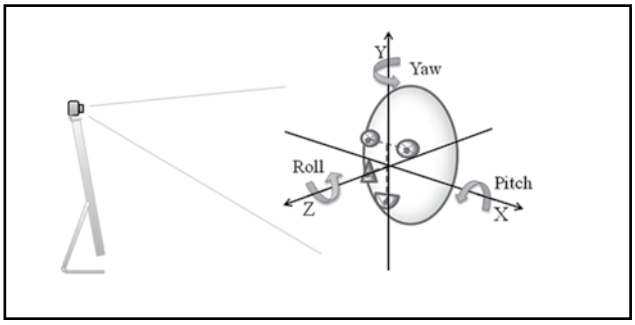


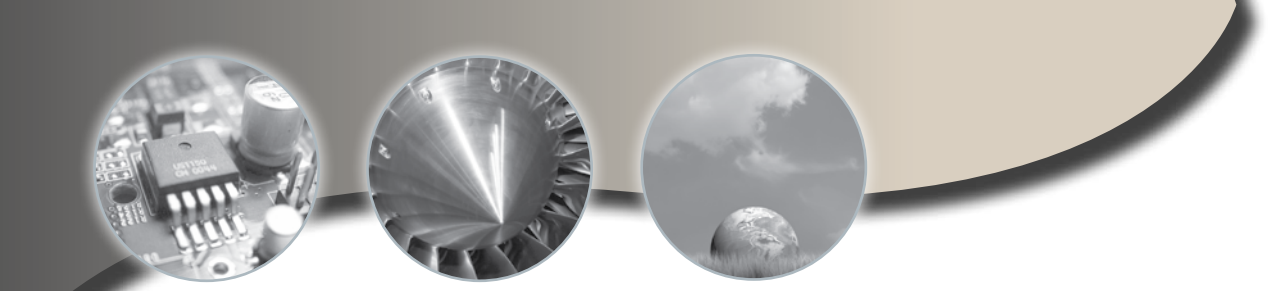
Figure 1: Tracking the Six Degrees of Freedom

Results and Achievements

Looking at the results obtained one can see that all the six degrees of freedom have been achieved within a reasonable degree of accuracy. Mean absolute errors of 3.03, 5.27 and 3.91 degrees were achieved for roll, yaw and pitch angles respectively. The rotation of the head is restricted to the angle at which the features become occluded. However, this does not limit the effectiveness of the system since if one is seated in a cockpit or in front of a laptop, these rotations are rarely exceeded. Moreover, if the features are lost, the system will automatically recover from failure by using geometrical constraints on the positions of the face features.

References

[1]S. Cristina, "Tracking of single eye gaze under stationary head conditions for mouse cursor control," B.Eng. dissertation, University of Malta, Malta, 2008.
[2]P. Viola and M. Jones, "Robust Real-Time Face Detection," International Journal of Computer Vision, pp. 137-154, 2004.
[3]A. Gee and R. Cipolla, "Determining the gaze of faces in images," Technical Report CUED/FINFENG/TR 174, Cambridge University Department of Engineering, March 1994.



SPATIO TEMPORAL MODELLING OF THE OZONE LAYER

Student: Sarah Tabone **Supervisor: Mr. Kenneth Scerri**

Introduction

The Earth's atmosphere is made up of several layers, being: the troposphere, the stratosphere, the mesosphere, the thermosphere, and finally the exosphere, which eventually merges with outer space. The ozone layer lies within the lower portion of the stratosphere. The purpose of the ozone layer is to protect the Earth's surface by absorbing the most of Ultra-Violet (UV) radiation reaching Earth. Acting also as a greenhouse layer it helps to keep the Earth warm. In 1985, a sudden drop of ozone over Antarctica was noticed, where mainly the ozone was less than 220 Dobson Units. Therefore scientists realized that the ozone layer was being depleted, leading to the introduction of the term: ozone hole.

Project Objectives

The aim of this project is to fit a mathematical model to the ozone measurement data. This will be done using both temporal modelling and spatio-temporal modelling. The results obtained will then be compared to identify the best model that fits this data. With the aid of this mathematical model, both analysis of the ozone layer dynamics and prediction of future trends can be done. All this mathematical and computational work was implemented in Mathwork's MATLAB©.

Project Methodologies

The following steps were taken in the process of the implementing these models:

- Freely available ozone concentration data was obtained from the TOMS website.
- De-trending of the data was carried out to obtain the noisy residues.
- Least Squares Estimate was applied on these residues, so as to fit a number of Auto-Regressive models.
- Correlation tests and validation techniques were then carried out for each model. These techniques included Mean Square Estimate, Akaike's Information Criterion measure and whiteness measures.
- Steps 3 and 4 were repeated again for Spatio-Temporal Auto-Regressive models.
- The performance of Auto-Regressive and Spatio-Temporal Auto-Regressive models were compared.

Results and Achievements

The first method that was used to de-trend the Ozone data was that of Median Polish. However this technique did not give satisfactory results as some seasonal trends were still present in the residues. Hence another technique using Least Square Estimates was used. This technique gave more satisfactory results and thus it was used for both Auto-Regressive modelling and Spatio-Temporal Auto-Regressive modelling. When fitting Auto-Regressive models to the residues, several orders were considered, typically up to 6 or 7. However the results obtained failed to capture the systems dynamics completely. Thus Spatio-Temporal Auto-Regressive modelling was considered. Spatio-temporal modelling showed a significant improvement in modelling the ozone dynamics as exhibited by the data.

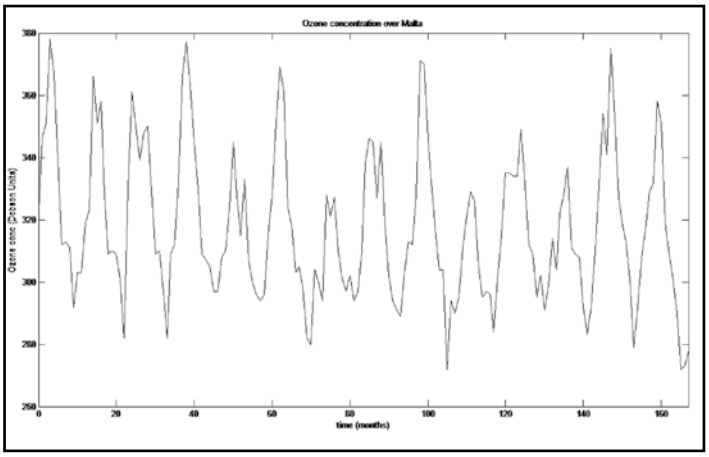
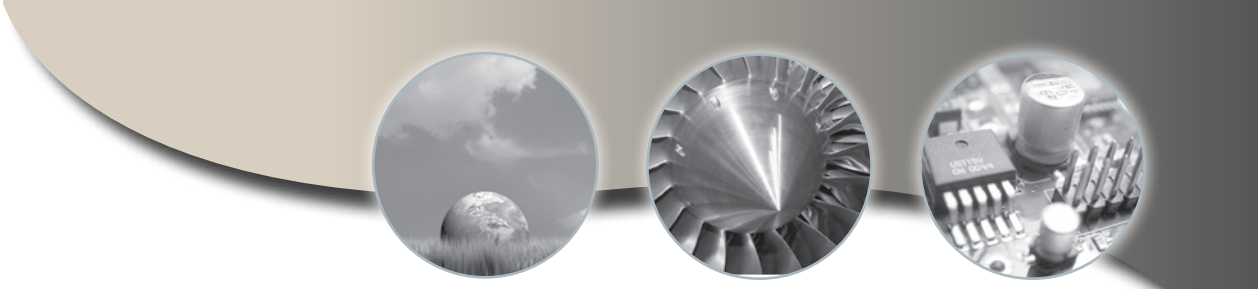


Figure 1: The Ozone concentration obtained over Malta from Jan 1979 till Dec 1992



IDENTIFYING GLOBALLY SALIENT LINE PATHS FROM SCRIBBLED DRAWINGS

Student: Clifton Vella **Supervisor: Ms. Alexandra Bonnici**

Introduction

Paper-based scribbles are the first medium onto which the designer's ideas are represented, especially in the conceptual design stages. These scribbles are eventually replaced by more elaborate and detailed drawings, following standard Engineering practices. Computer Aided Design (CAD) tools are often used at this stage of the design process, allowing the designer to easily create virtual prototypes of the concept design. However, these CAD tools differ from the designer's natural drawing habits and research on the use of sketch based systems that are closer to the designer's drawing habits are underway. Unfortunately, the majority of sketching interfaces being developed require that the user interacts with the interpretation system by means of stroke gestures in real time. This implies that the designer will still have to redraw the initial scribble.

Project Objectives

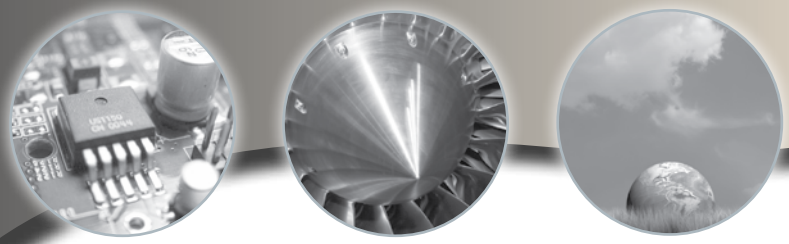
This project seeks to improve the paper-based scribble interpretation algorithms developed at the Faculty of Engineering, namely by extracting a sequence of globally salient line paths from the scribbled drawing. The current path extraction algorithm used by the scribble interpretation system uses only local saliency measures at junction points. While this may locally select the most salient path, the human visual system normally makes saliency judgements based on a wider and more global analysis of the drawing. Thus, the local saliency measures do not always match the human perception. By introducing the global saliency, this project aims at achieving paths that are closer to human perception.

Project Methodologies

- The image is assumed to be pre-processed by a quadrature bank of Gabor filters to group together strokes that belong to the same edge, and also to obtain an apporximation of the line orientation.
- The resulting response image is tracked by moving a seed segment along the path, adjusting its position to ensure that it is always centred on the path.
- While tracking, the measure of roughness of the scribbled strokes as well as the activity of the scribble strokes in the neighbourhood of the seed segment are used to give an indication of when the seed is approaching a junction. When it does, the rectangular seed is replaced by a circular one which is more adapted at locating all paths at the junction.
- Local saliency measures are used to determine the order with which the paths are tracked while other, global saliency measures, defined in literature are used to identify the globally salient paths from the drawing.

Results and Achievements

Shown here is an example of how the tracking algorithm works. Starting at the point shown, it tracks path A, arrives at the junction point, and starts paths B and C from the orientations detected at the junction using the circular seed segment. The algorithm also works out the local saliency measure which votes path C as being more salient than path B, since the angular difference between paths A and C is smaller than that between paths A and B. Also shown are the mean square errors of the tracked paths when compared to their respective intended paths, where it can be seen that the use of the position adjustment algorithm reduces by a large amount the error between the tracked and the intended paths.



CONTROL OF A ROTATIONAL INVERTED PENDULUM

Student: Steve Zahra **Supervisor: Ing. Marvin K. Bugeja**

Introduction

The rotational inverted pendulum also known as the Furuta pendulum, consists of a two-link mechanism were a motorized arm, which can rotate in a horizontal plane, is used to control the movement of a freely attached rod[1]. The control task is to swing-up the pendulum from its natural pendant position and balance it in the unstable inverted position, using only rotational movements of the horizontal arm. In addition, it is required to park the arm at some reference angle. This renders the control task more challenging. This control problem is theoretically interesting because it is inherently open-loop unstable, and more importantly because it is non-linear and under-actuated. Consequently, it is a classical benchmark problem in control, and is widely used to illustrate and motivate various control methods. Moreover, the control issues encountered when dealing with inverted pendulums are closely related to real-life applications involving robotics and space-rocket guidance systems.

