University of Malta

Faculty of Engineering

Engineering

Projects Exhibition

1 & 2 July 2010

Engineering Excellence

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Final Year Engineering Projects Exhibition 2010

Faculty of Engineering
University of Malta

Final Year Engineering Degree Projects Exhibition

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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 the academic year 2009-2010.

Each student briefly describes his or her project giving an overview of objectives and achievements. The range of subjects tackled in their work is very vast, spanning many aspects of mechanical and electrical engineering.

These projects are a very important element of the educational experience given to our students. The work, which spreads over the whole of the final-year, culminates in a document of around 100 pages, the dissertation or thesis, and requires the students to use all the skills that they have acquired during their previous years of study. Skills necessary for the successful completion of this work are: research in technical topics, design and setting up of experiments, testing with adequate scientific methods, analysis and interpretation of data to reach important engineering conclusions. All this is then reported into their dissertation, structured in a sound and logical manner, according to rules and standards widely recognised academically.

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 Ghirlando
Dean of the Faculty of Engineering

Faculty Facilities

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

Airborne vehicles
- Several airborne vehicles for autonomous flying and airborne electronic systems

Biomedical and rehabilitation engineering facilities
- Body Pressure Measurement Systems
- Electroencephalography (EEG) Acquisition Device
- Haptic Feedback Device
- Optical Motion Analysis Systems
- Robotic Manipulators

Control systems
- Analogue and Digital Control System Development Tools
- Computer Control Interface Boards
- Control Systems Design Software
- Pneumatic/Hydraulic Control Rigs
- Programmable Logic Control (PLC) Systems
- Robot Assembly Kits

Electronic circuit development
- Electronics bench equipment for electronic system design and analysis
- FPGA Development Environments
- Microcontroller Programming Environments
- PCB Design, Manufacturing and Testing

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

Flight simulation and rapid prototyping
- Display and Instrument Rapid Prototyping Software
- Multi-processor Desk-Top Flight Simulation Facilities

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

Industrial automation
- Automation Training and Prototyping Facilities for Pneumatic and Hydraulic Systems
- Cognex 535C Industrial Machine Vision System
- DVT SmartImage Sensor and Accessories
- Interfacing Hardware
- Mitsubishi RV-6SL Industrial Robot

- PLCs
- PUMA 260 Industrial Robot
- Various Actuators and Sensors

Instrumentation and calibration
- Calibration of Metrology Equipment in Roundness, Linear and Angular Measurements
- Electronic Calibration Systems
- High precision electronics measurement equipment
- Metrological Equipment Including CMMs and Surface Texture Measurement

Manufacturing facilities
- 3D Scanning
- CNC Vertical Machining Centre
- CNC Vertical Milling Machine
- Conventional Machine Tools
- Non-conventional Machine Tools, including Electric Discharge Machining, Water Jet Cutting, Ultrasonic Machining, and Abrasive Flow Machining

Mechanical testing and design
- Fatigue Testing Equipment
- Finite Element Methods Software ANSYS
- Impact Testing Equipment
- Sound Level Measurement Equipment
- Sub-sonic Wind Tunnel
- Tensile Testing Equipment
- Vibration Analysis and Testing Equipment
- Water Wave Generator

Metallurgy and materials engineering
- 9kW CO2 Laser with 4-axis CNC system and powder delivery systems
- Automatic Degreaser for component cleaning
- CNC Machine Tool Centre for die manufacturing
- Creep Testing Equipment
- Electric furnaces
- Fatigue Testing Equipment
- Gas fired furnace for Aluminium Castings
- High Magnification Optical Microscope
- High Pressure Quench Vacuum Furnace
- Ion Beam Assisted Deposition Equipment
- Macro and Micro Hardness
- Laser Confocal Microscope
- Nano Tester

Microscopes and specimen preparation equipment
- Physical Vapour Deposition (PVD) Plant for deposition of hard ceramic coatings
- Pin on Disc Wear Testing Equipment, Coating Adhesion Tester
- Plasma Nitriding and Gas Nitriding Furnace
- Potentiostat
- Rotary bending fatigue testing machines
- Salt Bath Equipment for treatments such as Martempering
- Salt Spray cabinet for Corrosion Testing
- Salt spray testing Facilities
- Sand Blasting Machine
- Scanning Tunnelling Microscope
- Stereo Microscope
- Tensile and Compression Testing Equipment
- Various Tribometers
- X-ray Diffraction

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

Product design and development
3D Scanner
3D Studio, AutoCAD, ProEngineer, Inventor
CAD Systems (2D, 3D, Animation)
CAD/CAM Systems
Concurrent Engineering Research Facilities
Thermoplastic Design Guidelines

Signal processing
Generic DSP Hardware
Signal and Image Processing Software

Areas of Research

Electronic systems engineering
Electronic system design; aviation safety; avionics systems; air traffic management, trajectory optimisation, flight control and guidance, traffic collision avoidance; surveillance, cockpit display and instrumentation design, flight simulation and modelling.

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.

Mechanical engineering
Aerodynamics; biomechanics; energy; fibre reinforced composites; finite element analysis applications; internal combustion engines; naval architecture; oil and gas industry applications; pressure vessels; refrigeration; solar cooling; sound and vibration; structural integrity; thermodynamics/fluids; welding residual stresses and distortion; wind turbines;

Metallurgy and materials
Metallurgy and materials ion-beam assisted deposition; laser surface engineering, material deposition and rapid fabrication; plasma assisted physical vapour deposition; plasma anodizing of light metals; thermo-chemical processing of medical grade stainless steel; novel dental materials; thermal treatments of shape memory alloys; solar desalination; surface coating for conservation of metallic artefacts; development of nano coatings for high efficiency solar energy absorption; degradation of composite materials; tribology and corrosion

Systems and control engineering
Computational intelligence; signal and image processing; biomedical signal processing; neural networks; machine and computer vision; automatic control systems; adaptive and intelligent control; robot control systems; spatio-temporal system modelling; bayesian estimation.

Externally Funded Projects

Design and Analysis of an Innovative Offshore Wind Turbine Support Structure for Deep Water Applications in the Maltese Islands
Department of Mechanical Engineering
Funding Source: MCST R&I 2009 Programme

Investigation of the Sealing Properties of Swellable Elastomers for Oil and Gas Industry Applications
Department of Mechanical Engineering
Funding Source: industrial partner Tendeka (Aberdeen, U.K.)

Innovative Fibre Reinforced Composites for Higher Structural Perfomance – Numerical and experimental analysis to optimize and develop new fibre reinforced composites able to withstand higher structural strength
Department of Mechanical Engineering and Department of Metallurgy and Materials
Funding Source: MCST R&I 2009 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

Collaborating organisations

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:

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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, and The Institution of Engineering Designers

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Mechanical Engineering Stream

Open Water Propeller Characteristics Testing

Student: Kimberly Attard
Supervisor: Dr. Claire De Marco

Introduction

In order to obtain movement of a ship in the sea, some form of reaction force has to be present between the ship and the fluid. This reaction is normally either due to air or due to water. Propellers are considered as the main type of propulsor used in ships. The thrust present due to the propeller, the torque which is developed in the shaft and the rotational speed of the propeller shaft and the propeller need to be known such that the open water propeller characteristics can be obtained. These are coefficients which are then used to determine the efficiency of the propulsor.

Project Objectives

The objectives of the project are:

- To investigate model propellers following the standards set out by the International Towing Tank Conference (ITTC);
- To obtain an 'open water' testing area using available resources;
- To investigate modifications or upgrades on the existing resources.

Project Methodologies

The project was aimed to test model propellers in open water and extract data such that the open water propeller characteristics, namely the thrust coefficient, K_T, the torque coefficient, K_Q, and the open water efficiency, η_o could be obtained. The steps carried out are outlined below:

- A literature review of the recommended procedures regarding open water tests set out by the ITTC, together with the study of related theory was executed;
- The design and construction of the equipment required - namely a test housing and a load cell - to obtain the necessary data to compute the thrust coefficient, K_T, the torque coefficient, K_Q, and the open water efficiency, η_o of model propellers was completed;
- The scaling from a full-scale propeller to model propellers using a scaling factor, λ, was carried out to obtain design parameters, such as speed of advance, rotational speed, thrust and torque for the models;
- Tests for different model propellers were performed by varying the water velocity in a circulating water channel and repeating the tests for different rotational speeds;
- Analysis of the results and suggestions for modifications of the available setup to improve the results were also outlined.

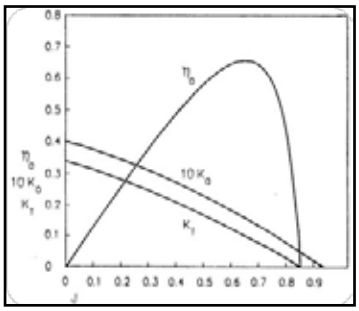


Fig. 1 – K_T-K_Q diagram [1]

Results and Achievements

The test results obtained were compared to expected values to find a discrepancy between the two. Investigation of the causes of such discrepancies led to suggestions for improvement of the setup. Some of the advances identified are the following:

- Larger circulating water channel to decrease the blockage factor due to the test housing, to also decrease the effect of the boundary layer and to allow a larger scaling factor, λ, to be used. This could also help to minimise ventilation, which is the sucking down of air from the water surface;
- Smaller components (motor, gearbox, load cell) such that the test housing dimensions could be reduced, thus contributing to the reduction of the blockage factor;
- Design and construction of a towing carriage which could be used in the wave-making tank available at the Fluids Lab to tow the housing with accurate constant speed rather than moving the water against it.

References

[1] J. P. Ghose, R. P. Gokarn, "4. The Propeller in Open Water," in Basic Ship Propulsion, 2nd ed., Allied Publishers, 2004, pp. 74

Ship Modelling Analysis

Student: Gianella Azzopardi
Supervisor: Dr. Claire De Marco

Introduction

Today ships carry 95 per cent of world trade [1] – evidently they play a very important part in today's economy. Besides being used in the trading world, ships are also growing increasingly popular in the tourism industry through cruises and ferry rides. As our society has become heavily dependent on computers, ship analysis is now faster and more flexible. Ship analysis is extremely important in evaluating its characteristics and so ensures the client is making use of a reliable ship that is designed for purpose. The client's needs and desires have increased as the technology has improved. Although computers have made things easier, they have provided several different possibilities with regard to ship analysis, making the engineer's job more intense and demanding.

Project Objectives

The objectives of this project are to generate a displacement sheet from which the areas, volumes, longitudinal and vertical centres of buoyancy and longitudinal centre of flotation are calculated. Plotting of the curve of areas, bonjean curves, metacentric diagram and multi-axis hydrostatic plots is also required as well as 3D plots of the curve of areas and bonjean curves.

Project Methodologies

This project generates hydrostatic results in both tabular and graphical form, from a set of lines plans. The following steps were carried out in the implementation of this project:

- Comparison of three types of freeware software able to carry out hydrostatic calculations
- Formation of a software-type displacement sheet through a Microsoft Office Excel 2007 workbook consisting of seven tabbed sheets

Digitizing of lines plan using DELFTship in order to obtain table of offsets

- Input of offsets into Microsoft Office Excel 2007 worksheet
- Transferring of necessary data into OriginPro 8.1 in order to create 3D plots
- Comparison of generated results to those generated through existing freeware software such as DELFTship

Results and Achievements

Some of the values achieved through the Excel software are comparable to the DELFTship results. However, when one considers the fact that approximation tools were used in achieving these results, then it is safe to assume that the Microsoft Office Excel software gave rather precise results. This project fulfilled all the objectives, in that a basic software able to calculate and plot hydrostatic characteristics was produced.

References

[1] E. C. Tupper, "Introduction" in: Introduction to Naval Architecture, Fourth Edition. Oxford, Butterworth-Heinemann, 2008, pp. 1.

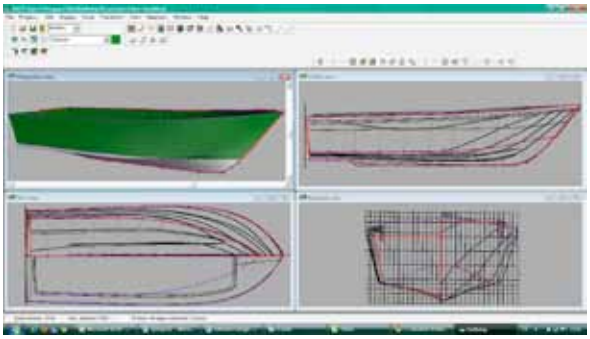


Figure 1: Digitized Lines Plan

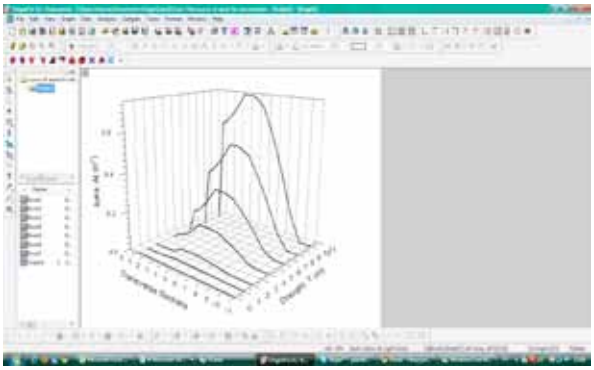


Figure 2: 3D Curve of Areas

An investigation of the aerodynamics of wind turbines in shear flow

Student: Daniel Baldacchino
Supervisor: Dr. Ing. Tonio Sant

Introduction

Wind turbines operate in the open air environment where they are subjected to complex flow phenomena such as wind shear, turbulence and gusting. The ever increasing size of these multi-megawatt machines has made them more susceptible to effects of vertical wind shear and it is therefore desirable to study their aerodynamic behaviour in such flow regimes. A wind turbine rotor operating in wind shear experiences a cyclic variation in induced loading due to the non-uniform flow field incident on it. This gives rise to fatigue loading and the latter is a major design issue in wind turbine development. The structure of the near wake is also of interest and whilst countless experiments have been conducted on model turbines in axial and yawed flow, published results in shear flow are lacking to date. Wind tunnel testing offers all the advantages of controlled conditions and low costs compared with field testing, however means must be sought with which to simulate atmospheric conditions.

Project Objectives

As a means of creating desirable conditions and for the testing of the model wind turbines, the following objectives were identified at the outset:

- The generation of shear flow inside the wind tunnel test sections – the square section wind tunnel would serve as the test bed for proving the concept and pave the way for further testing in the newly constructed circular section wind tunnel.
- Investigation of the main parameters affecting the generated velocity profile and identification of a suitable configuration to create a usable velocity profile for further testing.
- Testing of model wind turbines in axial conditions, as well as in shear flow.

To compare results with predictions from Blade Element Momentum (BEM) theory.

Project Methodologies

A thorough review of literature was necessary in order to identify a method suitable for creating shear flow. The wire grid overlay method, pioneered by McCarthy [1] was selected due to the possibility of creating reasonable velocity gradients in a relatively short distance. A test rig was constructed to investigate different screen settings and eventually a model wind turbine was positioned in the test section as shown in fig. 1. The characteristic power curve was obtained and the the pressure distribution around the model established for axial and shear flow. Subsequently, another composite screen was designed and constructed for the new wind tunnel facility, based on the same concept of wire grid overlay. A two bladed model wind turbine fitted with a small $48V$ $48V$, $150W$ $150W$ d.c. generator was tested in uniform (shown in fig. 2) and shear flow conditions. The power characteristic was obtained using a variable resistor to control the generator loading, and inflow measurements were again made using a Pitot-Static tube.

Results and Achievements

The combination of screens produced shear flow to a varying degree of quality, dependent mainly on the distribution of resistance offered to the flow. The more gradual the variation the better since this meant less local disruptions in the flow. Across the height of the model wind $\frac{3m}{s}$ $\frac{3m}{s}$, the velocity deficit created amounted to about for both wind tunnel test rigs. In the new wind tunnel facility, the equipment produced a wind front which closely matched a theoretical power law velocity profile with a wind shear exponent of 0.3 0.3 and was well in agreement with theoretical predictions. The lateral uniformity of the produced velocity profiles was also desirable and lateral variations along the cross section amounted to between $4\% - 7\%$ $4\% - 7\%$ for all screen settings. Upon testing the model wind turbines, it was evident that the distribution of induction around the rotors was a strong function of the azimuth angle and the angle of attack was estimated at the tip. The periodic nature of the variation was evident and should be a cosine function for vertical wind speed shear [2]. In both experiments, the effects of blockage were evident from the pressure measurements as well as from the power curve characteristic, more notably in the square section wind tunnel which has a smaller cross-sectional area. The extent to which blockage plays apart and thus, affects results is yet to be verified with the help of the BEM model.

References

[1] J. H. McCarthy, "Steady flow past non-uniform wire grids", Journal of Fluid Mechanics, vol. 19, pp. 491-512, 1964.
[2] J. F. Manwell, J. G. McGowan and A. L. Rogers, Wind Energy Explained, UK: John Wiley & Sons, 2002.

The performance analysis of a spark ignition engine

Student: David Bartolo
Supervisor: Dr. Ing. Mario Farrugia

Introduction
This thesis was about evaluating factors that influences the performance of the Spark Ignition (petrol) engine in both the natural aspirated set up and also the turbocharged set up.

Objectives
The aim was to go behind the theory of factors that influences the performance of the engine such as the combustion chamber, inlet and exhaust manifold design, the fuel delivery system. Also the evaluation of the effects of the introduction of turbocharger setup on the engine such as higher inlet pressure, higher air inlet temperature and the higher IMEP. A conversion of the fuel delivery system on a Ford 1.4ltr CVH engine from a carburetor system to a fuel injection system was carried out. A simulation was performed to evaluate the effects of several parameters on the engine such as the runner length, valve timing and the introduction of a turbocharger.

Methodology
- Research on the theory of various factors that influence the performance of the engine was carried out.
- A simulation model of the Ford natural aspirated engine was created and performance analysis was performed.
- Another simulation model was created, to simulate the Ford engine with a turbocharger and the evaluation of the reduction of the compression ratio, the change in valve timing and the comparison of the IMEP with the natural aspirated model was carried out.
- Experimental tests to evaluate performance characteristic of the carburetor system of the Ford engine were performed.
- The conversion to a fuel injection was carried out and the comparison of the two delivery system was analyzed.

Results
The results from the simulation showed that the compression ratio had to be reduced from 9.5 to 7 to reduce the affects of knocking due to the extra pressure and temperature of the air inlet. From the optimization of the inlet and the exhaust valves timing, a 7BHP gain was recorded for the natural aspirated and 10BHP gain for the turbocharged system running at 1.3bar.

From the comparison of the two fuel delivery systems, both the carburetor and the fuel injection systems gave similar performance characteristics but the fuel injection system has more controllability with respect to the carburetor system.

Performance Testing for a Grid-Connected Micro-Wind Turbine in the Urban Environment

Student: Jonathan Borg
Supervisor: Dr.Ing.Tonio Sant,
Co-Supervisor: Ing. Robert Farrugia

Introduction
The efficiency of wind turbines is largely dependent upon the aerodynamic properties of the turbine's blades. As the blades rotate, they experience two aerodynamic phenomena; stall delay and dynamic stall, which tend to improve the wind turbine's aerodynamic characteristics. Several theoretical models for both stall delay and dynamic stall have been developed; however, research has shown that these phenomena are still far from being completely understood.

Project Objectives
The aim of this project was to modify a BEM based program to include the effects of stall delay and dynamic stall and compare the results to data gathered from a micro wind turbine in the urban environment. The performance of these models in such an environment could therefore be analysed.

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

- An extensive literature review on stall delay and dynamic stall together with their respective theoretical models was carried out. This was followed by the implementation of four stall delay models and one dynamic stall model in a BEM based program. Through such a program, the performance curves of the wind turbine with and without the corrections for stall delay and dynamic stall could be extracted.
- Although the purpose of the tail vane is to align the wind turbine to the wind, due to the inertia of the wind turbine, some misalignment is inevitable. A yaw error sensor was therefore designed to determine the amount of misalignment.
- Following the maintenance work carried out on the wind turbine, it was installed on the roof of the Faculty of Engineering together with the required wind direction and wind speed sensors.
- A new data acquisition system was then set up which enabled the collection of the required data.
- Through the gathered data, the wind turbine's performance could be analysed and compared to the theoretical models.

Results and Achievements
The results of the different stall delay and dynamic stall models indicate an increase in the stall angle together with and increase in the performance characteristics of the wind turbine as predicted. Initial results gathered from the wind turbine do however indicate that the theoretical models give a significant over prediction of the efficiency of the wind turbine. Since the wind turbine is not being operated in a wind tunnel, and is therefore experiencing uncontrolled conditions, a considerable amount of data needs to be gathered and analysed before conclusive results can be established. Data was still being collected at the time of writing.

The Micro Wind Turbine installed on the roof of the Faculty of Engineering

Measurement and Analysis of the Dynamic Behaviour of a Model Floating Offshore Wind Turbine

Student: Joshua Borg
Supervisor: Dr. Ing. Tonio Sant

Introduction
The aim of floating wind turbines is to be able to set up wind farms in deep waters (above 60 metres). The technology of these floating systems is still in prototype stage and thus laboratory testing helps us in understanding their behaviour when subjected to a combination of forces, such as aerodynamic and hydrodynamic forces. Therefore through model testing, current designs can be tested and improved.

Project Objectives
The objective was to design and construct a model floating wind turbine based on the concept of a Tension Leg Platform (TLP) and install it in the wave tank together with the wind tunnel. Thus the behaviour of the system under different wind and wave conditions could be tested, enabling the study of certain aerodynamic effects, such as aerodynamic damping.

Project Methodologies
The aim of the project was to study the behaviour and characteristics of floating wind turbines. The following steps were carried out during the implementation of the project:

- Literature review in the field of offshore wind energy, wind turbine design and concepts for supporting wind turbines in deep waters.
- Design of a model floating wind turbine.
- Construction and installation of the model in the laboratory wave tank with the required instrumentation.
- Conduct experiments on the model, both when operated in propeller and turbine state.
- Measurement and analysis of results.

In order to study the dynamic behavior of the model floating wind turbine certain measurements had to be made, these include: mooring line forces, bending moment experienced by the tower and hull displacement.

Results and achievements
Aerodynamic damping is a phenomenon whereby the motion of the floating wind turbine is damped through the action of the aerodynamics of the rotor. This phenomenon is beneficial because smaller displacements mean less fatigue loads on the components of the wind turbine, leading to a longer lifetime. Some amount of aerodynamic damping was observed, however due to slow motion of the structure the effect was minimal when compared to the hydrodynamic forces exerted by the waves on the hull. From the conducted experiments it resulted that even the mooring system plays an important role since uneven force distribution in the mooring lines leads to swaying and yawing of the floating wind turbine.

Figure 1 - Assembly for testing in propeller state

Figure 2 - Assembly for testing in turbine state

Miniature A/C System

Student: Carl Camilleri
Supervisor: Dr. Ing. Christopher Micallef

Introduction
As the projected heat generation for high performance chips continues to increase conventional air cooling techniques such as radiation, natural convection, and forced air cooling will no longer be able to meet the required heat dissipation needs. The efficiency and reliability of the compressor are the main challenges that need to be addressed in electronics cooling applications. The Aspen Compressor (Model 14-24-000X) is a hermetically sealed miniature rotary compressor operating with a rolling piston mechanism. This compressor was used in the vapour compression test rig set up.

Project Objectives
The main aim of this dissertation was to integrate a hermetically sealed miniature rotary compressor in a vapour-compression refrigeration system and investigate the performance of this miniature rotary compressor. Therefore the objectives were:

- Design and construct a vapour-compression refrigeration system
- Determine the cooling effect and COP of the system for different pressure ratios
- Analyse factors influencing the mass flow rate
- Analyse the effect of capillary tube length on the mass flow rate and system performance

Project Methodologies
A design point for the test rig was found by superimposing the mass flow rate versus pressure ratio curves of the compressor and thermostatic expansion valve. This design point was used to calculate the length of coils required in the evaporator and the condensor. As an orifice was not available, a TEV was used as an expansion valve with the bulb left open to atmosphere instead. The TEV was later substituted with a capillary tube, as the former was still behaving like a variable opening expansion valve. The amount of refrigerant required in the system was determined by a calculating the volume of the various components where the refrigerant is in liquid state. Testing was done with both the TEV and the capillary tube as expansion devices.

Results and Achievements
Tests were carried out for different discharge pressures, compressor speeds, and evaporator temperatures. To analyse the effect of capillary tube length on system performance, three different lengths of capillary tubes were used. It was noted that while the cooling effect increased as the compressor speed was increased, the coefficient of performance (COP) decreased as the speed increased. For a compressor speed of 4500rpm, the cooling capacity was maximum for a capillary tube length of 36cm, and a drop in this parameter was noted as the length of the capillary tube was increased.

Figure 1 Constructed Test Rig

An Investigation of Noise Control Parameters and Measurement Techniques

Student: Noella Cassar
Supervisor: Dr. Ing. Duncan Camilleri

Introduction

The study of Environmental Acoustics, most often, relates to particular sounds termed 'noise'. 'Noise' is often unexpected, disturbing and unpleasant, causing a variety of reactions within the individuals perceiving it. Noise can be irritating and annoying as much as any other form of pollution, and may also be regarded as a danger to human health, especially since it is increasing with economic development. It has always been an issue, even though quite often, both in the past and present, neglected, or regarded as superfluous, by authorities. Noise Control is the term used when referring to the management of noise levels in any environment. It is imperative to consider when investigating human health hazards related to noise exposure. This refers to both occupational and community noise exposure. Noise control within a building is mostly dependent upon the building materials used for partitions, walls and building openings, due to the consequent method of sound transmission through them. Figure 1 shows the way sound behaves when incident upon a surface.

Project Objectives

The project was directly related to the local scenario. Noise Control within buildings is mostly related to the type of building material chosen for partitions or walls. There exist various parameters with which one would be able to measure the actual sound efficiency of a building material, as regards, both Noise Reduction, and Transmission Loss. This Noise Control parameter investigation was performed through Analytical Investigation, Experimentation and a Finite Element Simulation.

Project Methodologies

The project recognises different techniques used to determine the sound efficiency of a local brick wall, and also the use of different parameters. The following methodology was used in analysing the effects of different properties of a wall/ partition, and the effect these properties have on the sound efficiency of the same wall/partition:

- Literature review of the current methods used in analysing sound efficiency of a building element, and the various parameters that may be considered.
- Preliminary testing performed to verify the theory that was used. This included predicting Noise Reduction (NR) values between two rooms of an apartment by means of a mathematical model and also using properties of the wall and rooms. Following this, NR values were determined by experimentation, and later compared to the predicted values, to confirm validity of theory.
- Later on, further testing was performed at the University of Malta premises, using more advanced equipment. The same methodology as before was used, i.e. predicting NR values using theory and properties of the wall, then performing experiments according to ISO 140-3 methodology, for comparison.
- A finite element simulation, using ANSYS®, was modelled to further analyse the difference in sound pressure level (SPL), between adjacent rooms, for different frequencies ranges.

Results and Achievements

This final year project investigated the properties of a local building wall in relation to noise control. This was performed using various parameters and methodologies, and through these investigations, the actual sound insulating efficiency of a building material was determined, resulting in Sound Reduction Index values for the wall, across a frequency range. It is possible to associate these values with other local building walls, provided, the same properties and characteristics apply. The results showed that the mathematical model predicted the Noise Reduction of a partition with reasonable accuracy. However, a difference between actual values and those predicted, diverging with increase of frequency was noted in all sets of results. Further studies are recommended to investigate this divergence.

Comparative Analysis of the Stress-Strain Distribution for the Healthy and Pathological Spinal Segment

Student: Marija Cauchi
Supervisor: Dr. Ing. Zdenka Sant

Introduction

Various epidemiological studies have demonstrated that disability arising from chronic back pain has now become a major health and socio-economic problem worldwide. Patients with recurrent low back pain episodes often have to undergo surgical treatment. The design of medical implants prompts the need for the prior development of reliable computer models to investigate the biomechanical deficiencies imposed by pathological spinal segments. The generation of finite element computational models can be a promising tool as it can lead to a generic comparative analysis of the transfer of load and the stress-strain distribution for healthy and pathological conditions. The ultimate aim is to exploit an engineering approach in order to alleviate the clinical problem of spinal diseases as well as to enhance and prolong the life of patients.

Project Objectives

The main purpose of this study was to obtain a more realistic three-dimensional model of the L3-L4 spinal segment as well as to investigate the effect of the geometry and the material properties differentiation caused by different pathological conditions on the transfer of load and the stress-strain distributions. This was achieved through the use of commercial software packages: Rhinoceros (Rhinoceros®, USA) for NURBS (non-uniform rational basis spline) modelling and ANSYS (ANSYS, Inc. USA) for FEA (finite element analysis). With the use of such packages, in vivo spiral computed tomography (CT) of the entire vertebrae and FEA could be combined in order to generate patient-specific, three-dimensional finite element models.

Project Methodologies

Initially, it was essential to gather adequate knowledge on the geometrical features of a functional spinal unit as well as on the biomechanical role played by each anatomical structure within the system. A sequence of CT-scans of the lumbar spine of a healthy young male subject was used in Rhinoceros to generate a stack of splines. These, together with additional splines, were then used to create smooth non-planar surfaces that defined the geometry of the L3 and L4 vertebrae. Since CT-images are not suitable for reconstruction of soft tissues, the intervertebral disc and the articular cartilage were not modelled from the scans but as separate entities interposed between the bony surfaces. A simplified model of an osteoporotic L4 vertebra was also created by modelling two cavities within the healthy L4 vertebra. These models were then imported into ANSYS where the separate volumes were assembled to obtain the L3-L4 spinal segment (Figure 1) as well as the osteoporotic L4 vertebra (Figure 2).

A mesh convergence study and appropriate selection of the element type were performed during the finite element discretization process. All assigned material properties were assumed to be linear elastic and isotropic. The properties of the L3-L4 intervertebral disc were varied in order to study the effects of a degenerated disc on the load transfer and stress-strain distribution. Furthermore, to fully investigate the effect of osteoporosis, apart from altering the geometry by including cavities within the vertebra, the material properties were also altered to compare the biomechanical behaviour of healthy and osteoporotic vertebrae. Suitable boundary and loading conditions were applied to the models which were analyzed and compared under standing conditions with/without a carrying load.

Results and Achievements

The results obtained prove that both a difference in intervertebral disc properties due to disc degeneration as well as a difference in the geometry and material properties of a vertebra due to the effect of osteoporosis have an influence on the transfer of load and stress-strain distribution. Such results helped in the proper understanding of the biomechanical deficiencies imposed by pathological conditions that eventually lead to impaired mechanical function of the spinal segment.

Analysis of Stress-Strain distribution within the Sternum (Foam Model)

Student: Jeffrey Cilia
Supervisor: Dr. Ing. Zdenka Sant

Introduction

Open heart surgeries need the sternum to be bisected vertically, thus the need for good effective closure techniques. Testing of such techniques is done on sternum foam models. Successful tested techniques on foam models are assumed to perform the same on the patient. Thus there is the need of a quantitative comparison between the behaviour of the foam and bone sternum model.

Project Objectives

The aim of this dissertation is to obtain a computer based solid model. Three models will be obtained; one with foam properties; one with bone properties having a 1mm cortical shell and one with bone properties having a 2mm cortical shell. Investigation of the behaviour of such models under physiological loads will be done using Finite Element Software.

Project Methodologies

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

- Theory and literature were compiled to help understand the sternum physiological anatomy and biomechanics. In addition, some research on the use of solid rigid polyurethane foam models was done.
- Sternal physiological loads were identified from a simplification of the thorax.
- Bone and Foam material properties were identified.
- The sternum foam model was 3D scanned and imported into Rhinoceros 3D
- Subsequently, surfaces were created and exported into ANSYS in preparation for Finite Element Analysis.
- All the necessary material properties, element types, boundary conditions and forces were defined. Solid models were meshed, constrained, loaded. Solution and post processing were consequent.