Project Objectives

- Literature review on the control of inverted pendulum systems [2], particularly focusing on the rotary inverted pendulum configuration.
- Design and implementation of a simulation model of the Furuta pendulum,
- Design and implementation of the rotational inverted pendulum physical setup.
- Design and implementation of swing-up and stabilization control strategies for this pendulum topology.
- Testing and evaluation of both the simulation and experimental results.

Project Methodologies

The following steps were carried out during the implementation of the project:

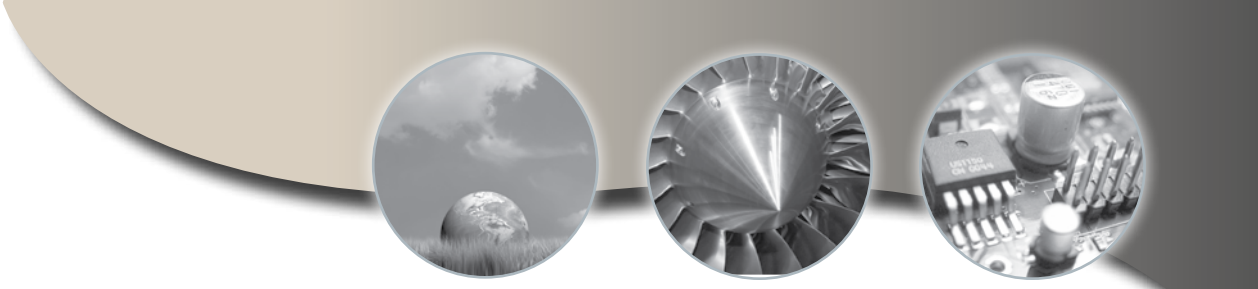
- Literature review on the dynamic modeling of the Furuta pendulum and the swing-up and stabilization algorithms for its control.
- Derivation of a suitable mathematical model for the Furuta pendulum setup [3].
- Verification and testing of published swing-up [4], [5] and stabilization algorithms, using the simulation model.
- Construction and implementation of the actual Furuta pendulum setup.
- Design and implementation of all the necessary electronics to interface the mechanical setup to the computer-based controller.
- Implementation and experimental validation of researched swing-up and stabilization algorithms on the actual rotary inverted pendulum structure.

Results

The obtained results show that the controllers designed to address the task at hand function successfully; since they swing-up the pendulum and maintain it stabilized in its inverted position, with the horizontal arm homed back to a predefined position. The stabilization controller proved to be highly robust in maintaining the pendulum inverted, even when subjected to external disturbances (manually hitting the pendulum). Results also show that the control task is ultimately fulfilled for any given initial conditions.

References

[1] http://www.control.tfe.umu.se/Set_Ups/Furuta_Pendulum/Furuta_Pendulum_info.html
[2]M.Bugeja, “Non-linear swing-up and stabilizing control of an inverted pendulum system.” , May 2002,http://www.eng.um.edu.mt/~sgfabr/bugeja.html.
[3]M.Gäfvert, “Modeling the Furuta Pendulum,” Department of Automatic Control, Lund Institute of Technology,1998.
[4] K.Yoshida, “Swing-up control of an inverted pendulum by energy-based methods,” proceedings of the American control conference, pp.4045-4047,1999.
[5]K.J. Åström and K.Furuta, “Swinging up a pendulum by energy control,” presented at 13th IFAC world congress,1996.



ANALYSIS OF BRAIN NETWORKS DURING SPECIFIC MENTAL STATES

Student: Ting Ting Zhu **Supervisor: Ms. Tracey Cassar**

Introduction

The brain is a complex system, composed of billions of neurons. These neurons interact and generate electrical activity which can be recorded non-invasively from the scalp through electroencephalography (EEG) (Figure 1). By analyzing relationships that exist between EEG recordings at different brain areas it is possible to identify brain networks which can possibly characterize the mental task being performed.

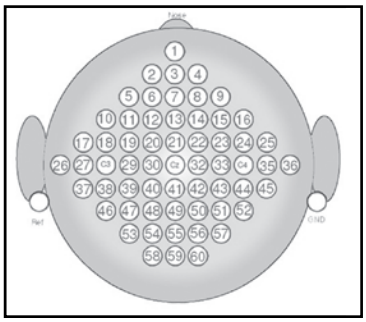


Figure 1: Top view of human brain with electrodes placed on the scalp which are recorded by EEG

Project Objectives

The goal of this project is to perform an elaborate analysis of brain networks to identify correlated activity across different parts of the brain while the subject is performing specific mental tasks and use this information to possibly identify what task is being performed.

Project Methodologies

The following steps were undertaken to reach the goals of this project:

- A literature review of techniques which have been developed to identify synchronization between time series recorded from different brain areas was carried out. Identification of the advantages and disadvantages of the different techniques helped to identify the best suited technique for this project.
- The chosen technique, called Partial Directed Coherence (PDC), was implemented using Matlab and thoroughly tested on multivariate simulated data to identify its limitations.
- The technique was then applied to real EEG data recorded from a subject performing imaginary left and right hand movements. The resulting brain networks were then analyzed to identify whether this information can serve as a biomarker to characterize the task being performed.

Results and Achievements

PDC was found to be a powerful parametric technique which can capture information flow across channels in a multivariate system. Its most prominent advantage is its weak dependence on the estimated model order and model parameters, thereby providing a simple and straightforward approach for brain synchronization. When applied to real EEG data typical in Brain Computer Interface (BCI) environments, differences in brain networks between the imagined left and right hand movements were found (see Figure 2), indicating the possibility of using this information as a biomarker to identify the task being performed.

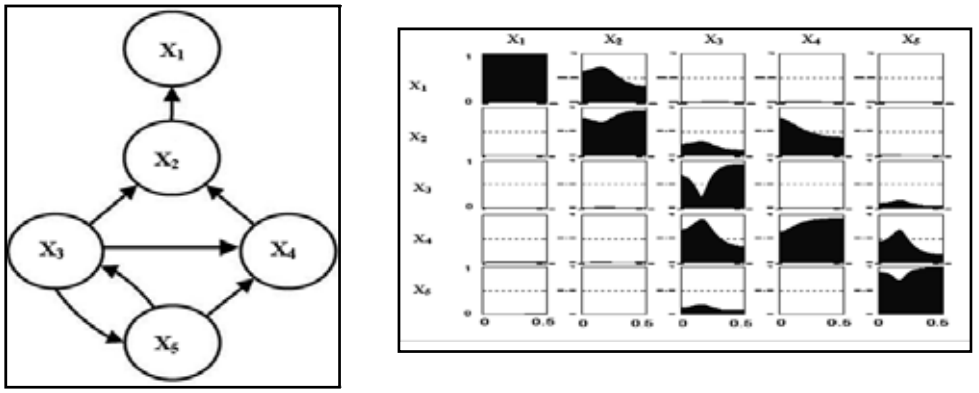
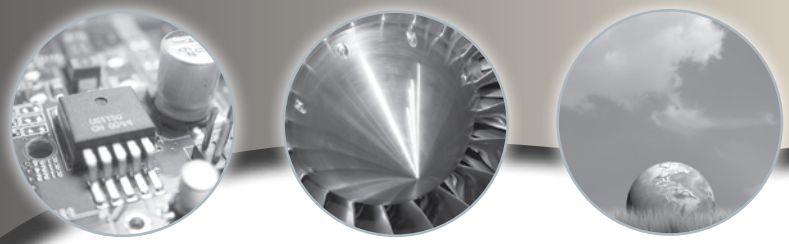


Figure 2: PDC results for simulated data. (a) shows the connections between the channels and (b) shows the PDC results. The diagonal plots in (b) show the information flow each signal is giving to itself. The rest of the plots show the direction flow from the source signal (along the columns) to the receiver signal (along the rows). The set of plots in the second column, for example, show that there is information flow from X_2 to X_1 but not to any of the other channels X_3, X_4 or X_5 as all PDC values are zero for the rest of the channels. This corresponds to the graph shown in (a).



INDOOR BLIMP – COMMUNICATIONS MODULE

Student: Andrew Bezzina **Supervisor: Ing. Paul Debono**

Introduction

It was proposed that an indoor blimp would be built to wander the faculty of engineering. Such a blimp may in the future provide vital information and promote events to students. The project has been divided into three sub-projects: the mechanical construction, control, and communications aspects of the blimp. My thesis deals with the communication aspect of the project.

Project Objectives

The first part of the project was to find what sort of communication will be used and what will be transmitted. It was decided that there would be a number of sensors onboard the blimp and that the readings would be relayed to a mobile terminal (in this case a laptop pc) using a wireless communication link. A mini onboard camera would also be installed to provide remote vision through the laptop. Later it was thought that it would also be useful to control the blimp through the terminal in addition to the radio–control RC transmitter. In order to achieve this, a microcontroller was needed to interface with the sensors and servo, and provide the output of these sensors both to the control module, as feedback to adjust propeller speed and direction, and to the wireless module to transmit them to the mobile terminal.
Three communication links where considered: Wi-Fi, RF, and Bluetooth. It was decided, (after various considerations which are discussed later in this document), that Bluetooth would be used transmit the sensor readings using a connectBlue serial port adapter, and RF would be used to transmit the video feed using an integrated mini wireless camera.

Project Methodologies

The main aspects of the project were,

- Researching suitable communication links to transfer the sensor readings and video feed to the terminal, as well as providing the possibility to send control signals to and from the blimp
- Design a complete system including a microcontroller to interface with sensors and with the control module of the project and wireless transmitter module
- Implement the communications module: Design and production of PCB to connect microcontroller to the sensor interfacing circuitry, Bluetooth module, servo for camera rotation, and control microprocessor
- Programming of onboard Microcontroller
- Programming of GUI application for the mobile terminal

Figure 1: Blimp Console

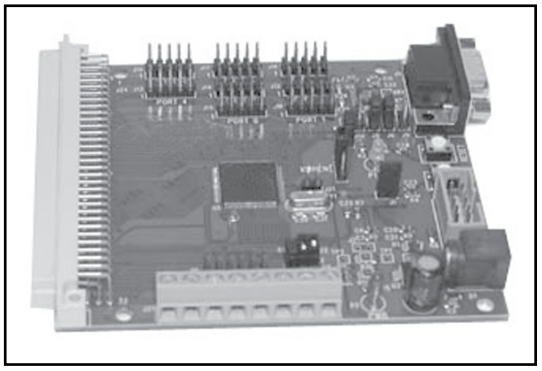
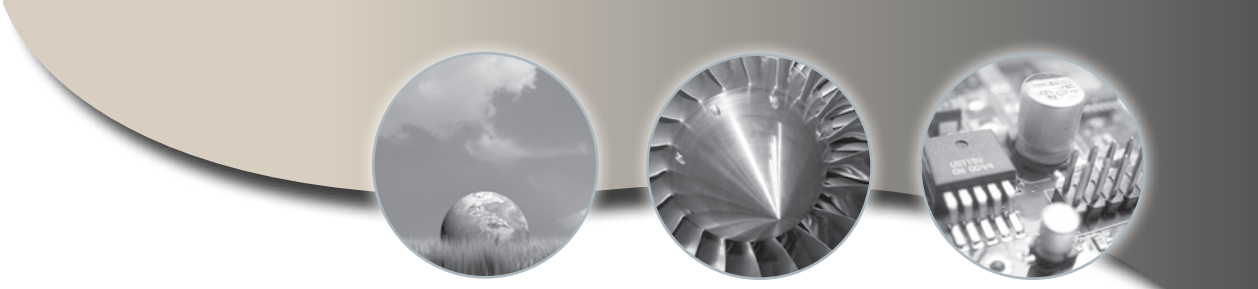


Figure 2: Microcontroller

Results and Achievements

A Communications module was successfully built that would communicate sensor readings to a Bluetooth enabled laptop, with the use of the Blimp Console a software program made using C# programming language and the .NET 2.0 environment.



AUTOMATED CORROSION MAPPING

Student: Daniel P. Cremona **Supervisor: Ing. Paul P. Debono**

Introduction

The field of corrosion control and prevention covers a very broad spectrum of technical activities within the sphere of corrosion monitoring. Corrosion measurement employs a variety of Non-Destructive Techniques (NDT) that seeks to determine how much metal loss the material has experienced. This field can be described as the quantitative method by which the effectiveness of corrosion monitoring and control, can be evaluated and thus providing the necessary feedback to enable corrosion control and prevention methods and techniques to be optimized. The focus of this project is corrosion mapping, that is, to accurately locate areas on the metal that are subjected to corrosion.

Project Objectives

With corrosion monitoring as the guiding principle, a semi autonomous robotic system was designed and built. The system integrated an ultrasonic set that reads the thickness of the material, with the emphasis on speed, efficiency, reliability and performance. It was to be faster than a human operator and yet, acquire and process data accurately. The design also focused on mobility and manoeuvrability, such that the system could access a wide variety of environments, places where humans would struggle to access. It is important to stress that the system was designed with monitoring in mind. Corrosion control and prevention are subject to further research and development.

Project Methodologies

In order to accomplish the tasks imposed by the monitoring procedure, an ordinary ink jet printer was used as the basis of the system. During printing an inkjet printer moves the printing head from left to right, whilst rolling the paper forward in order to move down the rows. Hence, the operational area is effectively divided into a 2D matrix. The system operates in the same manner. It is made up of an aluminium frame that was adapted to be able to move forward or backwards on the surface of the material under test. A probe, mounted on a transversing housing allows the system to scan any desired point on the surface.

The operation procedure is:

- The system moves to a desired location on the material surface (forward/backward)
- The probe is directed to required point co-ordinates (left/right)
- Prior to making contact with the surface, coupling liquid is squirted onto the test point
- The probe is lowered perpendicularly onto the surface to be tested. A reading is displayed on screen.
- The system saves the thickness reading in its memory, including the co-ordinates in relation to a reference point.
- The probe is then retracted and the cycle can take place all over again

Results and Achievements

The results, stored in the system's memory can be uploaded to a PC. The data interface was chosen to be a serial (RS-232) port. Once the raw data has been uploaded, the operator can manipulate it as he sees fit. If a sufficient number of readings have been taken, in depth analysis of the test piece can be carried out. This will reveal its structural integrity.

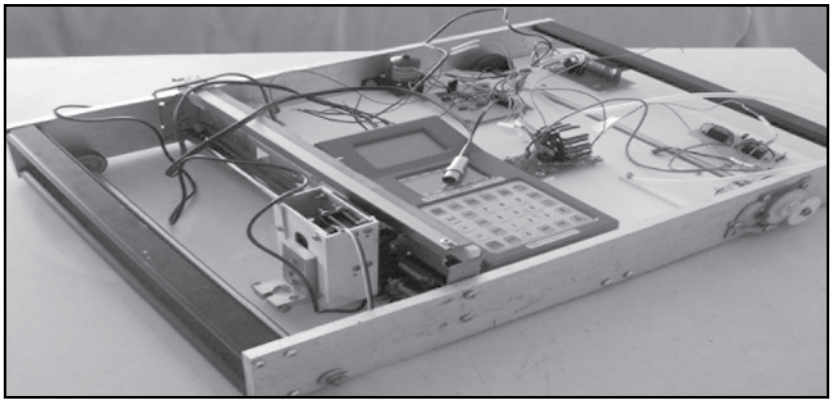
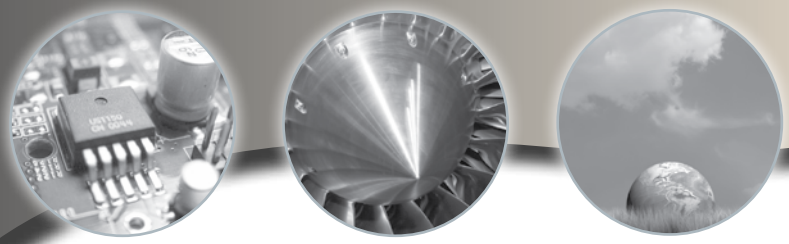


Figure1: Automated System during assembly



ROBUST VIDEO TRANSMISSION USING DATA HIDING TECHNIQUES

Student: Robert Facciol **Supervisor: Mr. Reuben Farrugia**

Introduction
Video is coded using variable length codes, which are very sensitive to transmission errors [1]. A single bit error in the bit stream can introduce artifacts in the reconstructed image which can severely degrade the video quality. However, if a transmission error is detected its effects can be corrected by using error concealment algorithms.

Project Objectives
The objective of this dissertation is to increase the robustness of video sequences by inserting watermarks into the DCT blocks of the video bit stream at the encoder side. These watermarks are then used at the decoder side to detect transmission errors.

Project Methodologies
The project identifies watermarking techniques as a feasible method for detecting transmission errors and thus improve the quality of the received video sequence. H.264/AVC was the video protocol used. The following steps were carried out during the implementation of the project:

- Literature review of current state of the art methods for increasing video robustness
- Implementation of two watermarking methods implemented in literature [2],[3]
- Implementation of two reversible watermarks, implemented using data hiding techniques [4]
- Comparison of the methods implemented and identification of the optimum watermark to use at different data rates

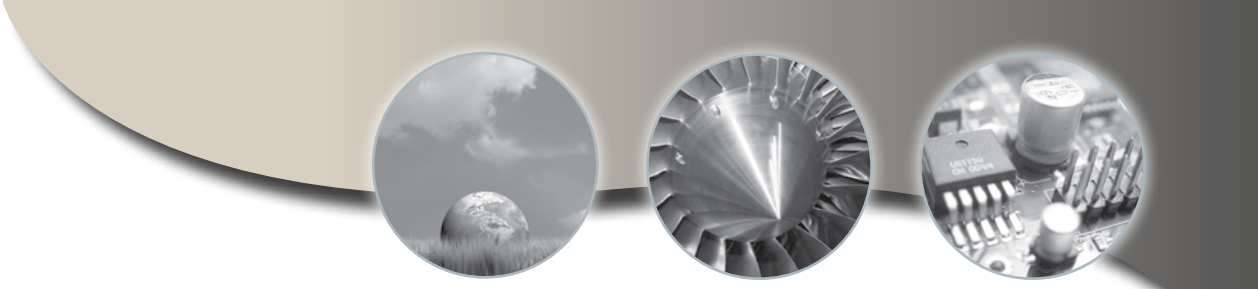
Figure 1: Video frame with undetected errors (left) and with errors detected and concealed (right) using one of the data hiding techniques implemented

Results and Achievements

The results indicate that with the insertion of watermarks, more transmission errors can be detected and the quality of the video sequence is improved. The data hiding techniques gave a better error detection rate than the other two techniques implemented and also resulted in better video quality after decoding.

References

[1] L. Superiori, O. Nemethova, and M. Rupp, "Performance of a H.264/AVC error detection algorithm based on syntax analysis," in Proc. Int. Conf. on Advances in Mobile Computing and Multimedia, Yogyakarta, Indonesia, Dec. 2006.
[2] M. Chen, Y. He and R.L. Langendijk, "A fragile watermark error detection scheme for wireless video communications," IEEE Trans. on Multimedia, vol. 7, pp.201-211, April 2005.
[3] O. Nemethova, G. Calvar Forte and M. Rupp, "Robust error detection for H.264/AVC using relation based fragile watermarking," Proc. of Int. Conf. on Systems, Signals and Image Processing (IWSSIP), Budapest, Hungary, September 2006.
[4] J. Tian, "Reversible data embedding using a difference expansion," IEEE Trans. on Circuits Syst. Video Technol., vol. 13, pp.890-896, August 2003.



REMOTE PROCESSING OF AN INTERACTIVE APPLICATION

Student: George Gauci **Supervisor: Dr. Ing. Saviour Zammit**

Introduction

Remote processing has been used in many different, mostly professional applications. This has been true until recently when a new project named Games@Large has been partially funded by the European Commission as part of the "Sixth Framework Programme". The aim of Games@Large which is also the aim of this dissertation is to enable gaming on devices that typically do not possess a full set of technical requirements to serve as an interface to run these video games.

Project Objectives

Design a system that will be able to run multiple Windows based games and stream each game as video and audio via WIFI to mobile internet devices (MID). Also implement a Windows application to be run on the gaming server that will receive any key presses from the MID, and emulate those key presses on the local machine.

Project Methodologies

The previous work done on this subject involves using hardware to grab the screen, encode the video stream and packetize it. While the final system should be implemented in hardware to get the best results, it is very useful to also implement a similar low-cost counterpart for testing in software. The project can be split up as follows:

- Literature review of the different techniques adopted to play games remotely
- Design of a system that will be able to receive commands from multiple gamers, each playing his own game, and stream the video to the respective gamer's device.
- Develop code to test the proposed system regarding CPU usage, latency and video quality.
- Identify the parameters that will affect the gaming experience offered. This includes the various buffers, different codecs and quality levels.
- Develop a code that automatically identifies the best parameters based on the gamers' mobile devices, the number of active players and the hardware resources available.

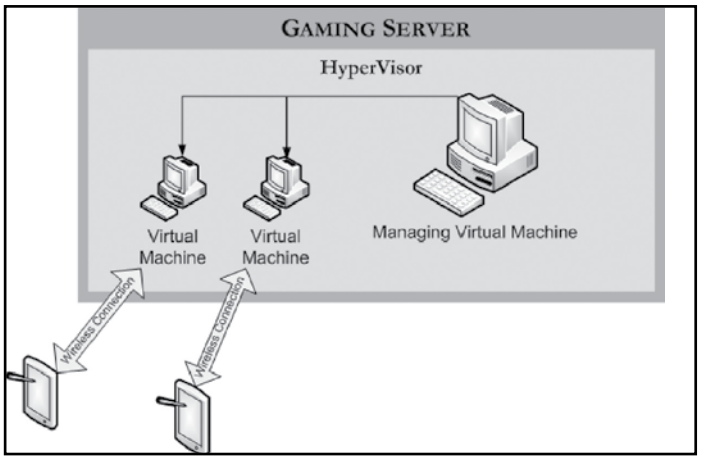
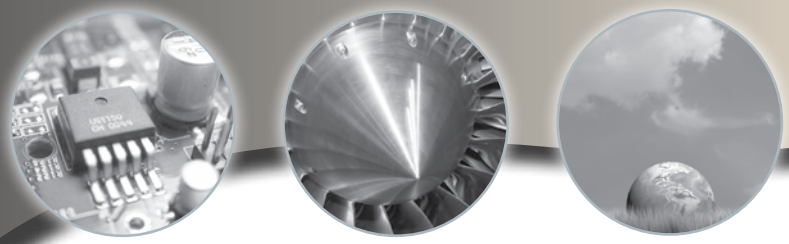


Figure 1: Basic diagram of the proposed system

Results and Achievements

A lot of software development and testing has been done to find how the system is performing. After a lot of tweaking and modifications, the system has been optimized for an acceptable gaming experience. Picture quality as seen on the mobile device is near to native quality, gaming latency has been reduced to around a third of a second and by using light video encoders and applications, CPU usage has been rendered less of an issue. While this software-based solution was designed to operate as a test system, results have shown that it can be used as a final implementation given some further improvements.