Results and Achievements

Computations were done and stress-strain distributions within the models were obtained. Maximum deformations were noted and indications are, that the deformation in the foam model is approximately three times as much that in the bone model. However such results are not yet conclusive, as more analysis has to be done.

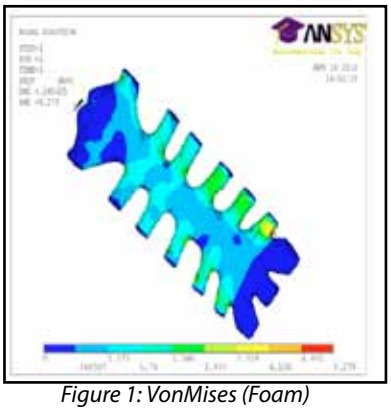
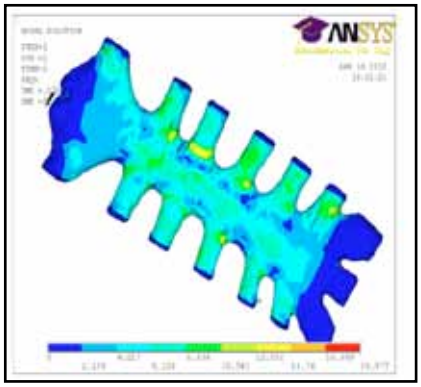


Figure 1: VonMises (Foam)

Figure 2: VonMises (Bone)



Conceptual Design of an Offshore Wind Turbine Installation Vessel

Student: Alan Coppini
Supervisor: Dr. Claire De Marco

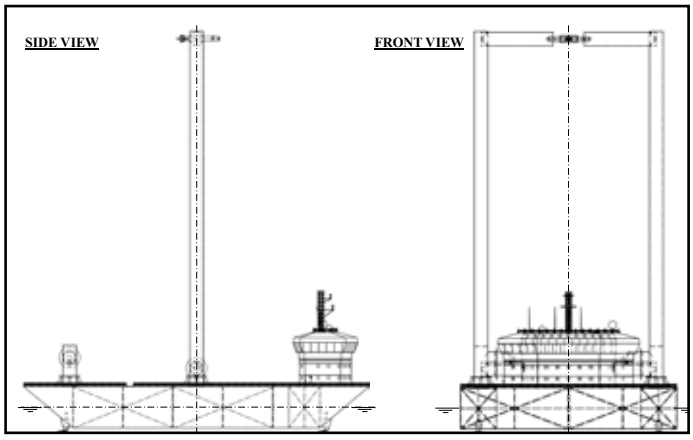
Introduction
The current demand for clean energy generation coupled with the long waiting lists and high rental costs of many vessels (estimated at €250,000 per day [HYPERLINK \l "Her02" 1]), have translated into a notable need for new and innovative offshore wind turbine installation vessels.

Project Objectives
To carry out a conceptual design of a turbine installation vessel capable of transporting and installing wind turbines; either fully assembled or in parts, in water depths of around 50 m. The total assembly weight is 1190.1 tonnes including a 60 metre tall jacket substructure weighing 350 tonnes, a transition piece weighing 160 tonnes and total turbine assembly of 680.1 tonnes. The turbine assembly consists of a 90 m long tower, a nacelle, rotor and 3 blades measuring 61.5 m from tip to tip.

Project Methodologies
In the early stages of the project, all the ideas that came to mind were put down on paper and compared. This was done in sync with the literature review which helped to generate innovative designs. Once the final concept was chosen, a number of sketches were drawn to ensure that the concept would work, and all the necessary calculations were carried out. Calculations included, determining the stability of the vessel, the trim and sinkage of the vessel due to the loads, the ballasting requirements, the resistance of the hull, the best suited propulsion system and the size of engine required to power the vessel. The development of the design was an iterative process and involved varying a number of interrelated parameters while keeping the project objectives in mind. A 3D parametric CAD design software was used to design the vessel which allowed certain parameters to be modified without making major modifications to the design.

Results and Achievements
The final design was made up of a U-shaped barge capable of handling the substructure and turbine separately. The vessel has an overall length of 67 m, moulded breadth of 42 m and depth of 8 m. The vessel does not require any winches or cranes to carry out the installation relying solely on systematic ballasting. The vessel has a design draught of 4 m and a maximum allowable draught during installation of 7.5 m. It is propelled and dynamically positioned by four L-drive azimuth thrusters powered by AC motors. The vessel has a total ballast volume of 6272 m^3 divided into 6 separate tanks which will be filled by operating mechanical valves and emptied using 6 independent pumps. All the electricity demands will be met by the 3 generator sets with a total power output of almost 1.5 MW.

References
S.A. Herman and H.J.T. Kooijman, "Installation Alternatives - Installation of a Wind Turbine in One Step," Netherlands Energy Research Foundation, Dutch Offshore Wind Energy Converter project (DOWEC), Petten, Report 2002.



Procedure for the Manufacture of Ship Models for use in a Test Tank

Student: Tiziana Maria Grima
Supervisor: Dr. Claire De Marco

Introduction
The first step in the life-cycle of a product is the design process. Before proceeding to the next stage, namely the construction of the actual vessel, it is a common and essential practice to build a scaled representation of the ship. Therefore model building is an indispensable tool when designing a ship, with its main purpose being to perform ship model tests. The outcome of these tests will then present and predict the performance of the ship based on the scaled results of the model. In addition, these will allow any potential problems to be detected in the early design stages, thus eliminating costly modifications on the full-scale ship. However, before testing models tests, one should be able to build a model correctly.

Project Objectives
The main purpose of this project is to develop a procedure for the manufacture of ship models to be used in a test tank. For convenience this dissertation is subdivided into the following objectives:

- To follow the standards set up by the ITTC (International Towing Tank Conference) to develop a procedure for the manufacture of ship models
- To provide a detailed instruction manual to be utilized predominantly by students
- To develop a framework to hold any apparatus or instrumentation to undertake basic ship model testing.

Project Methodologies
The following steps were carried out during the course of the project:

- The compilation of background information regarding the various types of models and on the different model tests possible, in a review of the literature
- A material selection exercise for choosing the most suitable material for model hulls
- Identification and a thorough analysis of the current methods for building model boats
- The drawing of a scaled lines plan of the model hull
- The construction of the model hull, based on the chosen material and procedure
- The marking of the transverse lines and the waterlines on the model hull
- The design and subsequent building of a framework with some instrumentation

Results and Achievements
Upon comparing various materials, it was decided that fibreglass should be used for the construction of the model hull. The method adopted for the construction of the fibreglass hull involved three main stages. The first step included the building of a wooden plug utilising balsa wood. From this plug, a fibreglass mould was created, which was then used for the building of the final fibreglass hull. Therefore the model hull is an exact replica of the wooden plug. Furthermore, the method selected for the building of the plug was the bread and butter on waterlines procedure; and for the application of fibreglass the hand lay-up technique was opted for. The whole procedure for building the model hull was documented in a detailed instruction manual.

Figure 1: The wooden plug

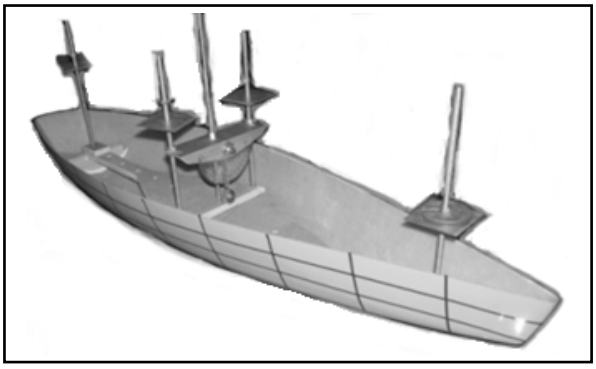


Figure 2: The fibreglass hull with the instrumentation

The Evaluation of an existing Fishing Boat Hull, developing relevant characteristics and properties

Student: Stephen Mallia
Supervisor: Dr. Claire De Marco

Introduction
Fishing vessels have been used by humans from the dawn of civilisation. For a small island such as Malta, vessels have proved to be an indispensable tool for the livelihood of our ancestors. Locally, these are designed and constructed in a traditional manner. Boats built in such a way omit the use of scientific knowledge to determine the important stability criteria, which is of paramount interest to both the boat builder and fisherman alike. The vessel to be analysed is a six meter and seventy centimetre (twenty-two feet) fibreglass fishing boat manufactured by 'Tar-Ratal Marine Crafts'.

Project Objectives
The main objectives of the project are to:

- Analyse the geometry of the existing hull form
- Establish and compute a mathematical and physical approach to determine the vessels primary characteristics, including that of stability criteria
- Compare the above with a software generated model
- Draw conclusions to how the hull could be optimised for improved stability criteria.

Project Methodologies
The gathered work highlights the extraction of the physical data, aided by a scaled replica of the hull, produced by the boat builder himself, prior to the manufacturing process. Evaluation takes place by both theoretical and practical methods. Furthermore, the derived results are compared against a leading naval architecture software; Maxsurf Academic, to ensure that the values attained are within a comparable range. Safety requirements, recommendations and standards have been observed, as to denote the current conformity of the vessel with local, European, and International specifications. The concerned bodies include the International Maritime Organisation, the International Organization for Standardization (ISO) and Transport Malta.

Some of the main physical properties derived by mathematical interpretation are the location of the centre of: gravity, buoyancy and floatation. The values obtained have been supported by physical experimental procedures, to ensure that a correct result has been determined.

A vessels' stability can be determined by the moment developed upon inclining the vessel to one side. The experimental procedure facilitated this measurement by using a 1:15 scale fibre glass replica, purposely constructed for this project. As seen in figure 3, a protractor-like plate was attached, as part of the experimental setup, together with studs to correct the vertical centre of gravity using weights as appropriate.

Results and Achievements
From the adapted theoretical procedures, physical measurements and experiments conducted, the results achieved are comparable with those calculated by Maxsurf. The vessel capsized at an angle of inclination greater than 40°, mainly due to the admission of water, leading to loss in stability. The vessel conforms to ISO 12217-1 under option 5, design category C. Stability can be optimised by increasing the deck height and width of the vessel. Lowering the centre of gravity also compensates this criterion.

Figure 1: The vessel used for analysis

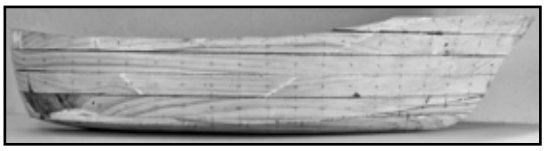


Figure 2: Wood model replica

Figure 3: 1:15 fibre glass model adapted for the experiment

Determining the Vibration Characteristics of Simple Structures via Model and Finite Element Analysis

Student: Cuneyt Micallef
Supervisor: Dr. Ing. Duncan Camilleri

Introduction

The study conducted on simple structures determines the vibration characteristics of steel shafts and aluminium aerofoils which are modeled as continuous systems. A continuous system is an extension of a system which is composed of discrete masses to one which has an infinite number of masses. Discrete modelling can help in the understanding of the dynamics of many vibrating systems. Nevertheless, in real life situations, systems are not made up of lumped masses but are in fact continuous systems. All structural elements such as beams, columns and plates are continuous systems [1]. The analysis of vibration characteristics in continuous systems is also known as modal analysis, and through this, the natural frequencies and associated mode shapes are established. Nowadays, modal analysis is used in conjunction with numerical techniques to study the natural frequencies and mode shapes of structures. Thus, the risk of failure can then be minimised when the structure is eventually built and operated at frequencies which are not in phase with the natural frequencies of the mechanism.

Project Objectives

The project entails the determination of the natural frequencies and corresponding mode shapes of shafts with different length to thickness ratios through analytical, experimental and numerical regime. These three methods are used to obtain the vibration characteristics and therefore this study focuses on the comparison of the results attained. Furthermore, the experimental and numerical techniques are also used to find the vibration characteristics of an aerofoil. The modes due to bending are investigated and henceforth other results are acquired as the aerofoil is systematically reinforced with strips of aluminium.

Project Methodologies

Free vibration analytical equations are used to determine the natural frequencies of different shafts. Through an experimental approach, the natural frequency obtained is assumed to be the frequency at which the shaft oscillates vigorously. Moreover, numerical techniques are applied to compare the results obtained from all the three methods. Likewise, the techniques are used to find the natural frequencies and associated modes when a rotor is added onto the shaft. Additional experiments are conducted on an aluminium aerofoil to deduce its natural frequencies and corresponding mode shapes. A frequency sweep is run and the maximum deflection is recorded through a data acquisition system. Thus, the results obtained can be compared to numerical solutions run in the Finite Element Software ANSYS.

Results and Achievements

Table 1 compares the first mode of oscillation of a shaft with a diameter and length equivalent to 6mm and 1.24m respectively. The values of the first natural frequency from the analytical and numerical approaches are compared. The discrepancy in the analytical result is due to an approximate calculation of the deflection of the rotor. With regards to the aerofoil, the first natural frequency was experimentally found to be 17.6Hz. Figure 1 shows a plot of the first mode of the aerofoil onto which the tests are conducted. Acutally, the result obtained from the numerical solution which is equal to 18.862Hz is very close to that obtained via experiment. Hence, this demonstrates that accurate modeling in ANSYS gives meaningful results.

References

[1] S. G. Kelly, Fundamentals of Mechanical Vibrations. New York: McGraw-Hill, 2000

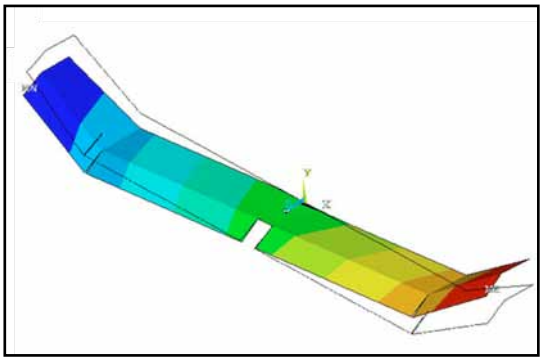


Figure 1 - The plot of the first mode obtained from ANSYS

Mode	Analytical (rad/s)	Numerical 2D (rad/s)	Numerical 3D (rad/s)
1	47.33	48.62	48.51

Table 1 - Comparison of results

Vibration Monitoring and Testing of Rotary Machines

Student: Miray Mifsud
Supervisor: Dr. Ing. Duncan Camilleri

Introduction

The use of machinery has significantly advanced the lifestyle led by human beings. Machines are present in every day to day task ranging from appliance to at our homes, to industrial machinery used to produce electricity. The dependence of engineering systems, in particular rotary machines, is so great that any possible failure can lead to potential loss and significant drastic effects on the economy. The early detection, identification and correction of machine failure, is paramount to ensure a continuous safe and productive operation. This can be achieved by employing condition based monitoring and proactive maintenance strategies. The most prominent technique used for condition monitoring is vibration monitoring and analysis. While various condition monitoring techniques exists, ranging temperature to pressure monitoring, the most prominent and proactive technique is vibration monitoring analysis. The vibration signals contain a wealth of complex information that characterizes the dynamic behavior of the machinery. By monitoring the vibration of rotary machines, an engineer can establish the condition of bearings, gears, shaft imbalances, turbine planes and many mechanical engineering components. By careful assessment of vibration signals one can identify a developing faulty component and their nature at a significant earlier stage, consequently shifting towards superior quality management and maximize profits.

Project Objectives

Condition based maintenance using vibration monitoring and analysis is a relatively new technique. The aim of this dissertation was to introduce this concept to the local industry, establish the merits and identify maintenance procedures to maximise productivity. This study is divided into two parts. The dynamic loading due to shaft and rotor imbalance is the most common source of fatigue failure leading to machine shutdown. Hence in the first instance, this study consists of the design and construction of a dynamic balancing machine to investigate and minimize dynamic unbalance loading in rotary machine. Fault diagnostics of various engineering systems through vibration monitoring was then investigated.

Project Methodologies, results and achievements

Design and construction of Dynamic Balancing machine

A soft dynamic bearing balancing machine was designed, constructed and finally commissioned to balance rotors. Prior to the construction of the machine, a clear definition of the components' and functionality of the dynamic balancing machine were established. The machine was coupled to a series of accelerometers, measuring vibration, together with the appropriate software to dynamical balance rotors and shafts of various dimensions. The final result obtained from the balancing process was positive. Typically a flywheel attached to a shaft was balanced to an equivalent ISO 1940/1 grade 1. Such grade of accuracy is usually used to balance grinding machine drives and other small electrical armatures to very stringent tolerances.

Fault diagnostics using vibration spectra analysis

Fault diagnostics using vibration signal analysis was next in line. Faults were induced on to a vibration rig that was especially set up for studying purposes and, the corresponding vibration profiles were obtained and processed using 'Vibrospect', a dynamic analyzer software. Analysis on the observed spectra then followed. Fault diagnostics on two other examples was also performed and the corresponding results were analysed.

Page Turner

Student: Steve Sciortino
Supervisor: Prof. Ing. Robert Ghirlando

Introduction
The number of people who might need assistance in turning the pages of a book or magazine is astonishingly quite high. In a recent study it was determined that more than 60% of a population will, at one moment in time, require the aid of some form of assistive technology due to injury, chronic disease or ageing. [1]

This part of the population is afflicted with conditions that challenge their ability to participate in some of the activities that enrich our lives. As such it is our duty, both as engineers and as human beings to develop ways in which the lives of these persons can be made easier.

Project Objectives
The main objective of this project was to design an automatic page turning device to aid persons who might find it difficult to turn pages of a book or magazine. Such a device can make life easier for whoever might need assistance in such a task.

Project Methodologies
- A literature review to identify the already existing products, including the relevant patents, was conducted.
- A survey was conducted to better understand the needs of the persons for whom this product is intended.
- The properties of different forms and sizes of books and bound documents available and the different grades of paper which the device is expected to be able to handle were identified.
- The steps involved in the manual process of turning a page of a book or magazine were studied.
- A Product Design Specification was produced.
- A Quality Function Deployment was constructed.
- A morphological chart was constructed.
- The most relevant options for turning a page were identified, tested and evaluated.
- The means which were identified as being most appropriate for performing the required tasks were implemented in a conceptual design.

The final design of the prototype was then refined.

Results and Achievements
The proposed design for the Proof-of-Principle prototype, which is to be used to test the functional aspect of the design decisions taken, comprises all the means chosen from the morphological chart.

References
[1] Forrester Research, Inc., 'The wide range of abilities and its impact on computer technology from http://download.microsoft.com/download /0/1/f/01f506eb-2d1e- 42a6-bc7b-1f33d25fd40f/ Research Report.doc as of 8/2/2010

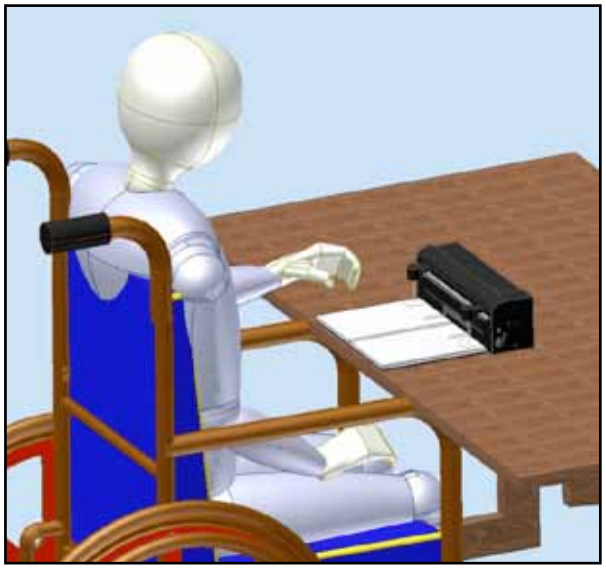


Figure 1 - a graphical representation of the considered design.

Investigation on a Diesel Engine with a Common Rail Injection System

Student: Charlo Seychell
Supervisor: Dr. Ing. Mario Farrugia

Introduction
Much more interest in diesel engines has grown very rapidly as common rail systems where being implemented and developed over the years. A strong increase in fuel economy and significant reduction of emissions as well as combustion noise has been achieved, thanks to both optimized fuel strategies and improved fuel injection technology.

Project Objectives
The aim of this dissertation is to investigate the injection system of a particular diesel engine analyse particularly the timing of diesel injection into the cylinders at idling and during loading the engine. The focus was on injection parameters such as injection duration and quantity, injection pressure, and injection events occurring during each injection process.

Project Methodologies
The objectives established in order to achieve the dissertation's target were as follows:

- Literature review on different types of injection systems with their components, and how they have developed throughout the years
- Designing, constructing and installation of a test stand for the engine
- Station the engine in front a dynamometer
- Connect a heat exchanger and radiator water cooling system
- Connecting the necessary sensors to LabVIEW software
- Investigating the injection system at idling
- Investigating the injection system with the engine on load

Results and Achievements
Two type of variables were used throughout the testing process being, the Revolutions per minute (RPM), and the load on the engine. Consequently a five by four matrix was produced so that different combinations of RPM's and load could be tested on the engine and simultaneously gather data from the LabVIEW software and the OBD cable. The five load values used were in the range of 50 – 250Nm in steps of 50Nm and the four RPM values were; 1000RPM, 1600RPM, 2200RPM, 3000RPM. Parameters such as Main injection duration, Pilot injection duration, start of main injection and start of pilot injection before top dead centre were found in crank angle and plotted in separate graphs against the load values. From these graphs it was concluded that all these parameters increase both with increasing revolutions per minute and load values.

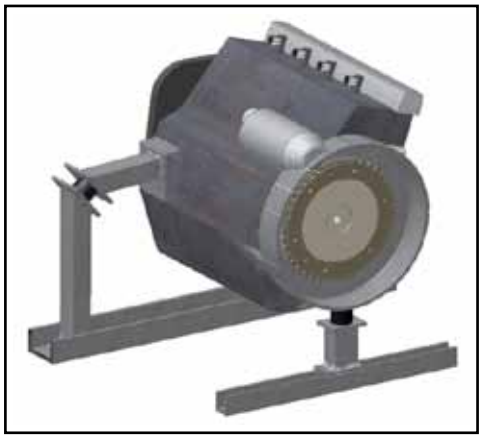


Figure 1: Representation of the engine and test stand

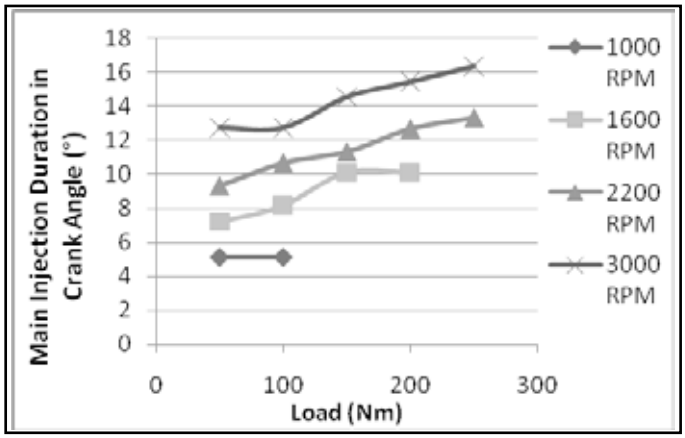


Figure2: Graph showing the change in crank angle as the Load and Revs per minute are increased

A lightweight UAV structure design and FEA

Student: Karmichael Sultana
Supervisor: Dr. Ing. Zdenka Sant

Introduction

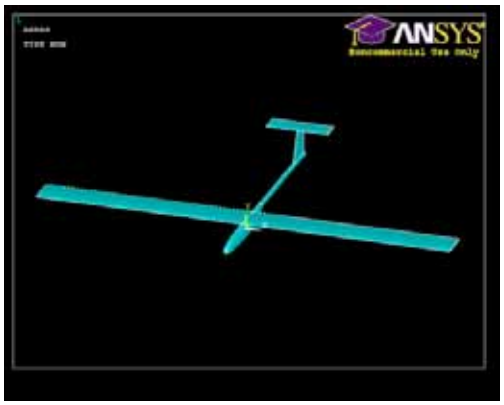
Research dealing with the area of unmanned aero vehicles powered by solar energy is very limited in Malta. This gives rise to the need of a project which analyses the issues related to the design of an unmanned aero vehicle. In fact the goal of this dissertation is to design a lightweight UAV structure that would be able to carry a specified payload. Such a model is to be created as a virtual model and a simulation will be run by means of a finite element analysis (FEA) software. The structure should withstand all stresses and strains experienced during operation over the area of Maltese territory for 24/7 hour period. As the title itself suggests, particular emphasis is to be made on the actual structure of the aircraft, which includes the analysis of the rib sections and their materials.

Project Methodologies and Results

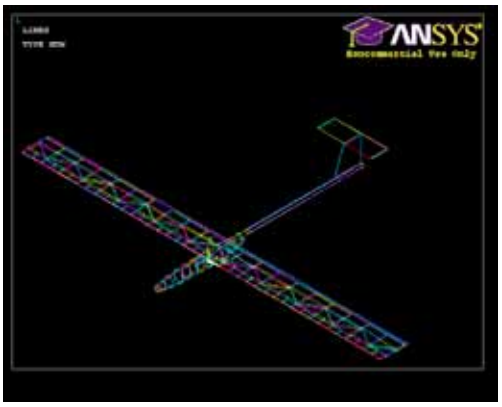
The first analysis which was carried out was that of balancing out the following two equations:

Total mass of aircraft = Total Lift produced
Energy input during the day = Energy needed during the day & night

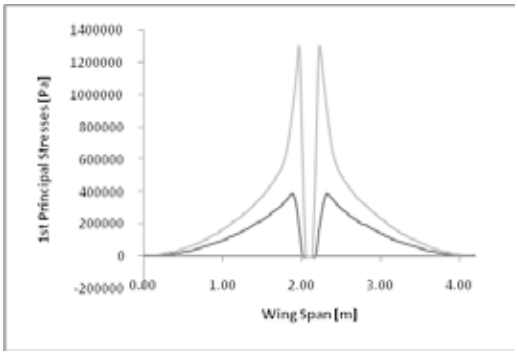
An analytical approach involving the gathering of relationships between each and every variable using established mathematical models was used to solve these equation. From this analysis a graph of wing span against the Aspect Ratio was plotted for different total masses. From this graph it was seen that for a total mass of 5kg, a wing span of 4.2m and an aspect ratio of 13 should be used. These were used to build a model which was analyzed using ANSYS with different material selection and different reinforcements. A material selection process was carried out and several models were built with different materials such as: carbon fibre reinforced polymer, glass fibre reinforced polymer, balsa wood and bamboo laminates. Such models were loaded with the pressure distributions generated by both the main wing and the tail plane. These simulations resulted in a maximum deflection of around 6.385 mm at the tip of the main wing and a maximum stress value of 5.59×10^7Pa in the reinforcements built in the main wing. All the models were compared to compare the deflection values and stress to be able to choose the best model at different angles of flight.



ANSYS assembly



1st Principal Stresses [Pa] vs Wing Span [m] for different models



Reinforcements built in main wing and fuselage

Weight Bearing Device (Lower Part)

Student: Karlos Taliana
Supervisor: Dr. Ing. Zdenka Sant

Introduction
Obesity is one of the various problems which may lead to accelerated joint wear in a human body; this condition is clinically known as osteoarthritis. Nowadays there are several treatments targeting the problems which may differ from surgical, physical exercising, to controlled weight loss program so as to obtain the results required and thus attain further improvements regarding one's own health status. The problem in today's life is that most of the time obese persons only have the surgical treatment option due to their excessive weight. This limits their movements thus constraining them from most of the physical exercises which a healthy person can do.

This is why through several studies and researches, technology is constantly undergoing through different evolution cycles, resulting in new alternative solutions for a particular problem.

Project Objectives
The main aim behind this project is to provide an alternative way instead of surgery, to help obese patients lose weight and prevent further deterioration of the bone joints, thus reducing the probability of developing osteoarthritis amongst other factors, such as cardiovascular diseases. For this reason the biomechanical modelling of an ankle support prototype will help in achieving that goal. The creation of a virtual prototype model of the ankle support will greatly aid the patient to lose weight and to relieve some of the stresses and strains acting on the ankle joint by analysing relevant data such as stress concentrations, regarding its function.

Project Methodologies
The following are the steps carried out during the implementation of this project:

- The study of the ankle anatomical structure and biomechanics, for a better understanding of its function during gait. Prototype parts and assembled structure were designed using Rhino®.
- The virtual model was then exported from Rhino® to Ansys®
- All necessary material properties, element types, boundary conditions and forces were defined and used for meshing and computation analysis of the prototype parts and assembly in Ansys®.

Results and Achievements
Computations are still being carried out. Stress and strain results versus body weight of the support structure will be recorded and analysed, discussing also the materials that have been proposed for the construction of the prototype.

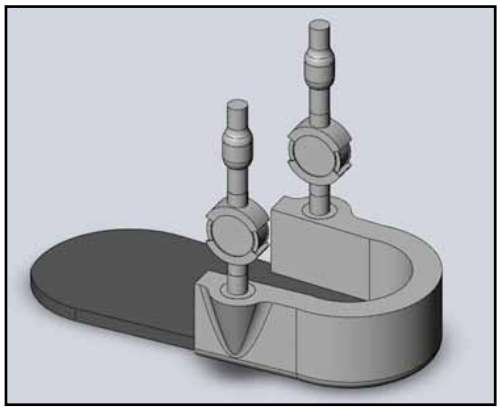


Figure 1 Prototype assembly using Rhino®

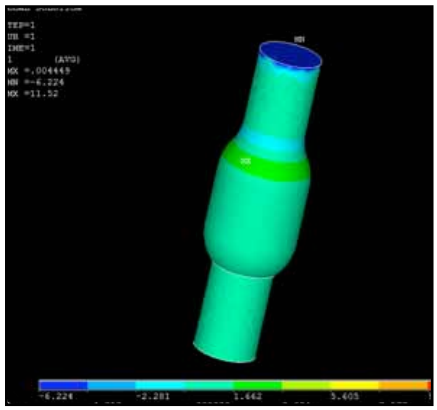


Figure 2: Solved model showing nodal solution for 1st stress distribution analysis of automatic height adjustment part.

Investigation on a commercial inverter air conditioner using manual speed control

Student: Owen Vassallo
Supervisor: Dr. Ing. Mario Farrugia

Introduction
Today air conditioning systems have become available and affordable and consequently the use has become extensive. [1] Unfortunately these systems consume large amounts of electrical energy and are estimated to account for 50 per cent of all building energy consumption.[2] It is claimed that matching the cooling capacity with the heat load by means of speed control, offers the most potential for energy saving, even up to 35%. [3]

In 2008, N. Grech [4] performed a study on a compressor designed to operate at fixed speed to try to confirm this. The results showed that varying the speeds did not result in an overall energy saving. Hence, these tests were also to be undertaken on compressors designed to operate at variable speeds.

Project Objectives
To analyse the performance of a variable speed air conditioner operating at different pre determined speeds; Compare the results to those obtained by Fenech [5] for the inverter operating on closed-loop control system at variable speed; Create software that compares the energy consumption of an inverter air-conditioner operating both at fixed and variable speed based on heat loads that are typical of the Maltese islands. It is anticipated that the results will test the claims made in terms of efficiency improvements.