USING A GENETIC ALGORITHM TO CONSTRUCT VLEC CODES

Student: Steven Grima **Supervisor: Dr. Ing. Victor Buttigieg**

Introduction

Communication systems are widely used in the modern era. Briefly stated the purpose of any communication system is to deliver information as quickly, as reliably and even at times as secretly as possible, be it in space or time. Use of source coding and channel coding is important to meet these objectives. VLEC codes combine the operation of source coding and channel coding into a single step. It is a very challenging problem since the former is removing redundancy yet the latter is adding it making a scheme which optimizes both nontrivial. The motivation behind this project is to build high-quality VLEC codes which may in turn be used in video standards such as H.264 and MPEG-4 which require enhanced error resilient capabilities.

Genetic algorithms (GA) are search algorithms inspired by Darwinian concepts of survival of the fittest and genetics. GA use a population of chromosomes which use a genetic encoding, called the genotype, which represents a solution, called the phenotype. GA mimics natural systems in process such as natural selection of the fittest, recombination of genetic material and mutation; in an attempt to search for optimal solutions.

Project Objectives

This project is aimed at trying to solve the complex problem of constructing superior VLEC codes through the use of GA. It is hoped that a GA will manage to conquer the Heuristic Algorithm constructed by [1] which up to date manages to build some of the best VLEC codes.

Project Methodologies

The project was organized in 4 phases:

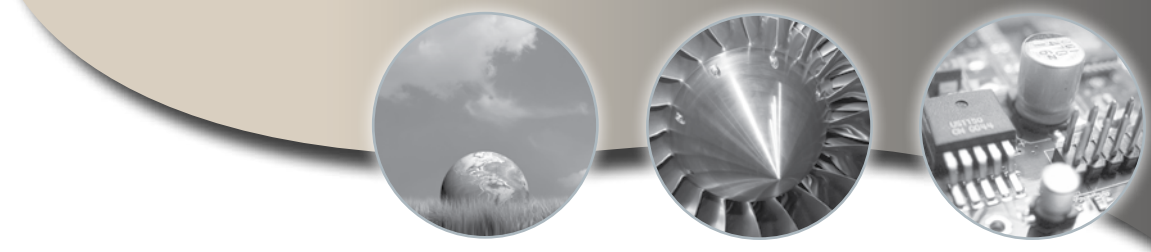
1. Conduct research on GA, parallel genetic algorithms (PGA), construction schemes of VLEC codes and reversible variable length codes (RVLC).
2. Use a GA to construct codes using the codebook as a chromosome.
   o First attempting to build fixed length codes.
   o Then proceeding to build VLEC codes.
3. Use a GA to construct linear codes using a generator matrix as a chromosome.
   o First attempting to build fixed length codes
   o Then proceeding to build VLEC codes
   o Compare with the scheme that used the codebook to build VLEC codes.
4. Use the Heuristic Algorithm proposed by [1] but incorporating a GA instead of other search processes used by the Heuristic Algorithm.

Results and Achievements

Although it was not possible to construct better VLEC codes than the HA using a GA, a fusion of the two algorithms in phase 4 managed to achieve better results. When a GA was used as part of the search process inside the HA better results were obtained as opposed to using the HA with its old search techniques called the majority voting algorithm (MVA). An appreciable reduction in the average codeword length was achieved leading to better compression and slightly better error resiliency. The Figure to the right illustrates a slight improvement in error resilience for a code with a distance of 5. The Average codeword length was reduced by 0.251bits/symbol.

References

[1] V. Buttigieg, "Variable-length error correcting codes", Ph.D. dissertation, University of Manchester, Manchester, United Kingdom, 1995.



IPV6 VIRTUAL TEST BED

Student: Josef Lia **Supervisor: Dr. Ing. Victor Buttigieg**

Introduction:

IPv6 is the next generation Internet protocol that will eventually replace the existing IPv4 protocol. This protocol is basically an extension to the IPv4 protocol. The need for more address space, better quality of service and better security were the main requirements for the design of this new protocol.

Project Objectives:

The objectives of this project is to build an IPv6 virtual test bed where most of the IPv6 features could be demostrated. The test bed built consists of a host machine on which two virtual machines are installed. One of these two virtual machines acts as a router, to route packets from the host machine to the other virtual machine and vice versa. All the three machines, that is the host together with the two other virtual machines were connected to the Internet using IPv6.
The aim of this virtual test bed is to provide hands on experience on IPv6.

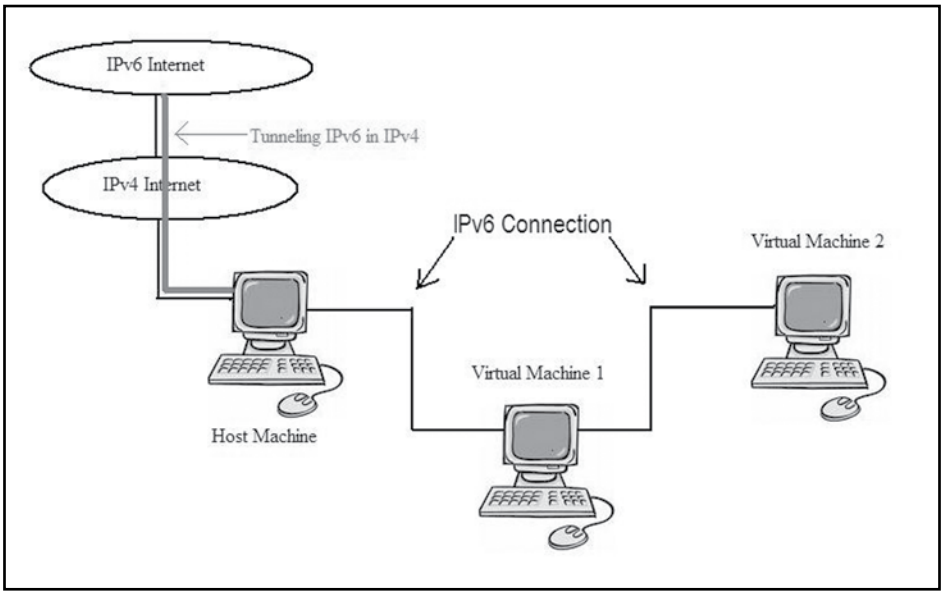


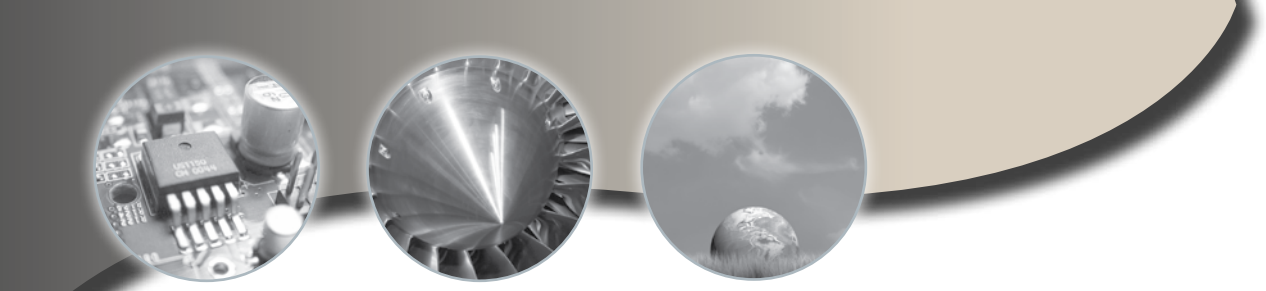
Figure 1: IPv6 protocol

Project Methodologies:

- Literature review to get familiar with both the IPv4 and IPv6 protocols;
- Build the virtual test bed;
- Find which IPv6 aspects could be implemented on the test bed;
- Implementation of various IPv6 aspects which included DHCPv6, DNS, ICMPv6, Neighbor Discovery, IPv6 Header, IPsec and Quality of Service;
- Create a CD on which the steps required to build the test bed and how to implement the IPv6 aspects are explained.

Conclusion:

IPv6 as the next generation protocol seems quite beneficial. From what was implemented in this dissertation, it seems that IPv6 should perform as good as IPv4 or even better and the changeover to IPv6 would be useful especially due to the shortage of addresses in IPv4 as is the case at the moment. The IPv6 virtual test bed and many IPv6 features were successfully implemented.



A STUDY ON THE QOS OF MULTI-VIEW VIDEO STREAMS TRANSMITTED OVER WIRELESS CHANNELS

Student: Brian Micallef **Supervisor: Dr. Ing. Carl James Debono**

Introduction

Multi-view video is expected to be the next generation in home and mobile entertainment. This dissertation studies the Quality of Service (QoS) experienced when transmitting multi-view video streams over a wireless channel and analyses solutions to improve it.

Project Objectives

The objective of this dissertation was to emulate a real-time multi-view wireless video system to determine its subjective and objective QoS under different transmission error conditions. A number of methods to improve the QoS were also suggested and implemented.

Project Methodologies

The following steps were carried out during the implementation of the project:

- Literature review of the current compression techniques used for multi-view streams
- Search for the latest version of the Joint Multi-view Video Model (JMVM ver.8) which replicates the current version of the standard (since this is still under development)
- Modify the model to accept erroneous data and to use a real-time coding structure
- Model the wireless environment to corrupt the multi-view bit-streams and setup the simulation environment as shown in Figure 1
- Determine the subjective and objective QoS of the modified model for the two main entropy encoders (CAVLC and CABAC) and determined which one should be used in a wireless environment
- Literature review of the current single-view error resilience coding
- Implement some single-view error-resilience techniques like the slice-coding tool, a variable cyclic Intra-coding period and the flexible macroblock ordering (FMO) tool in the multi-view model
- Determine the subjective and objective QoS improvement obtained by the use of error-resilience coding, for different videos and different bit-rates

Results and Achievements

From the tests it was concluded that:

- A new error propagation effect (not present in single-view) resulted between different views
- The best entropy encoder for wireless environments is the CAVLC
- The current multi-view video coding model (JMVM) behaves very badly under error conditions and thus error resilience coding is vital
- The slice coding tool with the smallest slice size, gave a very significant improvement in QoS
- A smaller cyclic Intra-coding period provided a better QoS
- The FMO tool with the dispersed type, offered an improvement in the subjective QoS
- Lower bit-rate video coding gave a better QoS
- The effects of error propagation between the views is difficult to reduce
- The QoS improvement obtained through error resilience coding was similar across video types

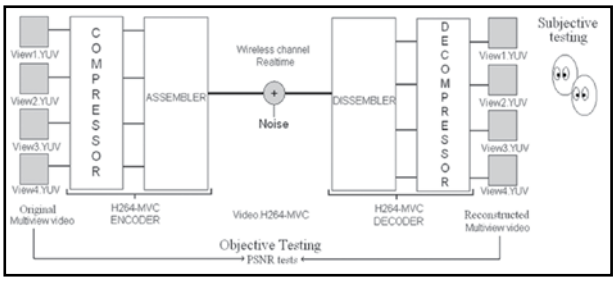


Figure 1: Setup of the simulation environment

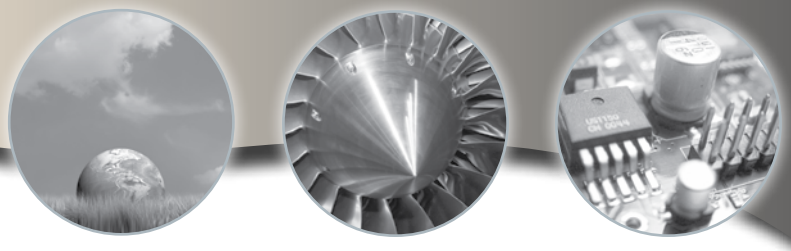


IMAGE & VIDEO SEARCH

Student: Jeffery Micallef **Supervisor: Dr. Ing. Victor Buttigieg**

Introduction

The increasing generation and dissemination of images and video clips due to the advances in the field of image and video analysis, multimedia computing, data storage and also in communication have created an urgent need for fast, efficient and robust image and video search engines. Image search engines are used in many application areas such as biomedicine, military, commerce, education, Art collections, Photograph archives, Retail catalogs. While video search has also a wide range of applications; such as TV broadcast monitoring, copyright enforcement, online video usage monitoring, video database purge, etc.