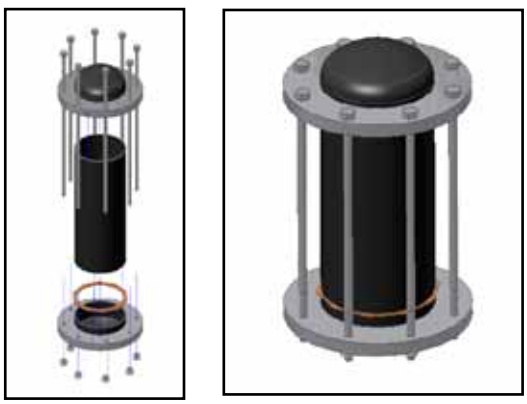
Project Methodologies
Familiarisation with all the parts incorporated in the system was required such that the investigations could be carried out. The following topics were reviewed: Rotary Rolling-Piston Compressors, Capacity and Speed Control of HVAC systems, Capillary tubes, and Induction Motors. The following steps were then carried out for the implementation of the project:

- Design an AC system that would be able to simulate various heat loads and be able to measure the relevant parameters. This design included sizing the capillary tube using an adiabatic model
- Design and manufacture the sealing of the compressor utilising concepts such as:
  - Bolt strength calculations
  - Finite element modelling of the flange design to predict inherent residual stresses and deformation

Results and Achievements
Values for cooling capacity, COP, refrigerant mass flow rate and power input were obtained for all possible compressor speeds and refrigerant temperature at condenser exit. These were plotted and analysed. Certain trends were noted and explained, even by contrasting with previously performed work. A mean compressor speed was then selected. The corresponding data concerning the variation of COP with ambient temperature conditions was entered into the software. The software uses this data for comparison with data, obtained by Fenech for a variable speed system operating in closed loop control, in order to perform an energy consumption analysis. The results were based on actual climate conditions and hence should be realistic.

References
Journals:
[1] I. Y. Chen, et al., "A Comparative Study Between a Constant-Speed Air-Conditioner and a Variable-Speed Air-Conditioner," ASHRAE Transactions, vol. 115, 2009.
[2] Carrier, "Variable speed screw compressor" Raising the bar for variable speed performance, 2005.
[3] T. Q. Qureshi and S. A. Tassou, "Variable-speed screw capacity control in refrigeration systems," Applied Thermal Engineering, vol. 16, 1995.

Dissertations:
[4] N. Grech, "Investigation on Variable Speed Operation of Air Conditioning," B ENG (HONS), Mechanical Engineering, University of Malta, Msida, 2008.
[5] G. Fenech, "Experimental Analysis of a Fixed and Variable-Speed Air Conditioning System," B ENG (HONS), Mechanical Engineering, University of Malta, Msida, 2009.



The final design

Laser forming of metal plates

Student: Stefano Cassar
Supervisor: Dr. Ing. John C. Betts
Co-Supervisor: Dr. Ing. Duncan Camilleri

Introduction
Laser material processing techniques are regularly applied in manufacturing, and include processes for cutting, welding, drilling, machining and surface modification. A relatively recent addition is laser forming. The laser forming process has proved to be useful in a wide range of applications, and has characteristics that provide advantages over conventional forming methods, the main one being that no forming tool is required. This reduces costs, eliminates 'spring back' effects and increases flexibility. The selection of the optimum parameters for a laser forming process depend on a wide number of factors which are categorized as material parameters, workpiece geometry parameters and process parameters.

Project Objectives
The aim of this study is to optimize process parameters for linear bending of sheet metal. Thus the main objective for this project is to perform a number of experiments with various parameters at different levels and determine their effect and significance on the bending angle. This will be useful to identify the optimum parameters. A statistical approach should be adopted for designing the experiments, followed by a statistical analysis of the results A finite element model will be developed to simulate the laser forming process and thus establish whether such a simulation can be utilised to understand the sensitivity of the process to various process parameters and in process optimization.

Project Methodologies
The laser forming process is dependent on various parameters/factors which determine the resulting bending angle. A review of the literature was carried out to understand the laser forming process and identify process-influencing factors. Initial experiments were conducted to identify the most influential factors and to set their levels to values satisfying the main criteria: maximising the bending angle without inducing surface melting. The Taguchi method was used for design of experiments and to determine the optimum conditions for maximising response. Statistical analysis of the experimental results was performed to determine the significance of the parameters. To validate this analysis and predicted performance, a set of experiments were then conducted with the optimum conditions. A finite element model was developed using ANSYS to simulate the laser forming process
.

Results and Achievement
From the experimental and statistical analysis it was concluded that power is the factor which has greatest effect on the bending angle, followed by scanning speed. The process simulation gives a good indication of the final bending angle and thus can be used to identify the effect of the selected processing parameters on the bending angle.

Figure 1: Laser forming process

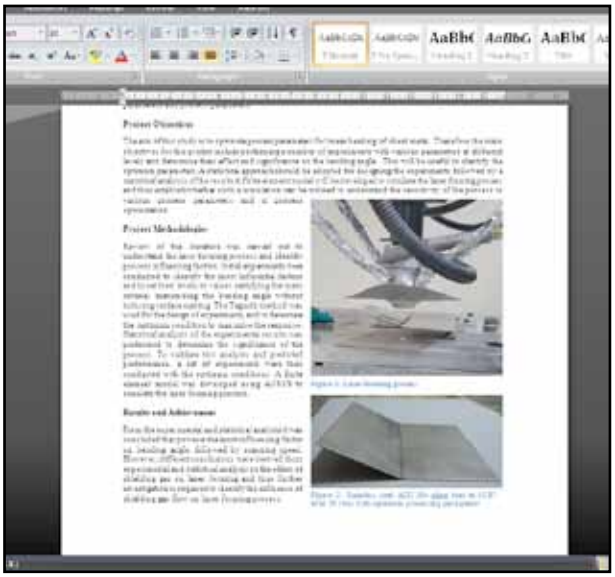


Figure 2: Stainless steel plate bent at 28° after 20 runs using optimum processing parameters

Corrosion Testing and Evaluation of a Ceramic Conversion Treated NiTi(Nitinol) Shape Memory Alloy

Student: Martina Cuschieri
Supervisor: Dr. Joseph P. Buhagiar
Co-Supervisor: Dr. Ing. John C. Betts

Introduction

Nitinol is a nearly-equiatomic alloy of nickel and titanium known for displaying both the shape memory effect and the superelastic effect. The biomedical industry is one of the areas of application where these alloys have found the widest use. Bodily fluids, however, provide a highly corrosive environment for the devices due to their high chloride ion content as well as their tendency to increase in acidity upon inflammation of the surrounding tissues [1]. These conditions require the material to have high corrosion resistance, as in such applications it is very difficult to eliminate the occurrence of crevices and fretting wear through design. It is therefore opportune, from both medical and scientific perspectives, to study the corrosion resistance of these alloys and find ways of creating a Ni barrier in order to avoid the occurrence of nickel sensitization in the surrounding tissue. This can be done by employing surface engineering processes to modify the thickness of the oxide layer formed on the surface. Ceramic conversion treatment is one such technique which consists in heating the material in air at a temperature above 300°C.

Project Objectives

The aim of this project is to investigate the corrosion properties of the untreated alloy and evaluate the effect ceramic conversion treatment has on such properties. An electrochemical corrosion test rig was to be designed and built in order to be able to assess the pitting, crevice, and fretting corrosion resistance of the material in simulated physiological solution at a temperature of 37±1°C.

Project Methodologies

A review of the literature published to date on the corrosion susceptibility of NiTi alloys in the untreated and oxidised states was conducted. An electrochemical corrosion test rig for the simulation of pitting, crevice and fretting corrosion was designed. Due to time constraints and limitations related to the machining capabilities available, the actuating mechanism designed to be able to simulate fretting corrosion was not built.

The material supplied was cut into square samples of edge 23mm by means of an abrasive wheel cutter. All samples were ground to a polished finish by means of metallographic abrasive papers. The samples were divided into three groups: those to be left untreated(UNT), those to be heated to 400°C for 50hours(CCT400) and those to be heated to 700°C for 0.5 hours(CCT700). The samples were degreased with isopropanol, the central portion of each sample was masked and a uniform layer of lacquer was sprayed on the samples. The mask was removed and the lacquer was left to dry after which potentiodynamic testing of the samples was conducted using the test rig built. In this technique the current is measured while the voltage is varied by means of a potentiostat. Breakdown of the passive film present on the surface of the samples is marked by a rapid increase in current and therefore the higher the voltage at which this occurs, the better the corrosion resistance of the material. The data obtained from such electrochemical tests was analysed and compared in order to rank the corrosion susceptibility of the material. Metallography and characterisation techniques were used to investigate the composition and structure of the base metal as well as the thickness of the oxide layer formed on the surface under different ceramic conversion treatment conditions.

Results and Achievements

The breakdown potentials measured suggest that, as expected, the presence of a crevice lowers the breakdown potential of the material. Furthermore, it may also be concluded that the ceramic conversion treatment of the material improves its corrosion resistance considerably, increasing the breakdown potential with increasing treatment temperature.

References

1. Brojan, M., et al., 'Shape memory alloys in medicine'. RMZ - Materials and Geoenvironment, 2008. 55(2): p. 173-189.

Determination of the Physical Properties of a Novel Biomaterial used in Dentistry

Student: Andrew P. Cutajar
Supervisor: Dr. Bertram Mallia
Co-Supervisor: Dr. Josette Camilleri

Introduction

In the mid 1990s, Portland cement (PC) was introduced as a dental biomaterial. Its main function was to seal the root end of the tooth during root canal treatment. Bismuth oxide is added in 1:4 proportions to increase the radiopacity of the material in order to be distinguished from the surrounding anatomical structures on a radiograph once implanted in the human tooth. This material was approved by the Food and Drug Administration (FDA) and marketed as Mineral Trioxide Aggregate (MTA) in 1998. The toxicity of elemental bismuth together with the reduction in the mechanical properties of Portland cement following the solubility of bismuth oxide necessitates research to find a more suitable alternative.

Project Aim and Objectives

The aim of this project is to investigate the suitability of zirconium oxide (ZrO_2) as an alternative to bismuth oxide in Portland cement and determine the optimum filler loading of zirconium oxide replacement for MTA to be utilized as a root-end filling material. The objectives of this study were to prepare and/or investigate:

- cement samples with different amounts of zirconium oxide
- physical properties of the cement samples
- the chemical characteristics of the cement samples in simulated body fluid
- the radiopacity value of the cement samples at different periods of time

characterization of the microstructure using microscopical analysis

Project Methodologies

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

- Literature review of the current research conducted on MTA.

Conduct tests on cement specimens mixed with different percentages of zirconium oxide and different water/cement ratios in order to determine the physical properties and chemical characteristics.

- Conduct SEM/EDS analyses and optical microscopy to characterize the microstructure of the different cement samples.
- Compare quantitatively the properties of MTA with the different cement samples.
- Suggest a suitable cement composition with its percentage zirconium oxide and water/cement ratio as a replacement for MTA.

Results and Achievements

During this study, various properties were analyzed including setting time (Figure 1), radiopacity (Figure 2), compressive strength, porosity, pH, leaching, water uptake, water sorption and water solubility. Characterization of the various specimens was also completed (Figure 3). This study shows that Portland cement having between 30% - 50% zirconium oxide content with a water/cement ratio of 0.3 have superior physical properties and chemical characteristics than MTA.

Figure 1. Setting time testing apparatus

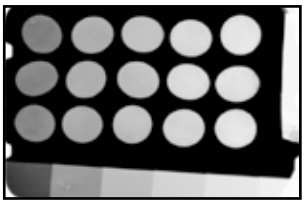


Figure 2. Radiopacity test showing various specimens with varying amounts of PC and ZrO_2

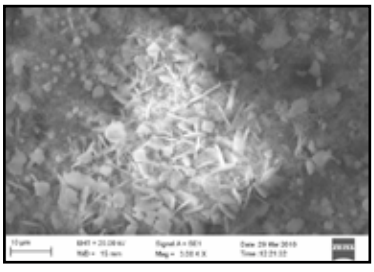


Figure 3. SEM/EDS analysis showing the microstructure of PC mixed with 30% ZrO_2 with a water/cement ratio of 0.3

Laser Surface Heat Treatment of Austempered Ductile Iron

Student: Christopher Ellul
Supervisor: Ms. Ann Zammit,
Co-Supervisor: Dr. Ing. John C. Betts

Introduction
Austempered ductile iron (ADI) has emerged as an important engineering material. Not only is it much cheaper than steels to produce, but its properties are easily varied by simply adjusting heat treatment parameters. For a considerable fraction of engineering environments, it is necessary for a component to possess a tough bulk capable of resisting the action of impact stresses and fatigue cycles but at the same time a hard exterior is often required to resist several wear modes. This paradox has been overcome by an array of surface engineering techniques. One such technique is that of laser surface hardening.

Project Objectives
The principle aim of this project was to:

- Study the effects of different laser spot parameters on the microstructure of ADI and the resulting hardness profiles of the laser spots

Project Methodologies
The following steps were pursued throughout the course of this project:

- Literature review on the current developments of ADI and laser surface treatment technologies and their effect on material properties.
- Heat treating specimens of ductile iron to produce austempered ductile iron using a process known as austempering
- Subjecting the ADI samples to a number of laser spots, each time varying the parameters of beam power, diameter and duration to induce hardening of the material's surface down to an appreciable depth
- Characterization by means of optical microscopy and hardness measurements on the spot surface as well as hardness profiling along depth of the spot section and heat affected zones using a microhardness tester
- Identifying the optimum laser parameters in order to produce a defect-free hardened spot on the surface of ADI

Results and Achievements

- Laser processing significantly increased the hardness of ADI at the spot centre, with average hardness values for the majority of spots reaching and exceeding 55HRC.
- Graphite nodules are still intact in the hardened zone. This improves the material's friction properties
- No cracks or pores were seen in the hardened spots
- Hardness profiles revealed a maximum case depth of 0.23mm

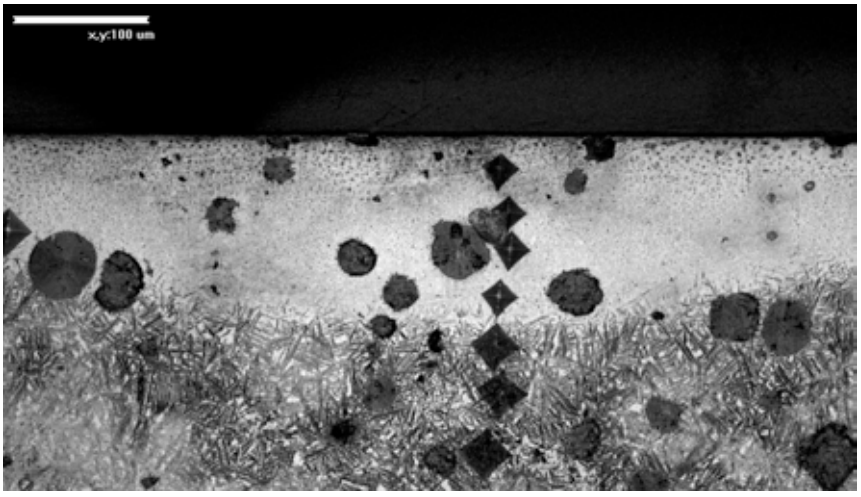


Figure 1: Micrograph of a sectioned laser spot showing indents from hardness tester (etched)

Conducting a Feasibility Study in PET Bottle Recycling in the Maltese Islands

Student: Clyde Falzon
Supervisor: Dr. Bertram Mallia

Introduction

Polyethylene Terephthalate (PET) is a relatively new material for the local industry. This is mostly used for beverage containers. Such increase in popularity in the last half decade has led to large quantities of valuable PET waste being landfilled. The latter is a highly unsustainable practice due to various drawbacks such as land use and emissions. On the other, hand there exist advanced recycling methods which output a high quality recycled PET material. In fact, this dissertation is intended to evaluate the possibility of recycling this material locally in view of the specific Maltese characteristics.

Project Objectives

The aim of this project is to determine the feasibility of PET recycling in the Maltese Islands and which current technology is more appropriate for the local scenario.
The principal objectives are:

- Evaluate the existing PET recycling technologies within the Maltese scenario namely: geography, economies of scale, quality of recycled material and recycling targets set by the European Union.
- Assess the economic aspect of the current practices.
- Make use of scientific decision making methods with respect to the problem understudy.
- Identify which recycling technology is the most suitable for the Maltese Islands, if any.

Project methodologies

- An intensive literature review was carried out to analyse the characteristics of the Maltese Islands together with the current recycling technologies concerning PET material.
- From this study a list of attributes was generated. These attributes were ranked according to their importance with respect to the local necessities, in order to determine their weighting.
- Research on scientific decision making methods suitable for this problem was carried out and three methods were selected. Ultimately the calculations were carried out.
- Further results were obtained through infield research performed through questioners amongst companies' representatives related to the field of waste management. This information was mostly related to current local practices and figures.