Project Objectives

The aim of the dissertation is to study and implement algorithms used for image and video search engines, and to write a program, which given a query image, will be able to retrieve all images in the image database that are visually similar (image-to-image matching), or to identify shots in a video which contain the same features that are present in the query image (image-to-sequence match). On the other hand if the user selects a video clip as a query, it should retrieve the video the clip belongs to (sequence-to-sequence matching).

Project Methodologies

The following steps were carried out during the implementation of the project:

- Literature review of the current state of the art algorithms used to compare videos and images.
- Implement and test the Colour Layout Descriptor (CLD), Scalable Colour Descriptor (SCD), Colour Structure Descriptor (CSD) and the Edge Histogram Descriptor (EHD) which are used to extract the features from an image, and their respective distance metric, needed to calculate the similarity between two images.
- Use these algorithms to implement image-to-image search.
- Literature review on different algorithms that can be used to extract limited and meaningful representative information (key-information) for all parts of the video.
- Implement and test the algorithms used for shot change detection and selection of the appropriate representative key frame, and use them to implement image-to-sequence matching, by comparing the query image with these representative key frames.
- Literature review on different algorithms used to compare two sequences together.
- Implement and test the Levenshtein distance, which is used to compare two stings together, and use it to investigating the relation among the key frames (which are used as shot-representatives) of the two video sequences, for sequence-to-sequence matching.

Results and Achievements

From the measurements of the retrieval performance that were carried out on a general purpose database (WANG dataset), it was found that the Mean Average Precision (MAP) for the EHD, SCD and CLD, were very similar to those given in published work, showing that the algorithms gave the expected results. It was concluded that the CSD gives the best results when considering each descriptor on its own, however when the descriptors are fused together, using either Entropy or Average, they perform much better. The average is preferred, because it performed slightly better and is less computationally expensive. Figure 1 shows the results retrieved by the application, from the WANG dataset, when the top left image is used as the query image, and when the images are compared using the average of the scores given by the four different descriptors.

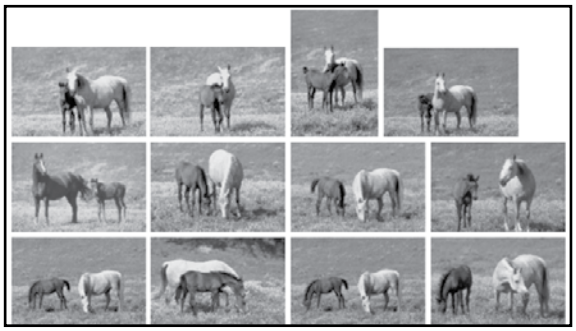
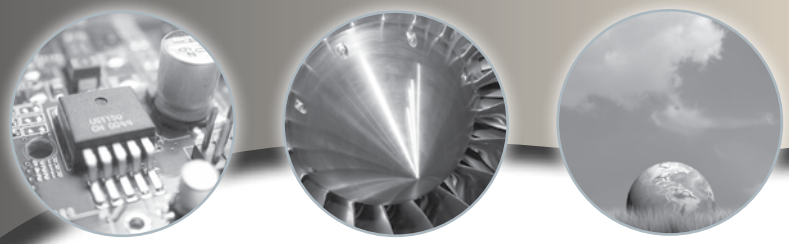


Figure 1: Retrieval results for image-to-image matching.



ADAPTIVE AND DISTRIBUTIVE ROUTING USING ARTIFICIAL INTELLIGENCE

Student: Chris Saliba **Supervisor: Mr. Reuben Farrugia**

Introduction

The demand for communication network services' and the load imposed on them has increased exponentially in the past decade making techniques for network control fundamental in maximizing the available resources, ensuring provision of the best possible service to the end user. The core of this network control lies in the network routing, and in the routing algorithm [1].Various dynamic routing mechanisms has been developed. However one particular area showing promising results is the development of adaptive and distributed routing using artificial intelligence [2], where agents flow in the network gathering up "knowledge" of their surroundings, and with this knowledge builds the required routing tables.

Project Objectives

The main objective of this project was to adopt artificial intelligence, more precisely cooperative intelligence inspired from ants, to provide dynamic routing. The performance of this algorithm was then compared with other classical approaches currently being used in communication networks like the Internet, dominantly Link State (LS) routing and Distance Vector (DV) routing. QoS performance constraints such as delay and throughput where considered for comparison.

Project Methodologies

This project proposes a routing algorithm based on the behavior ants show in nature of trail-laying/trail-following. Unlike other traditional routing algorithms, such routing algorithm is able to find the shortest path between a source and a destination, optimizing both the spatial and the temporal distances [3]. The following steps were carried out during the implementation of the project:

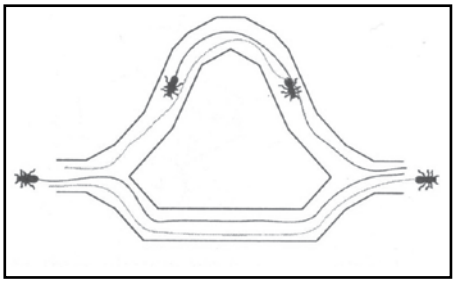


Figure 1: The trail-laying/trail-following behaviour of ants in nature

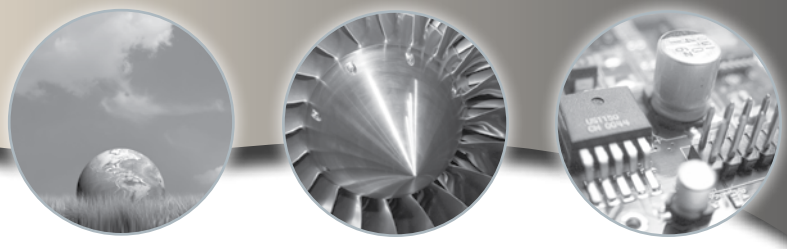
- Literature review of the current routing techniques used, and the various routing algorithms based on artificial intelligence
- The identification and implementation of two routing schemes, based on the launching of artificial ants
- The development of a routing algorithm based on the former works, with the addition of a number of modifications, such as the implementation of a QoS-aware routing and the dynamic launching of ants proportional to the network load.
- The comparisons of the performance of the proposed scheme with traditional routing methods.

Results and Achievements

The traditional routing methods such as LS and DV showed smaller instantaneous data delivery delay. However given time to converge, the ant based schemes were able to match and outperform them. With regards to throughput the ant based schemes perform better than the traditional schemes, as load balancing is inherent such schemes. Furthermore the proposed algorithm was able to match the performance of the other ant based schemes and outperform them whilst keeping a fixed size ant message allowing for piggy-backing, minimising their cost on the network. The proposed algorithm is particularly suitable for networks requiring a high throughput percentage and with varying traffic oscillations; such as the wired Internet backbone.

References

[1] D. Bertesekas, and R. Gallager, Data Networks, New Jersey, Prentice-Hill, 1987, pp. 297-418.
[2] S. Liang, A. N. Z. Heywood, and M. I. Heywood, "Adding more Intelligence to the network routing problem: Antnet and Ga-agent", Applied Soft Computing, vol. 01, no. 05, pp. 164-178, Jan 2005
[3]R. Schoonderwoerd, O. Holland, and J. Rothkrantz, "Load Balancing in Telecommunications Networks", Adaptive Behaviour, vol. 5, no. 02, pp. 169-207



SOLAR POWERED WIRELESS NETWORK

Student: Sylvana Scicluna **Supervisor: Dr. Ing. Savior Zammit**

Introduction

The modern world, with all its superlative advances and technological knowhow, faces numerous crises, which can fundamentally undermine the status quo. By combining solar energy and wireless communication, a network can be made truly independent of thepower grid, making the wireless connection truly wireless and independent of its terrestrial components. This autonomous installation approach provides a solution to remote areas, especially in developing countries, which very often lack basic infrastructure such as access to the public telephone network (PSTN) or even to electricity. If utilised in a developed society, such a system helps to reduce the carbon footprint and alleviate pressure on the power grid.

Project Objectives and Methodologies

The main project objective is to implement an autonomous solarpowered telecommunications system which is independent of external power sources. The system utilises an Access Point powered by a solar panel and its performance is analysed under varying load conditions. The system makes use of a lead-acid battery as back-up storage and a Battery Management Unit is used to monitor the battery's dynamics and determine the operational state and performance of the system in real time.
From design to assembly, the following major steps were undertaken:

- Research was conducted in order to establish the operating principles of similar systems;
- Testing was carried out on the Mikrotik Access Point and back-up battery;
- Given the test results, the most efficient method for monitoring the battery's performance and state was identified;
- The system was designed, including its layout and positioning within the enclosure;
- The power consumption was determined by running the system on various loads;
- Tests were carried out in order to verify whether the overall system met the objective of being autonomous;

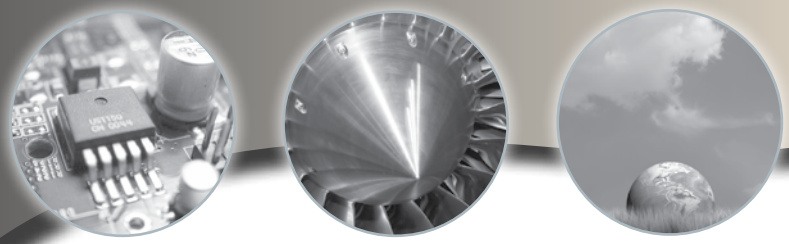
Results and Achievements

Ever since the system was set up on the roof and allowed to run continuously, the data collected from the BMU has shown that in 24 hours, the minimum voltage that was registered by the battery was 12.36V, which indicates that even during cloudy days, the system should be able to sustain itself for a significant period of time. As expected due to the climatic conditions of Malta, it could be seen that in a typical Spring day, the battery would be charging for about 8 hours, discharging for about 8 hours and for the remaining 8 hours, the battery would be neither charging, nor discharging; the energy generated is being used up by the load, completely.
So far, preliminary testing of the effect of loading on power consumption has been undertaken and thus, more testing needs to be carried out in this respect. Moreover, there is a possibility of introducing a voltage regulator if it is seen that the voltage of the battery is fluctuating beyond the ideal limits of 10.5V to 14.4V.

Figure 1: The final set-up set on the roof

References

[1] Francesco Javier Simo Reigadas et al., "The design of a wireless solar-powered router for rural environments isolated from health facilities" in IEEE Wireless Communications, June 2008.