Results and Achievements

The main conclusions derived from this feasibility study were the following:

- Mechanical recycling is the most suitable recycling method for the Maltese Islands.
- An estimation of the running cost of the resulted recycling method was carried out for different reprocessing rates. Ultimately a cost comparison between the available waste management techniques was carried out.

An Investigation of the Erosion of Limestone by Abrasive Cleaning

Student: Clayton Farrugia
Supervisor: Dr. Ing. John C. Betts

Introduction

The erosion of limestone is usually considered a crucial problem, especially in the Maltese Islands where its use is extensive in masonry. The most frequently used limestone found in Malta is Globigerina Limestone, which occurs as two types of building stone: the resistant 'franka' and the easily weathering 'soll'. Limestone degradation can occur both naturally and as a result of human action. It is common practice to use abrasive blasting techniques to remove unwanted dirt or encrustations covering limestone surfaces such as large walls vandalised with aerosol spray paint. Air-abrasive techniques are directly affected by a number of variables which ultimately determine the amount of material removed during a grit blasting operation.

Project Objectives

The aim of this dissertation can be broken down into the following objectives:

- Investigation of the erosion of limestone under controlled conditions, and determination of a correlation between the material loss and the operational parameters including: the air pressure, the nozzle distance from the limestone surface, the angle of impact, and the abrasive material.
- The compilation of a collection of images describing the eroded surfaces.
- Testing the research findings on cleaning painted or encrusted limestone samples.

Project Methodologies

- Review of the literature on the process and problems of dry air-abrasive and other cleaning methods.
- Construction of jigs to hold the limestone specimens and the blasting gun during the experiments.
- 'Franka' Limestone samples cut to a dimension of 165mm by 60mm and sprayed with aerosol paint.
- Specimens weighed before and after they were abrasively cleaned to calculate the mass lost.
- Abrasive blasting of the first 27 samples using fine milled marble powder abrasive and of another 18 samples using ground walnut shells which were collected and crushed locally.
- Use of statistical software to correlate the operational parameters amongst each other and with the material lost and image compilation of the specimens for comparative surface roughness evaluation.

Results and Achievements

Erosion was quantified using mass loss to a precision of ±0.1mg and comparative photography analysis of each specimen tested. Using statistical software it was possible to analyse the importance of each process parameter. It was observed that when using round abrasive particles such as those of the fine marble powder, the pressure and the nozzle-surface distance are the most influential parameters, whilst when using the angular and sharp particles of the walnut shells, the angle of impact is very important since small angles are likely to cause a ploughing effect which is very degrading for soft materials like limestone. Cleaning is accomplished by the impingement of particles which dislodge or pulverize the surface layer and the dirt adhering to it; thus air abrasive cleaning should only be considered when less aggressive methods cannot be used.

Figure 1: Equipment setup used during the experiments.

Figure 2: Original smooth limestone surface (above), cleaned and eroded specimen (below).

Figure 3: Ground walnut shells used as abrasive.

Material Selection for the exterior structure of the shock absorber of a nuclear pulse propulsion spacecraft

Student: Martin Pearsall
Supervisor: Dr. Ing. John C. Betts

Introduction
President Barack Obama very recently announced that "By 2025, we expect new spacecraft designed for long journeys to allow us to begin the first-ever crewed missions beyond the Moon into deep space." [1] This quote echoes the numerous efforts made to conquer what many have termed the final frontier of human exploration. A fact not well known is that during the late 1950s and 1960s researchers worked on a concept that would have potentially allowed mankind to reach alien planets and the moon within reasonable time limits. This concept (never realized) is the nuclear pulse propulsion spacecraft (NPPS). The latter operates as follows; low yield nuclear pulse units (effectively nuclear bombs) are firstly detonated consecutively and externally behind the craft then, the high velocity and high density plasma resulting from these explosions impacts a large circular plate (the "pusher") transferring its momentum. The latter results in high accelerations which are then smoothened by a two phase shock absorber to levels that can be tolerated by the upper vehicle.

Project Objectives
Charles et al [2] state that "Materials Selection should be an integral part of the design process." The objective of this dissertation is to identify adequate material objectives and constraints for the shock absorber of the NPPS. The constraints will then be applied to screen out inadequate materials followed by use of appropriate material selection techniques to ascertain which material best soothes this critical NPPS component. It is to be understood that more than coming up with a feasible material or set of materials, the selection methodology adopted for this unique device under these special set of operating circumstances is what is really important. It is potentially the methodology that should have been (or perhaps will be if the craft is ever realised) applied in tandem with the design process for the shock absorber.

Project Methodology
The methodology adopted consisted of firstly accurately defining the function of the component which is; to allow momentum transfer to the upper section of the NPPS in such a manner that the peak acceleration is reduced to within the tolerable limits. Additionally however, the shock absorber is expected to operate in the adverse conditions of space. The next step was thus to set material objectives and constraints with respect to the operational conditions which include both those encountered in space and those related to the use of nuclear bombs for propulsion. The final step was a thorough consideration of the available material selection methods

Results
This section will involve the selection of the appropriate material selection methods and a thorough justification over why some techniques were opted for and why others were disregarded. Considerations related to cost will also be explicitly discussed. The constraints will also be talked about in detail, where an opinion will be rendered on whether more constraints should be applied and how institutions such as NASA or the ESA go about determining material suitability. The discussion will also extend to the setting of the objectives. Material selection techniques related to multiple materials will also be discussed.

References;
[1] Available: http://news.bbc.co.uk/2/hi/science/nature/8623691.stm
[2] J.A Charles, F.A Crane, J.A.G Furness, "Selection and Use of Engineering Materials", Butterworth-Heinemann, 2001

Crevice Corrosion of Medical Grade Austenitic Stainless Steel used in Orthopaedic Applications

Student: Abigail Rizzo
Supervisor: Dr. Joseph P. Buhagiar

Introduction
Biomaterials, in particular austenitic stainless steel alloys, have been used extensively in the orthopaedic field for a number of years. Any implanted prosthetic device is intended to perform safely, effectively and above all reliably in the human body for prolonged periods of time. The study of crevice corrosion on a medical grade austenitic stainless steel will therefore give further insight as to how and why such a biomaterial corrodes, and what could be done to reduce as much as possible the probability of such corrosion occurring.

Project Objectives
In this study the crevice corrosion of high-Nitrogen medical grade ASTM F1586 stainless steel will be investigated and compared to a leaner stainless steel alloy, AISI 304 and industrial grade stainless steel AISI 316L. It is important to establish the main requirements needed in achieving adequate crevices on the surface of the steels. Tests are to be repeated to ensure precision in the results. Once the materials are successfully corroded, the samples must be analysed so as to identify the number of crevices formed, the depth of these crevice and so on.

Project Methodologies
The project identifies the considerable difference in the localised corrosion resistance of industrial and medical grade stainless steels. The following steps were carried out during the implementation of this project:

- Literature review of the various austenitic stainless steels, in particular the alloying elements, inclusions and corrosion mechanisms of those designated as medical grade
- Develop two adequate set-ups according to standards that would aid in testing for crevice corrosion of the different austenitic stainless steels
- Prepare samples prior to testing: grinding and/or polishing of all sample faces to be tested
- Indentify the different optimum parameters necessary to achieve crevice corrosion on each austenitic stainless steel (vary force, sample preparation etc) and repeat tests for better accuracy

Results and Achievements
All the AISI304 samples tested showed a set of very deep crevices – almost an exact replica of the crevice former was created on the sample face, as shown in Figure1. Although type 304 stainless steel has found its common use in the industry, based on the amount of corrosion after only two days (and with a polished surface), it is clear as to why this particular alloy is not specified as a medical grade.

Even after just one day of testing, Figure2 shows that industrial grade AISI 316L samples showed considerable amount of crevices, however in this case not all the crevices formed took the full shape of the crevice former. This could be due to a number of reasons; one of them being the better localised corrosion resistance of this alloy achieved with the addition of Mo.

Polished ASTM F1585 samples showed little or no crevice corrosion, even after four testing days. On the other hand, small uniform crevices could be seen on the ground samples, Figure3. Although particularly large, these crevices were not very deep. This decrease in crevice corrosion can be attributed to the high-nitrogen content that this alloy contains in solid solution.

Bearing in mind that all the test specimens were successfully corroded and that data obtained from the repeats of tests showed great accuracy, one can say that the chosen test methods and their respective parameters gave the optimum results possible.

Figure1: Crevice Corrosion on AISI304 SS (scale 10mm)

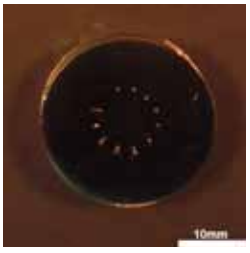


Figure2: Crevice Corrosion on AISI316 SS (scale 10mm)

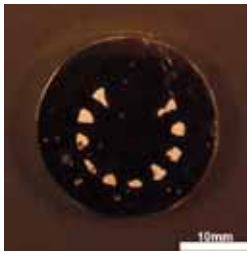


Figure3: Crevice Corrosion on ASTM F1586 (scale 10mm)

The Utilization of Fine Crumb Rubber Tyres in Hot Mix Asphalt by the Dry Process

Student: Anton Schembri
Supervisor: Dr. Ing. Stephen Abela

Introduction
The frequent, premature road deterioration has urged road material engineers to design better roads and to use the materials to their full potential in order to increase the life-in-service of roads. This deterioration, often encountered in our local roads, has elicited the need to improve the road performance. A convenient way in which this can be accomplished is by adding fine crumb rubber tyres in the conventional mix of roads. Apart from building more durable roads, this process disposes a myriad of discarded tyres.

Project Objectives
This study will deal with the addition of Fine Crumb Rubber (CRM) tyres in a Dense Hot Mix Asphalt by the Dry Process. Different percentages of CRM tyres will be added, varying from 1 to 3 per cent and for each percentage of rubber a Marshall Mix Design will be performed to achieve the optimum percentage of bitumen. Then, Bituminous Beams will be manufactured by simulating in field compaction. These beams will then be tested for skid resistance and flexural fatigue. The latter has never been performed on the island and no machines are available for such a procedure, thus a testing jig had to be designed, manufactured and fitted on a three point testing machine.

Project Methodologies
Rubber Modified hot mix Asphalt Concrete (RUMAC) is achieved by first blending the aggregate with the crumb tyre rubber, then the asphalt cement is mixed into the blend. The performance characteristics of the dry process are based on two phenomena. Primarily, the large particles of crumb rubber act as a flexible substitute to the aggregate they replaced and the small rubber particles react with the binder making it more viscous, which in turn would help in decreasing the temperature susceptibility of the asphalt and having a greater deformation resistance.

In general, the main objective for the design of HMA mixes is to determine an economical blend and gradation of aggregate and asphalt cement. This method is outlined in ASTM D 1559. Generally, the Marshall Mix Design starts by checking whether the aggregate and bitumen meet the required specifications. In order to establish the optimum percentage of bitumen for a certain mix design, the following steps are performed:

Preparation of Marshall Specimens
Density and Voids Analysis
Marshall Stability and Flow Tests

The fatigue life of asphalt pavement can be simulated in a laboratory by the flexural test. This test is usually used to compare various mixtures, ranking them according to their relative performance. A testing jig had to be designed and built so that the specimens can be tested in accordance to the above mentioned standard using a conventional testing/compression testing machine.

Results and Achievements
The optimum percentage of bitumen was found for each respective percentage of rubber and as expected, the bitumen content is higher for higher concentration of rubber. Some reports argue that the addition of crumb rubber will impair the properties of pavement and that the results obtained by the Marshall Mix design do not conform to conventional ones, however, the results obtained in this study show that they do conform to the Marshall Mix Design. Another positive outcome is that the maximum Stability of the 1 per cent rubber mix was higher than the conventional mix. This means that the addition of rubber up to 1 per cent would result in better road performance since it could withstand greater loads.

This study takes the first step towards a better use of materials when dealing with road construction. More studies ought to be undertaken to confirm that the addition of CRM increases the road performance, resulting in more durable roads and ensuring maximum cost benefit.

An Intelligent Tool for Prototype-Making Technologies Selection

Student: Marylou Abdilla
Supervisor: Dr. Ing. Philip Farrugia
Co-Supervisor: Prof. Ing. Jonathan C. Borg

Introduction

Prototyping technology improves communication as it clearly delivers a new product's design to everyone and makes the intangible concept physical and real. Without a prototype that fits the needs in time, cost and quality, one can lose direction when it comes to manufacturing. All prototyping-making technologies offer this benefit of improved communication if the right process is chosen for a certain application. When this happens costs are reduced, lead-time cut and quality is improved. However, it is really difficult to select the appropriate technology because there are so many prototype-making technologies, and the best selection depends on many criteria. Furthermore, each system has its own strengths, defects, applications, utilities and limitations. Picking the optimal technology requires experience, information, and understanding of all prototype-making technologies. This is a skill that few possess [HYPERLINK \l "Des05" 1].

Project Objectives

The aim of this project is to develop a computer-based tool that assists designers in choosing the right prototype-making technology for product development. The computer-based tool must be able to take into account several factors such as the material properties, accuracy, and stability, post processing work, surface finish, feature definition, part size, build times and cost required by the specific application.

Project Methodologies

The development of the Intelligent Tool for Prototype-Making Technology Selection involves a number of major steps. These include

- Technology determination which should include both additive and subtractive technologies
- Identification of criteria influencing RP technology selection
- Selection of a decision support technique
- Planning of the RP technology selection methodology
- Setting up a database on the determined RP technologies
- Development and implementation of the framework architecture
- Evaluation of the system to verify its effectiveness

Results and Achievements

The developed Knowledge based Decision Support System is designed to be interactive, user friendly and easy to use. It is structured to assist users to select an RP technology based upon their specific requirements.

Works Cited

Jim Destefani, "Additive or Subtractive? Which Rapid Prototyping process is right for your job?," Available: www.sme.org/manufacturingengineering April 2005.

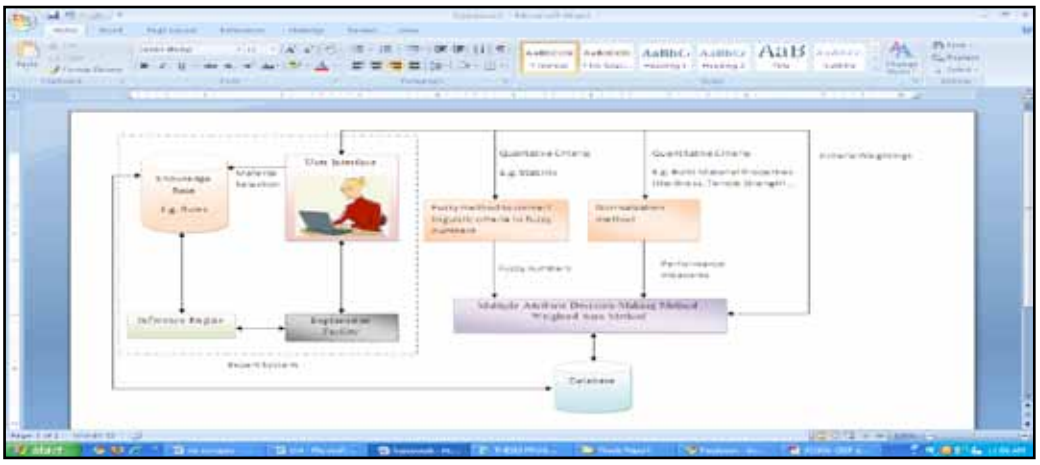


Figure 1: System Framework Architecture

Factory Planning Through Sketch-based 3D CAD Modelling

Student: Gilbert Attard
Supervisor: Dr. Ing. Philip Farrugia
Co-supervisor: Ing. Emmanuel Francalanza

Introduction
Nowadays, when the need for a change arises, the most common method used in factory planning consists of drawing and discussing the layout plan on paper and then represent that layout in 3D through CAD software. This method has a number of disadvantages namely the fact that 3D CAD model takes hours or even days of concentrated work to be done and requires skilled personnel [1].On the other hand, sketching an idea on paper takes only seconds or minutes. This is usually enough time to convey the idea. Therefore one possible way for shop floor planning to become faster and more efficient, is to integrate sketching with factory planning.

Project Objectives
The aim of this dissertation is to exploit the benefits of computer-aided sketching (CAS) technology for factory planning and develop a tool that creates a 3D CAD model of a factory from a paper based sketch layout.

Project Methodologies
This project identifies a gap in the state-of-the-art technology, between sketching and 3D CAD modelling, in the conceptual stage of manufacturing system design. In order to create a tool that converts the simple sketches done in the conceptual design stage into a 3D CAD model for better visualisation, the following steps were carried out:

- A literature review: to identify the current factory planning environment in order to model the tool on its strengths and try to eliminate its weaknesses; to identify the preferred sketching medium by engineers and designers; and also a review of state-of-the-art sketch based tools and state-of-the-art factory planning tools;
- Development of a Framework Architecture that supports a basic paper-based sketch of a shop floor layout, as an input, and turns it into the 3D CAD model.
- Creation of a number of symbols that represent shop floor processes;
- Conduction of a survey in order to have to most representative and clear symbols;
- Creation of 3D CAD model for each process, and convert them into VRML V1.0 ASCII format;
- Development of a proof-of-concept tool, based on the Framework Architecture;
- Implementation of the tool and evaluation of its effectiveness in industry;

Results and Achievements
The results achieved so far consist of a proof-of-concept tool, with minimal human intervention, that has the ability of creating a 3D model of a factory shop floor from a simple paper-based sketch with particular symbols drawn on it.

References
Journal:
[1] C.-y. H. Lynn Eggli, Beat D Bruderlin and Gershon Albert, "Inferring 3D Models From Freehand Sketches and Constraints," Computer-Aided Design, vol. 29, pp. 101 - 112, 1997.

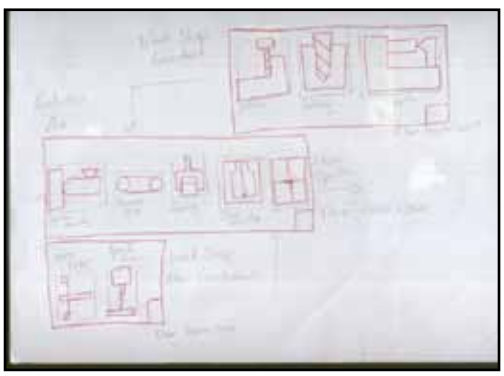


Figure 1 - Shop Floor Layout Sketch (input)

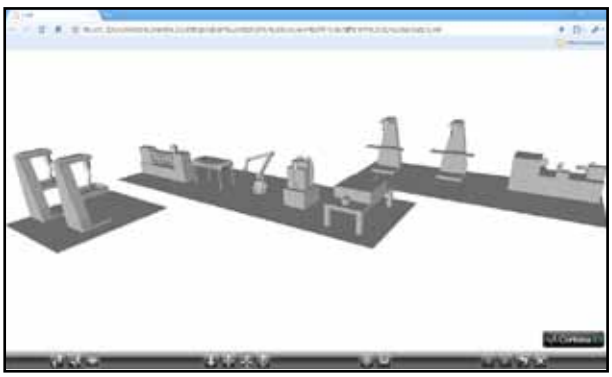


Figure 2 – 3D Model of Shop Floor (output)

Development of a new, non-matrix type fingertip touch and force sensor

Student: Tony Bartolo
Supervisor: Dr. Ing. Michael. A. Saliba

Introduction
In robotic grasping and handling, it is important for the robot hand to be able to sense contact with the object, as well as the forces that it is imparting to the object. This is extremely important both for a hand that is operating autonomously, as well as for a hand that is being tele-operated. Any sensors installed on the hand, however, should be as small and light as possible, so as not to interfere with the grasping or manipulation process itself.

Project Objectives
The aim of this project is to design and develop a new fingertip sensor that can sense both position and magnitude of a point force. This is to be done using a non-matrix type approach, in order to drastically reduce the number of individual sensor elements needed, and therefore to reduce sensor complexity and cost. The stages of the project are summarized below:

- Determination of the objectives and required specifications of the device
- Generation and Evaluation of different concepts
- Concept selection and detailed analysis of chosen concept
- Detailed design based on the selected concept
- Manufacturing of a prototype
- Prototype testing and evaluation

Project Methodologies
The project was carried out as follows:

- Literature review of tactile sensors implemented on artificial anthropomorphic hands and tactile sensing technology available.
- Brainstorming to generate ideas, sketching to visualize idea, analysis of construction and of the basic concept and evaluation of pros and cons of concept.
- Selection of concept based on lowest number of sensor elements and cost.
- Detailed analysis of selected concept by using the 'Ansys v11.0' software and developing algorithms through which the approximate position and magnitude of a point load can be inferred from strain gauge readings.
- Design and manufacture of the prototype (Figure 1). Solution testing and results to compare theory with practice.

Results and Achievements
Algorithms were produced by means of four strain gauges. In Figure 2, Ratio vs Position graph for strain gauges A and B is quite consistent for various rows and loads. After determining position along the x-axis, the corresponding graph of Ratio vs Position for strain gauges C and D for that column along the z-axis is acquired. When position of the force is determined, the graph of Strain vs Force for the location is acquired for each strain gauge where all values resulted in approximately the same. The theoretical and actual values varied in magnitude (actual gave higher values) in the extreme regions while relatively close near the centre region of the plate. This may be due to the manufacturing of the prototype.

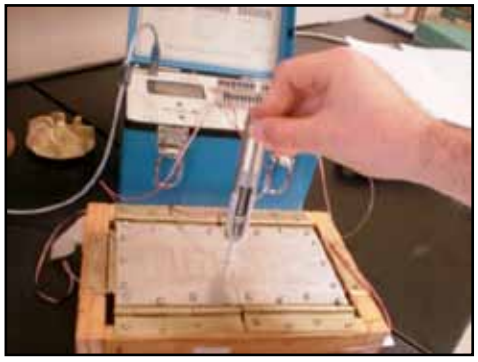


Figure 1: Flat Plate Test Rig

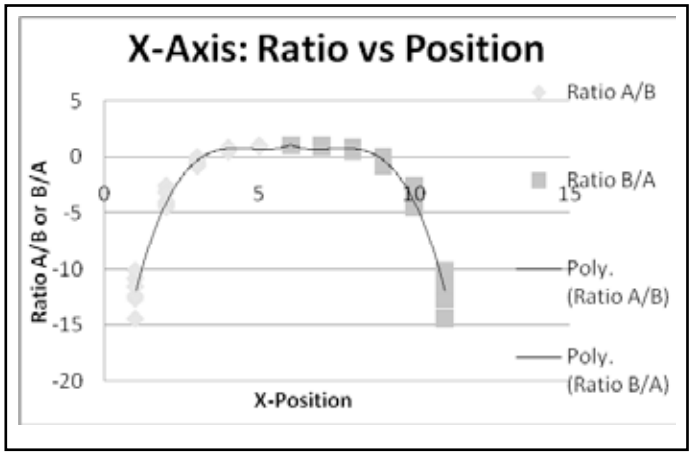


Figure 2: Graph of Ratio vs Position along X-Axis (Theoretical - for various rows and force magnitudes)

Machining Using a CO_2 Laser

Student: Donnalise Cachia
Supervisor: Ing. Pierre Vella
Co-supervisor: Dr. Ing. John C. Betts

Introduction
Along the years, the need to machine newly developed metals and non-metals, the need for unusual and/or complex geometries that cannot be easily accomplished, the need to avoid residual stresses and surface damage and the need to have a surface finish and dimensional accuracy better than those obtainable by traditional processes led to the need for non-conventional processes.[1] Laser machining is one of these processes. Through careful control of the motion and geometry of the workpiece as well as the laser beam delivery system, lasers can be used for a variety of one-, two- and three-dimensional machining applications.[2]

Project Objectives
From an industrial point of view the project aims to establish a small range of materials and features which can be satisfactorily machined using the CO_2 laser and to critically evaluate the strengths and limitations of the CO_2 laser in machining the selected features in the materials tested. On the other hand, from an academic point of view, the project aims to define a set of specifically designed experiments whose results will be used to further assess the capability of the CO_2 laser for machining a small selection of features in a range of materials. In addition to this the test results must be analysed and evaluated and areas which require further studies should be identified.

Project Methodologies
The project identifies different features which can be machined in ceramics using the Rofin Sinar Triagon 9000 9kW CO_2 fast-axial flow laser, which is found in the Department of Metallurgy and Materials Engineering. During this project the following methodology was adopted:

- An intense literature review on ceramics and the processing techniques used was carried out. The latter refers especially to laser beam machining of ceramics. The parameters governing the performance of the laser were also listed. Different types of lasers were considered. Design of Experiments (DOE) formed an essential part of the literature review carried out in order to be able to meet one of the academic goals.
- After several tests were carried out, the parameters governing both drilling and pocket machining were identified.
- DOE was finally used to determine the optimal runs.

Results and Achievements
It was noted that the surface of the machined features was not clean and the boundaries were not sharp. This is due to the fact that material was not removed by vaporization. The entrance diameter of the drilled holes and the width of the pockets are always smaller than the required dimensions and this happens because of the presence of the resolidified layer. It is evident that as the pulse duration and peak power are increased, the presence of this layer is more pronounced. Vaporization is also the reason behind taper formation. A smaller diameter reduces the taper as laser power losses as the beam propagates to the hole are minimised. Results also show that the shorter the pulse duration, the smaller is the Heat Affected Zone. According to the Optimal Runs generated by Minitab 15 Statistical Software a deep hole is achieved by using a square wave rather than a triangular wave because, in the latter case, much less of the peak power is efficiently delivered for drilling.

References
[1] Ing. P. Vella, Advanced Manufacturing Processes Slides, MFE3001
[2] N. B. Dahotre and S. P. Harimkar, "Laser Fabrication and Machining of Materials", New York: Springer Science & Business Media, LLC, 2008, pp. 69-96

Figure 1: Laser Beam Machining of Ceramic

Towards Integrated Sketch-based Modelling and Laser-based Manufacturing

Student: Ryan Cann
Supervisor: Dr. Ing. Philip Farrugia
Co-supervisor: Ing. Maurizio Fenech

Introduction
Many designers use Computer-Aided Design (CAD) software to visualize their ideas. However, there are many designers that prefer to use sketches. Moreover, there are designers that argue that having a 3D physical model is the best tool when it comes to visualization [1]. To produce 3D physical models additive rapid prototyping techniques are used. These build models layer-by-layer. Due to the advances in laser technology a new rapid prototyping technique was developed. This is known as laser cladding. Currently the only way to produce 3D physical models using laser cladding is by first designing the model using CAD software thus not exploiting the advantages sketches have to offer. The system that will be developed in this project builds 3D physical models directly from a paper-based sketch.

Project Objectives
The objectives of this project are: to identify technical requirements to link the current sketching prototype tool with laser-based manufacturing; to develop a set of rules in order to guide engineers to use the optimum parameters for efficient manufacturing of a 3D virtual model; to implement a proof-of-concept tool based on the technical requirements and rules concerning the optimum parameters; and to evaluate the feasibility of the developed technology.

Project Methodologies
This project identifies the tools required to transform a 2D sketch into a 3D physical model. The following steps were carried out during the implementation of this project:

- Literature review on the different methods of laser cladding and the current systems which transform sketches into a virtual model and in some cases into a physical model.
- Determine which laser cladding parameters influence clad geometry.
- Find the optimum laser cladding parameters which would produce a net- shape physical model.
- Modify the current prototype sketch tool system developed by Ms Alexandra Bonnici [2], to transform a 2D sketch into a virtual model made up of a number of vertices which will be transformed into a G-code program which will be used to guide the CNC worktable.
- Develop the Framework Architecture of the system which would transform a 2D sketch into a 3D physical model (figure 1).
- Combine the optimum laser cladding parameters found with the framework architecture developed to implement a prototype tool.

Results and Achievements
The optimum parameters of the laser cladding process were found by experiments conducted in a systematic manner. Each experiment dependent on the results that were obtained from the previous set of experiments. The main achievement of this project was the ability of producing a direct link between a paper-base sketch and a 3D physical model which can be used to reduce the time-to-market of a product.

References
[1] S. Scali, A. M. Shillito, and M. Wright, "Thinking in space: concept physical models and the call for new digital tools," in Craft in the 20th Century. Edinburgh, 2002.
[2] A. Bartolo, "Perceptual simplification and vectorization of paper-based scribbles," in Department of industrial and Manufacturing Engineering: University of Malta, 2007.

Physical model produced directly from a paper-based sketch

Design and Simulation of a Flexible Manufacturing System

Student: Maria Caruana
Supervisor: Ing. Emmanuel Francalanza

Introduction
Nowadays, customers order less of the same product, but more often. This means that the system has to be versatile and capable of producing a wide variety of part types with minimal changeover times and costs to switch from one product to another [HYPERLINK \l "Hay941"1]2]. Toly Products (Malta) is a global supplier of high quality plastic packaging components for cosmetic products. Owing to the myriad products produced by the company, Toly has to invest in new and innovative ways which would enable faster changeovers while ensuring high production efficiency.

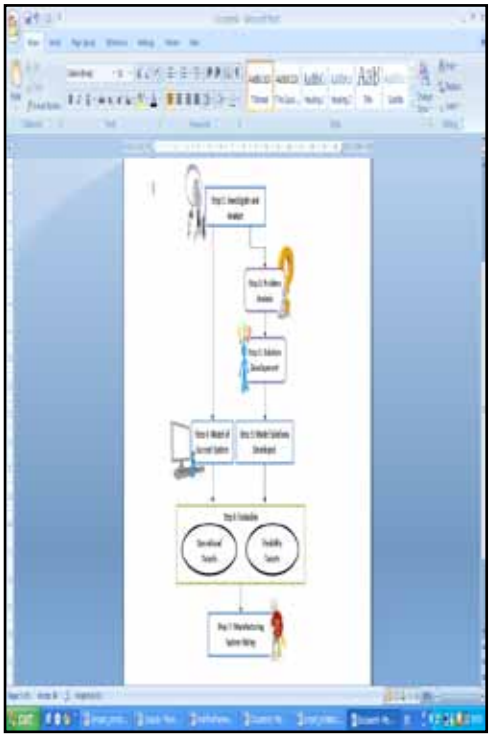
Project Objectives
Academic Goals: From an academic perspective, the goals include investigating and analyzing the current assembly layouts. Additionally, a design methodology for a Flexible Manufacturing system has to be developed. This design methodology has to be followed to design new assembly layouts that provide higher flexibility and shorter setup time. Moreover, an evaluation tool had to be developed, enabling a flexibility evaluation of the proposed assembly layouts.

Industrial Goal: The industrial goal of this project involves investigating and identifying a solution that would improve the current assembly lines at Toly, possibly making them more flexible. An investigation of the problems that lead to long changeover time is carried out, and each problem is tackled.

Project Methodologies
A method which provides a systematic way of leading the system designer from the current manufacturing system design to an improved design was first developed as shown in figure 1. First an investigation of the current manufacturing system was carried out. The problems of the system were then analyzed. Following this, a number of tools were used to come up with possible solutions. A final solution was chosen and it was modelled using simulation software. A flexibility evaluation tool was developed using AI techniques, and this same tool was used to evaluate the systems in terms of flexibility.

Results and Achievements:
The Production Flow Analysis that was carried out resulted in better grouping of the products. Since the number of product-families decreases, then fewer changeovers are required. An important result from the problem analysis showed that one of the main causes of long changeover time was the re-alignment of the pick-and-place automation. The material handling system was therefore redesigned to reduce changeover time. A flexibility evaluation tool was developed and the proposed layout was evaluated and compared to the current layout using this intelligent tool.

References:
[1] Andrea Matta, Q. Semararo, and T. Tolio, "A Framework For Long Term Capacity Decisions in AMSS," in Design of Advanced Manufacturing Systems – Models for Capacity Planning in Advanced Manufacturing Systems. Italy, 2005.
[2] Robert H. Hayes and Gary P. Pisano, "Beyond World Class: The New Manufacturing Strategy," Harvard Business Review, p.77, January-February 1994.