LONG DISTANCE MIMO LINKS

Student: Jean Marie Vella **Supervisor: Dr. Ing. Saviour Zammit**

Introduction

A communication system using more than one antenna at both the transmitter and the receiver is referred to as a Multiple-Input Multiple Output (MIMO) system. MIMO has promised an increase in the channel capacity equivalent to the smallest value between N_t and N_r, where N_t and N_r are the number of transmit and receive antennas respectively. It also can increase the range without requiring an increase in transmit power although the 'keyhole' effect can be observed if no other techniques besides spatial multiplexing are implemented. The 'keyhole' effect results in a degenerate channel with reduced channel capacity and hence throughput. This is a result of diffraction at a roof edge with the antennas being vertically separated [1] or in a line of sight environment where the number of scatterers is limited [2]. The use of polarization diversity or artificial scatterers [3] can eliminate the keyhole effect.

Project Objectives

The objective of this project is to analyse how polarization diversity can augment the range for 802.11n devices while eliminating the 'keyhole' effect. 802.11n is an amendment to the 802.11 family of standards increasing the throughput by using spatial multiplexing and improving the MAC layer by using frame aggregation and block acknowledgement. The aim of this project is to maintain the high throughput that 802.11n draft 2.0 devices offer for a larger wireless local area network in the outdoor environment.

Project Methodologies

A series of measurements were taken both in the indoor and the outdoor environment. The devices used are a Conceptronic C300BRS4 802.11n wireless broadband router, a Conceptronic C300Ri 300Mbps Wireless PCI card, a MSI M670 laptop, a computer, and an ethernet cable. The indoor measurements observed the effect of distance on throughput for the 1x1 system with both 20MHz and 40MHz channels and for the 2x2 MIMO system considering only the 20 MHz channels, using 2dBi dipole antennas. However for the outdoor environment throughput measurements were obtained for the (i) 1x1 horizontally polarized systems, (ii) 1x1 vertically polarized systems, (iii) 2x2 polarized systems with all the antennas vertically polarized and (iv) the 2x2 polarized implementing polarization diversity. These measurements were taken for different environments having different distances between the transmitter and the receiver using 4 outdoor high gain directional yagi antennas with linear polarization. Their gain ranged from 12dBi to 15dBi.

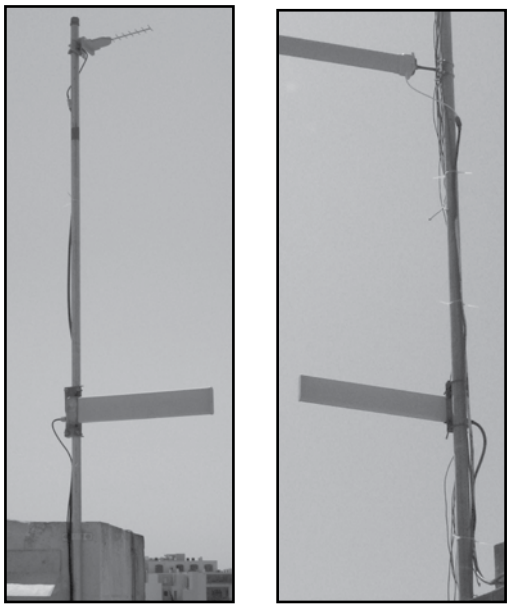


Figure 1 The 2x2 MIMO system

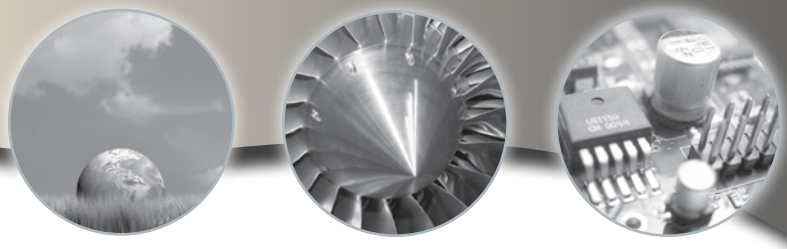
Results and Achievements

The resulting throughput for the indoor enviroment was congruent with theory namely proving that (i) the throughput achieved with SISO using 802.11 20MHz is better than 802.11g, (ii) the throughput doubled with 40MHz channels for both SISO and 2x2 MIMO and (iii) the throughput decreased with distance. For the outdoor environment it was shown that polarization diversity does increase the throughput when compared to the same 2x2 system but without polarization diversity, eliminating the keyhole effect.

References

[1] D. Chizhik, G. J. Foschini, M. J. Gans, and R. A. Valenzuela, "Keyholes, correlations, and capacities of multielement transmit and receive antennas," IEEE Transactions on Wireless Communications, Vol. 1, No. 2, pp. 361-368, Apr. 2002

[2] D. Gesbert, H. Bölcskei, D. A. Gore and A. J. Paulraj, "Outdoor MIMO wireless channels: models and performance prediction," IEEE Transactions on Communications, Vol. 50, No. 12, pp. 1926-1934, Dec 2002



A SUPPORT VECTOR MACHINE APPROACH TO LOCATION ESTIMATION IN AN URBAN 3G NETWORK

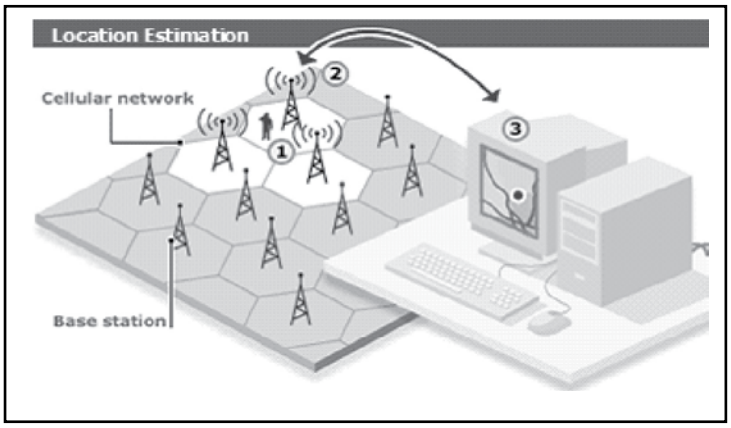
Student: David Xuereb **Supervisor: Dr Ing. Carl James Debono**

Introduction

This project is concerned with one of the most complex problems in cellular technologies, namely location estimation. The procedure adopted in this work is based on Cell-ID and RF signal strength measurements and involves the use of a machine learning method known as Support Vector Machines (SVM). Location estimation in Universal Mobile Telecommunications System (UMTS) networks is an emerging application that infers the location of a mobile device using multiple signal strength measurements. While geometrical solutions and signal propagation models have been studied and implemented to tackle this problem, several impairments have limited the accuracy of such location estimation. Using Support Vector Machines, we have investigated the possibility of improving current results which adopt similar methods.

Project Objectives and Methodologies

The objective of this project was to develop an effective algorithm to be used for location estimation in a UMTS network and to verify its accuracy using statistical tools. This concept is shown in Figure 1.



1) Phone sends signal to nearby Base Stations

2) Positioning Software performs a triangulation calculation

3) The data is converted into a geographical location

Figure 1: Urban 3G Network

The methodology used can be summarized in:

- Conduct research on UMTS, Radio Propagation Mechanisms and Support Vector Machines.
- Develop a UMTS radio model of an urban area using radio propagation models and taking into consideration certain anomalies which occur in wireless transmission.
- Develop a location estimation algorithm based on the use of Support Vector Machines.
- Verify the theoretical accuracy of the system through a statistical study.
- Develop a Graphical user Interface (GUI) to simplify the use of the system developed.

Results and Achievements

The error margin for 67% accuracy which was required to compare with published studies was found to be 225m, whereby the average error of these correct estimations was determined to be 112.13m with a standard deviation of 58.07m. The average runtime of the algorithm was 2.452 seconds which is almost real time.

References

[1] BBC News: Tracking a suspect by mobile phone. [Online] Available: http://news.bbc.co.uk/2/hi/technology/4738219.stm

MULTICAST STREAMING OVER 802.11

Student: Shuo Yang **Supervisor: Dr. Ing. Saviour Zammit**

Introduction

Multicast streaming over 802.11 is a mechanism for one-to-many communications over wireless networks. It is an advanced and efficient technology since it requires the source to send any packet to multiple destinations only once. This is quite important with wireless networks having limited throughput available and it is cost effective since it conserves bandwidth. However, the lack of an error recovery mechanism is a challenge that needs to be addressed.

Project Objectives

The challenges of multicast video stream over wireless network are due to the wireless channels. The wireless environment changes rapidly and unpredictably due to noise, interference, and fading. The IEEE 802.11 standard does not provide any recovery mechanism during multicasting. The current MAC layer sends multicast packets in open-loop mode as broadcast packets without any possible acknowledgements. This thesis, focuses on this problem, and investigates the repercussions on video quality.

Project Methodology

The following methodologies were followed in the pursuance of this project:

- Understanding the basic IEEE 802.11wireless multicast standard and MPEG2 concepts;
- Studying multicast operation and research previous work regards to any existing multicast protocols;
- Building a test-bed for multicast system analysis and testing.
- Analyzing the performance of multicast video streaming whilst varying different parameters such as the distance or transmitting rate, to understand their repercussions on video quality.

Results and Achievements

Following background research and a literature review, a test-bed was built as shown in figure 1, to study video multicasting over IEEE 802.11 wireless networks. To study the effects of packet and frame loss on video streaming, video is streamed from a Videolan server to multiple clients over a multicast capable 802.11 AP. Various tools were adopted, modified and coded to allow packet and frame loss to be detected and correlated with video quality measured using PSNR of the YUV frames.

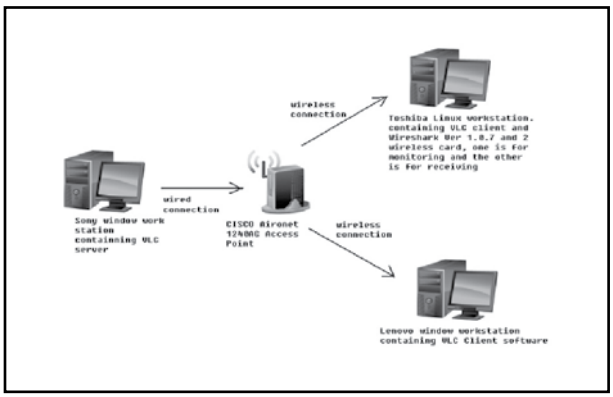
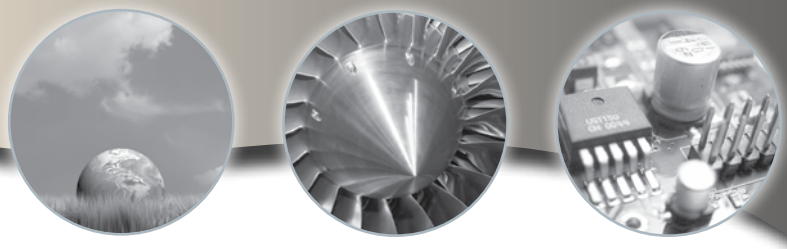


Figure 1: Multicast Network structure

An unexpected challenge was the identification of an AP which handles multicast as expected. Amongst the tested APs, only a CISCO Aironet AP was found to handle multicasting as per standard. Testing the APs involved setting up an 802.11 monitoring station based on a modified Wireshark sniffer running on a Linux station. This setup shows all multicast related information in the packet headers and shows the bit-rate at which each multi-cast packet is transmitted. Lost packets can be identified and the mode of transmission verified.

To measure the PSNR between the transmitted stream and the received stream, a software tool is used which operates on the YUV raw frames. ffmpeg is used to generate the yuv frames from mpeg-ts streams generated and stored by the Videolan servers and clients. The proper ffmpeg commands were studied to avoid stream inconsistencies. The PSNR tool provided by YUV tools was found to calculate the PSNR values between frames of two yuv videos without compensating for lost frames. If any frame is lost, the next one will fill up the position of previous frame causing low PSNR to be reported for the remainder of the sequence. This was remedied to allow accurate PSNR measurements.

The test-bed has been set up successfully and can be used to study multicast streaming in depth and will allow further work on packet loss mitigation techniques, to allow successful multicast streaming of video over 802.11 wireless networks.



IMPLEMENTATION OF A WIRELESS INFRASTRUCTURE FOR THE MANAGEMENT AND CONTROL OF A UTILITY NETWORK

Student: Tonio Zammit **Supervisor: Dr. Ing. Carl James Debono**

Introduction

Internet, networked computers and digital phone connections (voice over IP) significantly increase and enhance productivity and therefore have become mandatory requisites in any modern utility installation. Data as regards production, distribution, storage as well as quality may be collected instantaneously by means of remote sensing, nowadays commonly known as SCADA. In fact, a SCADA system is already implemented at the Water Services Corporation (WSC), though only a fraction of the total sites are connected.

Project Objectives

The project proposed in this dissertation connects the newly commissioned North Wastewater Treatment Plant (NWWTP) to the WSC network through an IEEE 802.11b link that provides ample bandwidth for VOIP, video/CCTV streaming, internet, and telemetry data at a relatively smaller installation cost and also at significantly reduced sustainable costs.

Project Methodologies

The project was carried out as follows:

- A Literature review on the various aspects of WLAN implementation was carried out. The IEEE 802.11 standard was analysed deeply. Other standards such as the IEEE 802.3, IEEE 802.2, H.323, and the Modbus protocol were referenced. An overview of the communication technologies was done in order to select the most appropriate technology for the WSC WLAN.

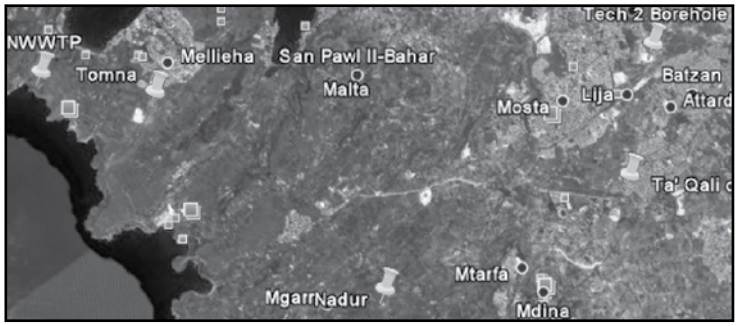


Fig 1: 18km link from NWWTP to WSC Ta' Qali (source Google™ Earth)

- System Design and Implementation which comprised of the following tasks: 1) site selection, 2) analysis of radio-path profiles for the selected paths, 3) site surveys, 4) selecting and ordering of equipment, 5) configuration/coding of the Cisco bridges and other radio equipment.

Results and Achievements

The initial aim of this project, that of providing a reliable high bandwidth connection between the WSC Ta' Qali router and the NWWTP router was successful. The total link cost is less than the phone line alternative at NWWTP, with the added benefit of no monthly or yearly fees. A much greater advantage is the fact that the additional hops, such as the Tomna reservoir, the Nadur reservoir, and the Naxxar Tech2 borehole that were required to implement the whole link, can now be also connected to the WSC LAN. Moreover, the WLAN can now connect nearby WSC sites to these listed hopping sites, namely the Nadur Borehole, the Fiddien Reservoir, the Fiddien Booster, and the Rabat Tank. The ADSL and phone line rents at sites like Nadur Borehole can be terminated, thereby increasing the added value of this project.

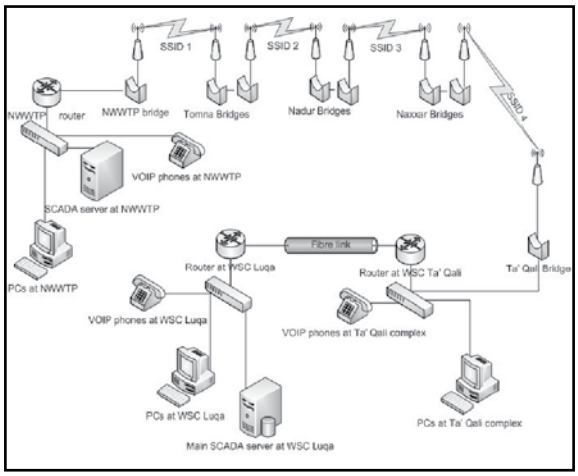
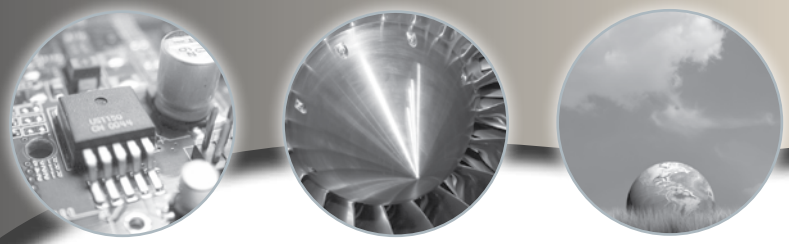


Fig 2: Network map from NWWTP to WSC Luqa



ANALYSIS OF LINEARITY IN CMOS AND BICMOS BUILDING BLOCKS

Student: James Apap Brown **Supervisor: Dr. Ivan grech**

Introduction

In low voltage low power CMOS systems both the high input offset and noise voltages of MOSFETs and also the moderate gain of op amps limit the accuracy of analog circuits[1]. The aim of a device is to provide the highest possible linearity, efficiency and gain over the relevant signal frequencies and amplitudes. Instrumentation amplifiers are seeing ever increasing use in testing equipment where a greaterdegree of accuracy and linearity is required. Instrumentation amplifiers can be broken down into simple building blocks such as differential pairs, OTA's and current mirrors. It is the linearity of these individual building blocks that sets the upper limit for the linearity of the complete device. Analysis of less complex blocks is easier to undertake than that for the entire structures. Hence such structures will be examined individually, in order to obtain the best design in terms of linearity, gain bandwidth product, phase margin, slew rate and a host of other merits.

Project Objectives

The aim of this research is to optimize various CMOS and BiCMOS building blocks in terms of linearity and Total Harmonic Distortion (T.H.D).These optimized building blocks would then be combined into one functional highly linear device. The devices chosen to be implemented was a highly linear class AB op amp since the class AB architecture offers a signal to-noise plus distortion ratio of up to 10 times better than other architectures[2]and an instrumentation amplifier. A bench mark for linearity, T.H.D levels and response characteristics was set and achieved by varying design parameters.

Project Methodologies

In order to obtain a good design for each stage of the Class AB op amp, current mirrors, differential pairs and other analogue building blocks were analysed for linearity in terms of total harmonic distortion (T.H.D.). Transistor sizes, bias currents, supply voltage, frequency and other circuit conditions where varied in steps, noting T.H.D values each time. The building blocks were then combined into a highly linear class AB op amp with distortion levels as low as 0.04% at the complimentary output stage. The class AB was in turn developed into a highly linear Instrumentation amplifier.

Results and Achievements

From the tests carried out, a highly linear op amp was designed with T.H.D values and design parameters summarised in table 1 at the nodes indicated in Figure1

Gain (low frequency)		87 dB	
Gain Margin		5 dB	
Phase Margin		69.8°	
NODE	N_1	N_2	N_3
T H D %	1.61E-06	0.315	0.04268

Table 1. Class AB op amp design parameters

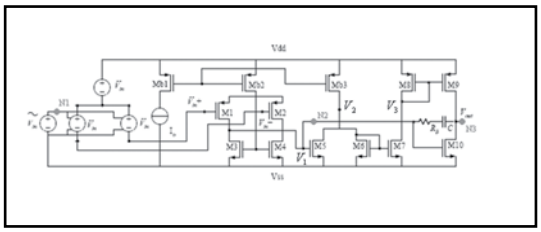
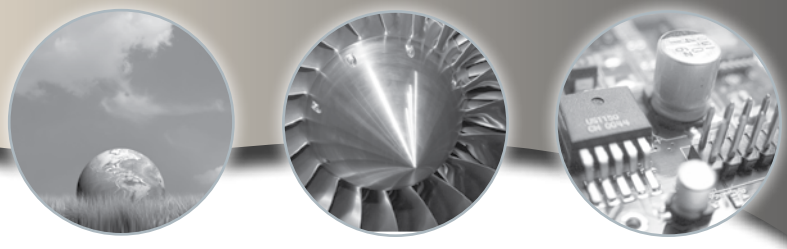


Figure 1: The class AB op amp

Further improvement on T.H.D, phase margin and low frequency gain was achieved by placing source depletion resistors on transistors M3 and M4 in the diagram above. Tests performed to date on the Instrumentation amplifier show a very good design in terms of linearity, distortion levels measured as well as noise performance

References

[1] Falconi, C.; Faccio, M.; Dapos;Amico, A.; Di Natale, C. 'Circuits and Systems'25-28 May 2003 Page 537 vol.3
[2] Simon Bramble, Austriamicrosystems AG. 'Achieving low distortion and noise with Class-AB amps' Pg1



IMPLEMENTATION OF A RADIAL BASIS FUNCTION NEURAL NETWORK AS AN ASIC

Student: David Balzan **Supervisor: Dr. Ing. Edward Gatt**

Introduction

One big aim in research is the creation of systems with artificial intelligence, which could work in a way like the human brain works. The analogy, between the brain and an artificial neural network, is that they both acquire knowledge from their environment through a learning process. Knowledge is then stored by means of inter-neuron connection strengths also known as synaptic weights. The learning procedure, known as learning algorithm, alters the synaptic weights of the network in a methodical way to achieve a desired design objective. Hence, the modification of synaptic weights supports the established method for the design of neural networks. Subsequently, once the system parameters are fixed, the testing phase follows and the system is organised to solve the problem at hand [1].

Project Objectives

The main aim of the project is to build a Gaussian Radial Basis Function Neural Network (GRBFNN) to recognise a database of handwritten digits containing 30,000 examples and label them with their corresponding value. This database with all the necessary files can be found from [2]. The digits available are pre-processed and formatted and ready for the learning techniques and pattern recognition methods to be applied on them. The learning algorithm applied was tested on a trivial XOR problem and a VLSI implementation was also carried out.

Project Methodology

1. Conduct research on the following topics:
   - Artificial Neural Networks and their typical architectures
   - Learning Algorithms focusing on the supervised one.
   - VLSI implementation of a GRBFNN
2. Design MATLAB programs to implement diffrent learning algorithms to solve the same problem. All the learning algorithms tested used a Gaussian function as their non-linear activation function as well as linear weights to complete the network. MATLAB code was written to solve both the XOR problem as well as to recognise the database of handwritten images.
3. The hardware part of the project consisted mainly of two building blocks: the Gaussian function synapse cells and the Gilbert multiplier to perform linear multiplication. Only the XOR problem was implemented as hardware using Cadence.
4. When the software part was tested to work correctly, the parameters of the Gaussian functions and the linear weights used were recorded to implement them in Cadence such that the complete neural network will be VLSI implemented.
5. Comment and compare the behaviour of the Gaussian Radial Basis Function in use to solve pattern classification problems, both software-wise and hardware-wise.

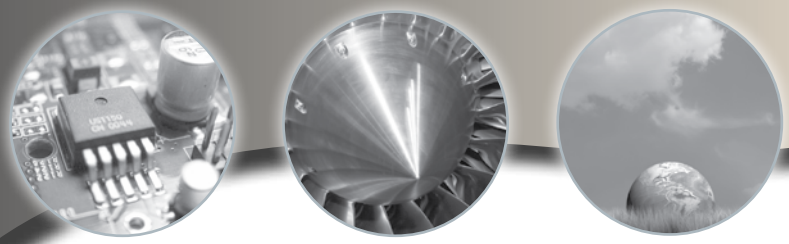
Results and Achievements

The structure of an RBF network is unusual in that the constitution of its hidden units is entirely different from that of its output units. This makes the Gaussian function in the hidden units a powerful and efficient classifier in single-layer artificial neural networks. Both software-wise and hardware-wise, this architecture proved to be a robust solution for pattern recognition, with only a single hidden layer and hidden-to-output linear wieghts to be trained. Furthermore, this makes the implementation of such a system in VLSI an easier task.

References

[1] S. Haykin, Neural Networks – A Comprehensive Foundation, Second Edition. Pearson Education, 2005, pp. 85, 304-306

[2] http://yann.lecun.com/exdb/mnist/



DESIGN OF A LOW VOLTAGE BICMOS UPSTREAM CATV AMPLIFIER

Student: Charlene Caruana **Supervisor: Dr. Ivan Grech**

Introduction

The cable television industry is nowadays one of the main service providers since it allows data transport over upgraded Cable TV (CATV) networks. Hence, today's wideband CATV networks transform into a huge information highway system, among which there are analogue and digital TV channels, telemetric signals, telephone, multimedia services and internet access [1]. An upstream CATV amplifier is needed to amplify an existing good signal so that it can be transmitted over larger distances.

Project Objectives

The primary goal of this project was to design a cable TV (CATV) amplifier by using CMOS/BiCMOS technology and optimising for low power consumption. Keeping this in mind other secondary goals were set, such as, to obtain an overview of commercial and research CATV upstream amplifiers, finding a suitable CATV amplifier design using either one of the Bipolar, CMOS and BiCMOS technologies, and meeting DOCSIS/EuroDOCSIS, DVB Cable Modems, OpenCable and Set-Top Box specifications with the design [2].

Project Methodology

The following steps were carried out during the implementation of the project:

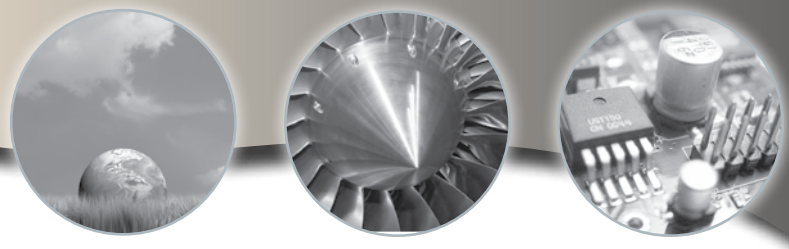
- Literature review and research on:
  1. Commercial Cable TV (CATV) upstream amplifiers
  2. Typical amplifier classes, specifying mainly on classes A, B and AB
  3. Variable Gain Amplifiers (VGAs)
  4. General information on DOCSIS/EuroDOCSIS, DVB Cable Modems, OpenCable and Set-Top Box specifications
- Selection of the most appropriate VGA designs for the application at hand. Implementation of these VGA designs with the Cadence software using different technologies, that is, Bipolar, CMOS and BiCMOS, in cases where this was possible. Carrying out several simulations, such as dc sweep, ac magnitude sweep and ac sweep in decibels (dB), for varying values of control voltage. Optimisation to choose the design giving the best results so as to use it in the final CATV design.
- Design and implementation of the output stage using AMS 0.8 μm BiCMOS technology working with Cadence software. Carrying out several simulations with the parameters of main concern being the distortion and the output amplitude. Testing the output stage with different types of bipolar transistors.
- Optimisation of the VGA and the output stage in order to obtain the best results out of each stage individually.
- Connecting the different stages together so as to form the upstream CATV amplifier. Optimisation of the final circuit design to meet the specifications needed.

Results and Achievements

The VGA chosen to be used in the upstream CATV amplifier design is a two-quadrant Gilbert multiplier as shown in the figure, which gives a linear in dB gain values from -22 dB to 5 dB. The output stage consists of a Class A differential transformer-coupled amplifier with parallel output transistors so as to obtain a reasonably good output amplitude and the minimal distortion. The output amplitude obtained is 1.102 Vpk while the total harmonic distortion value is of 0.1259%. Currently work is centred on the improvement of the VGA and output stage. Testing and analysis of the upstream CATV amplifier system connected together will then follow to conclude the project.

References

[1] http://www.linktionary.com/c/cabledata.html
[2] MAXIM, Upstream CATV Amplifier, MAX3503 Datasheet.



DIGITAL IMPLEMENTATION OF SELF-ORGANISING MAPS

Student: Michelle Cutajar **Supervisor: Dr. Ing. Edward Gatt**

Introduction

Neural networks are becoming more popular in today's technology, as problems are becoming more complex and an increase in speed, mainly for real-time applications, is required. The most important property provided by neural networks is their learning capability.[1] The processing power of today's technology is much faster than the human brain capability. However, for tasks such as pattern recognition, perception and motor control, today's technology is still inferior to that of a human being.[2]

Project Objectives

The aim of the project was to design a digital implementation for the Self-Organising Maps (SOMs). For this project the SOM was applied for handwritten digit recognition. The network's highest recognition rate for both the Euclidean and Manhattan methods, was calculated using three different testing techniques. Afterwards the SOM was implemented on an FPGA, to compare also the speed performance and the area consumed for both implemented methods.

Project Methodologies

This project identifies two methods on how a SOM network can be trained to recognize different styles of handwritten digits. The following steps were carried out during the implementation of the project:

- Literature review on SOMs and current technology with respect to the recognition of handwritten digits.
- Design of two methods for implementing SOMs; the Euclidean method implements the original Kohonen algorithm, while the Manhattan method is hardware oriented.
- Comparison of the recognition rate obtained from both methods, by using three different testing techniques.
- Digital hardware implementation of both methods on an FPGA board.

Results and Achievements

The three testing techniques adopted are the statistics method, the confusion matrix and the recognition of neurons method. These three testing techniques provide approximate recognition rates. Thus the choice of the technique which will be used will depend on what parameter needs to be optimised. The highest recognition rate obtained was 71.2667%. The recognition rate obtained per digit is shown in Table 1 below:

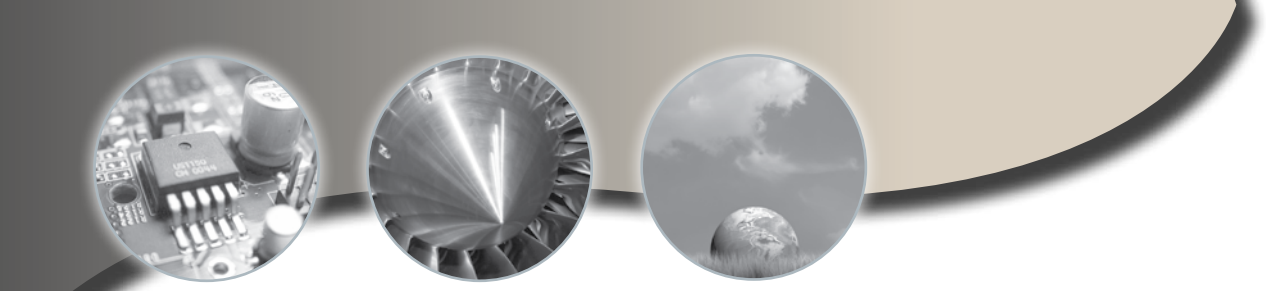
Recognition rate (%)			
Digit		Digit	
0	89.1026	5	67.6923
1	97.3529	6	80.9211
2	77.6978	7	67.6012
3	66.3580	8	60.6498
4	64.6853	9	35.5705

Table 1: Digit's recognition rate

Some examples from the NIST database [3]

References

[1] B.J. Sheu and J. Choi, 'Neural Information Processing and VLSI', Kluwer Academic Publishers, 1995.
[2] Simon Haykin, 'Neural Networks A Comprehensive Foundation', Pearson Prentice Hall, Canada, 1999.
[3] L.B. Batista, H. M. Gomes, and R.F. Herbster, 'Application of Growing Hierarchical Self-Organizing Map in Handwritten Digit Recognition', [Online], Available:http://www.vision.ime.usp.br/~sibgrapi2003/posters/p023.pdf



FPGA IMPLEMENTATION OF TIME-INTERLEAVED SIGMA-DELTA DACS

Student: Christine Gatt **Supervisor: Dr. Ivan Grech**

Introduction

The ongoing evolutionary process of CMOS VLSI technologies has produced ever increasing operating frequencies which shifted signal processing to the digital domain. The Sigma-Delta Modulator gained popularity when developments in digital VLSI technologies provided means to implement the large digital signal processing circuitry [1]. These modulators have now become the most obvious choice for high-resolution data conversion due to their robustness against circuit non-idealities and because of the need for spectral efficiency in systems like ADSL and UMTS [2].

Project Objectives

The aim of the project is to design a time-interleaved Sigma-Delta digital-to-analogue converter and implement the model on a Xilinx SPARTAN-3 XC3S200 FPGA board. The target is to build a second-order Sigma-Delta model with a specified number of time-interleaved modulators. This work can serve as a platform for extending the concept to a model that is capable of interleaving any general number, N, of Sigma-Delta modulators. There are a number of advantages derived from using a time-interleaved Sigma-Delta structure. First and foremost, every single modulator will be working at a sufficiently low frequency whilst the overall structure will handle high-resolution, wide-bandwidth signals. The result is reduced complexity is processing and circuitry as well as increased power consumption efficiency.

Project Methodology

The project was divided into 5 main stages as follows.

1. Literature review consisting of the coverage of the following topics
   - Basic principles of Sigma-Delta Modulators including Oversampling, Noise Shaping, Decimation and Quantisation Noise and Practical Aspects of Sigma-Delta Modulators.
   - Operation of Sigma-Delta Modulators and analysis of transfer functions in the Z-domain.
   - Limitations of Conventional Converters that are based on the Nyquist Rate Criterion.
   - Sigma-Delta Modulators as a solution for high-resolution applications.
   - Comparison between Nyquist Rate Converters and Over-Sampling Sigma-Delta Converters.
   - Time-Interleaved Sigma-Delta DACs.
   - Overview of HDL and Background information regarding FPGA boards.
2. Design and Simulation of the Converters using ModelSim PE Student Edition 6.4b
   - Design and Simulation of First Order Model.
   - Design and Simulation of Second Order Model.
   - Time-Interleaving of multiple DACs for both models.
3. Transfer the VHDL code from ModelSim to Xilinx ISE 10.1.
4. Implement the models on a Xilinx SPARTAN-3 XC3S200 FPGA board.
5. Finalize the project by implementing the entire model.

Results and Achievements

The first and second models were successfully designed, time-interleaved and simulated using ModelSim. The model consisting of four time-interleaved, second-order Sigma-Delta Modulators was then implemented on the FPGA board. The time-interleaved models can reach significantly high-operating frequencies without stressing the individual components.

References

[1] http://www.numerix-dsp.com/appsnotes/APR8-sigma-delta.pdf
[2] http://www.intersil.com/data/an/an9504.pdf