Manufacturing System Development and Evaluation Method

Machining of Dies and Moulds by Electrical Discharge Machining

Student: Matthew Cauchi
Supervisor: Ing. Pierre Vella
Co. supervisor: Ing. Maurizio Fenech

Introduction
Poor machinability using traditional mechanical processes such as milling results in high tooling costs. Therefore, non-traditional machining methods, such as electrical discharge machining (EDM) have been explored to machine moulds and dies. This technique has been widely used in modern metal-working industry and its versatility and ability to cut fully hardened steels has enabled it to be widely accepted, especially in the die making industry in addition to high speed machining applications [1]. Furthermore this process can be used to manufacture complicated shapes and tiny apertures with high accuracy and with no mechanical stresses as opposed to those generated by tool contact processes.

Project Objectives
The aim of this project is to research, design and perform experiments on the Dieter Hansen EDM situated in the non-conventional machining workshop at the University of Malta, in order to evaluate its effectiveness in using it to machine hardened tool steel samples, used for die and mould making. The ultimate goal is to measure the output characteristics resulting from the EDM machining on AISI D2 and AISI H13 such as material removal rate, surface finish, overcut, and thickness of white layer and compare them with the respective output characteristics obtained from the machining of mild steel. Finally the input parameters that have the most effect on the output characteristics mentioned above will be determined.

Project Methodologies
In this project the parameters among pulse current, on-time, and off-time that have the most influence on the output characteristics such as material removal rate, surface roughness, overcut, and thickness of re-cast layer are determined by the use of Design of Experiments (DOE) and Analysis of Variance (ANOVA). The following steps were carried out during the implementation of the project:

- Literature review on the EDM process and on the hardened tool steels that include AISI D2 and AISI H13,
- Design of experiments using L-9 orthogonal array based on the Taguchi method,
- Machining of eighty-one samples on the Dieter Hansen EDM machine,
- Acquisition of results followed by analysis using the statistical software Qualitek-4
- Discussion of results.

Results and Achievements
Based on the S/N ration and the ANOVA obtained from the statistical software, it was determined until now that surface roughness of AISI D2 steel is significantly affected by the factor pulse current. Further more it was concluded from graphs of S/N ratio versus parameter level that as the pulse current is reduced to a lower value the surface roughness will decrease indicating a better surface quality. From the ANOVA results regarding material removal rate it was determined that pulse current has the most contribution towards its variation, although there were some errors involved in the calculations indicating that the variation is attributed to other parameters that are not investigated in this project such as electrode polarity and gap voltage. The source of error may also be attributed to the fluctuation in the efficiency during EDM machining. Regarding overcut similar to material removal rate, based on the S/N ratio it was determined that pulse current has a significant effect on overcut. Off-time had a very small contribution towards the variation of overcut.

[1] J. Y. Kao, C. C. Tsao, S. S. Wang, and C. Y. Hsu, "Optimization of the EDM parameters on machining Ti–6Al–4V with multiple quality characteristics," Journal of Advanced Manufacturing Technology, vol. 47, pp. 395-402, Jul. 2009.

Development of a Modular and Ergonomic Surgical Instrument Handle Prototype

Student: Maria Victoria Felice
Supervisor: Prof. Ing. Jonathan C. Borg
Co-supervisor: Ing. Alexia K. Grech

Introduction

Minimally invasive surgery (MIS) offers a lot of advantages, such as reduced scarring, but is more demanding on the surgeon since both vision and manipulation are indirect. Surgeons who perform MIS often experience pain and fatigue because the current MIS instrument handle designs are not ergonomic enough and are designed with the mentality that 'one size fits all'. Minimally Invasive Plastic Surgery (MIPS) procedures are considered to still be in their evolving stages and were therefore used as a case-study for this project.

Project Objectives

The main aim of the project was to develop a modular and ergonomic surgical instrument handle that would be suitable for all surgeons whatever their gender, handsize and handedness. The objectives were:

- To carry out a literature review covering relevant topics such as ergonomics and anthropometry
- To construct a detailed morphological chart and draw several sketches of different design concepts
- To create a 3D model and a prototype of the design
- To list the lessons learnt in the form of design guidelines
- To carry out a study of the solution from a manufacturability perspective.

Project Methodologies

Following the literature review the basic design cycle was followed. In the Problem Analysis stage various tools and methods were used to identify the customer needs e.g. handle of right size, understand these needs, prioritize them and convert them into corresponding engineering characteristics e.g. variable angle between handle and shaft. In the Solution Synthesis stage various concepts were sketched and these were ranked according to their feasibility and how well they would satisfy customer requirements. The best concept was converted into a detailed design and modelled in 3D using Computer Aided Design (CAD) software. In order to evaluate the design a prototype was made which was tested and compared to existing handles.

Results and Achievements

Following the literature review and a survey conducted with plastic surgeons it was concluded that there are problems with MIPS instrument handles and that a better instrument handle can be designed. A suitable modular and ergonomic solution was achieved which is shown in the table. The ergonomic handle does not have finger rings and the part from where it is held is available in various sizes, and the shaft is available in different lengths and can be oriented at different angles to the horizontal axis of the handle. While offering all surgeons a handle and shaft that are suitable for them, this solution avoids the manufacturing and organisational problems that producing and using variations of entire instruments would cause.

surgeons	different handle parts (shaded)	different shaft orientations	different shaft lengths	end effector, actuation mechanism etc. represented as black box
e.g. Ms X	small	45°	8cm	
e.g. Mr Y	medium	0°	10cm	

Analysis, Simulation and Optimization of Tool Crib Operations in an Aircraft Maintenance Hanger

Student: Edward Gingell
Supervisor: Dr. Ing. Michael A. Saliba

Introduction
The interest in this project was mainly due to the extensive facilties development this company has been undertaking in Malta over these past years. Lufthansa Technik Malta is the local branch of the Lufthansa Technik Group, offering repair and overhaul services for Airbus and Boeing aircraft. They have recently increased their capacity and shifted their operations to new premises. The usefulness of the project is that the potential results could effectively improve the efficiency at this relatively new work environment.

Project Objectives
The aim of the project is to carry out a study of the current operations in the tool crib of the new hanger facilities, with the aim of optimizing the use of the available resources, and the identification of any new resources that may be required to improve the efficiency of the operations. The project will include an analysis of three parameters, being 1.Number of human servers dispensing tools to the aircraft maintenance technicians, 2.Stock level of each stored item and 3. Location of each stored item in the tool crib. The average waiting time spent in the queue is to be minimised through analysis and simulation.

Project Methodologies
The scope of this project is to optimize a specific objective function. The project will eventually identify the one or group of solutions which can improve the overall efficiency of the operations. This was achieved in a systematic manner, following a number of steps;

- Literature review on aircraft maintenance, warehouse management and queuing theory.
- In-depth observations of current operations

Development of software to aid the data gathering and store it in a systematic manner.(Figure 1)

- Development of a simulator to analyze current operations and alter variable parameters for optimization of objective function.(Figure2)
- Suggestion of possible solutions to Industrial Partner for improved efficiency at Tool Crib.

Results and Achievements
Preliminary analysis has already identified a number of high demand items that are currently stored towards the back of the tool crib, as well as a number of items that are often unavailable in stock. The simulation program has been developed and is currently being used to determine optimum values for stock levels and locations, and the effect of changing the number of human servers.

Figure 1 - Time Keeper

Thermoforming added moulding process

Student: Mark Magro
Supervisor: Mr. Arif Rochman

Introduction
Due to the increasing demand for manufacturing smaller and more compact parts, the need for micromanufacturing is also increasing, [1] [2]. The trend points also towards the use of high performance polymers due to their outstanding properties both thermally and chemically. However, conventional processes meet restrictions when handling these polymers. This project focuses on overcoming this problem.

Project Objectives
The aim of the project is to carry out a feasibility study of a new method capable of producing medium sized and thin walled parts and, design a thermoforming added mould. The study was carried out for compression moulding process.

Project Methodologies
The project investigates current conventional methods and, with the knowledge acquired it comes up with a list of conceptual methods from which the best is chosen to carry out the actual mould design. The following steps were carried out during the implementation of the project:

- Literature review on polymer classification and some current conventional polymer processing technologies
- Development of a prototypic part to put the new process to the test
- Concept generation followed by identification of the ideal one
- Generation of chosen concept by implementation over a compression moudling mould
- Simulation of overall process

Results and Achievements
The thermoforming added process turned out to be feasible however, further studies have to be carried out before its implementation in compression moulding. Such studies were pointed out and finally, once it has been optimized, it was suggested to test and to implement this process also in other technologies such as injection moulding.

References
[1] NEXUS, "MST/MEMS Market Analysis III," Key Diagram, 2005-2009.
[2] A. Rochman, "Development of a novel method for manufacturing thin-walled polymeric micro components," PhD Thesis, Queen's University of Belfast, United Kingdom, 2009.

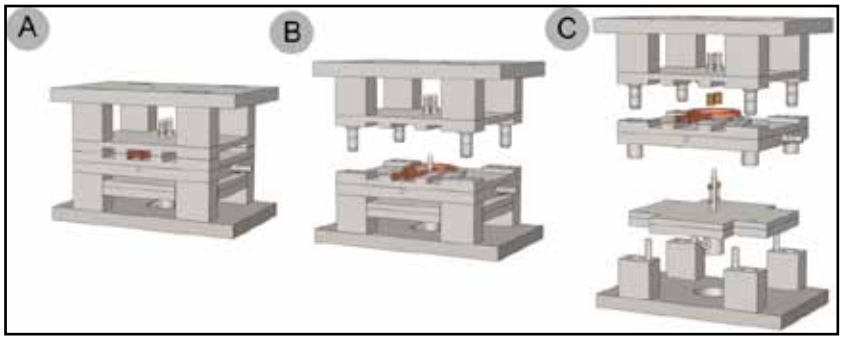


Figure 1: Compression mould with thermoforming added process, (A) closed position, (B) open position, (C) partially exploded view

Design of a Novel "Mascara Application" Device

Student: Joanna Tabone
Supervisor: Prof. Ing. Jonathan C. Borg

Introduction
The application of liquid mascara, which is a fairly recent addition to the cosmetics company, lies in the mascara applicator. Although a large number of different mascaras and mascara applicators are available on the market today, when mascara users were asked about their experiences with mascara, about 87% claim that they have encountered some type of problem during application at one point or another.

Project Objectives
The aim of the project is to design an alternative application system device to the existing mascara applicators which counteracts the problems currently encountered whilst bringing about the required effects.

Project Methodologies
The project brings to light alternative options for applying mascara. To reach the goal of designing a novel mascara application device, the following steps were carried out:

- Critical study of existing mascara application devices / systems and related patents.
- Study on the users' interaction with mascara.
- Identifying the steps involved in applying mascara.
- Identifying how current mascara applicators / brushes are produced.
- Generation of alternative solution concepts.
- Evaluation of the concepts with respect to functionality, practicality and manufacturability to mass production levels.

Results and Achievements
The main problems which are commonly encountered by mascara users are smudging, clumped lashes, difficulty in reaching the inner lashes, mascara lumps on lashes and drooping lashes when applying mascara. The design process of the mascara applicator aimed at eliminating such problems from occurring.

The customer requirements for such a product were studied and concepts for alternative solutions were analysed with respect to practicability during use and ease of manufacturing for mass production levels. The best solution was chosen and developed further so that a prototype could be built for further analysis.

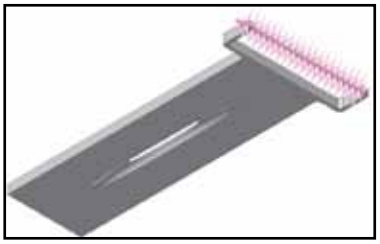


Figure 1 – A proposed concept for a mascara applicator

Figure 2 – A proposed concept for a mascara applicator

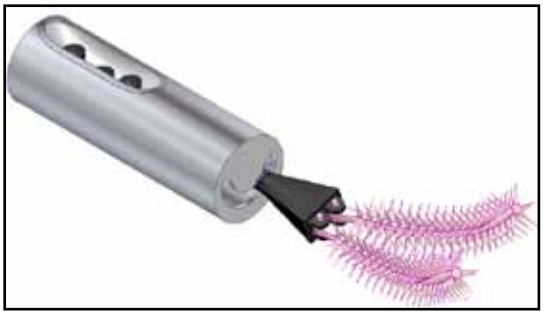


Figure 3 – The chosen optional concept for a mascara applicator

Human strength amplification – A case study for one limb joint

Student: Wang Yifei
Supervisor: Dr. Conrad Pace
Co-supervisor: Dr. Ing. Michael A. Saliba

Introduction
Human strength is limited, and it is virtually impossible to create an artificially intelligent robot that is capable of simulating the human brain. Hence, a combination of the human control and the external power supplied by means of machines would give a superior system.

Project Objectives
The objective of this project is to analyse the behaviour and develop a human strength amplification system applied to one limb joint (Elbow). In such a system the human arm provides motion control to the mechanised arm, which then provides the requested motion in real time. A simple model of the system is shown in figure below.

Project Methodologies
The project is divided into:

1. A literature review providing an insight into human force amplification systems including current research and technology that is related to the system. Possible application of such systems are also addressed.
2. An identification of the main system functions together with a conceptualized solution of the basic system working principles.
3. A detailed system analysis including the static and dynamic aspects of the system.
4. A simulation of the system using MATLAB-SIMULINK, which provides a verification of the system behavior allowing the comparison of the simulated results with the expected system behavior.
5. An identification of system parameter values derived from the simulation – based analysis, to be applied into the physical system.

Results and Achievements
The SIMULINK model has provided a basis for a deeper understanding of the mechanical arm motion and control characteristics. Through the simulation a control approach has been developed which gives a reasonably desirable behavior of the system.

Electrical Engineering Stream

Investigation of an Inverter Air Conditioner

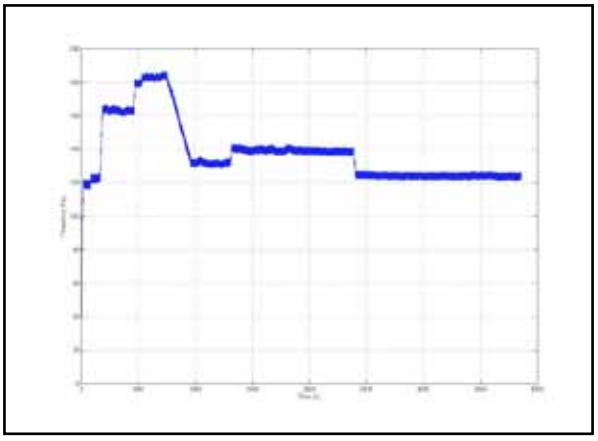
Student: Christian Borg
Supervisor: Dr. Ing. Cedric Caruana

Introduction

Inverter air conditioners vary their cooling capacity so that they meet the cooling demand (load) imposed on them. This is achieved by varying the mass flow rate of the refrigerant. The mass flow rate may be controlled by varying the rotational speed of the motor driving the compressor. Thus, a very good temperature control is accomplished. Apart from temperature control, these inverter driven air conditioners are advertised of consuming 30 per cent less energy than conventional (fixed speed) air conditioners.

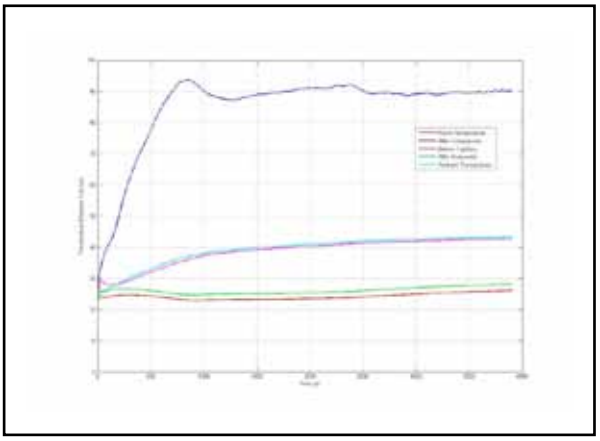
Project Objectives

- Investigation of a commercial inverter air conditioner to determine the type of motor used, range of frequencies, hardware used, measured data for control, etc.
- Analysis of the motor driving the compressor and the drive strategy in use.
- Analysis of the control strategy determining the operating point of the compressor.
- Real time monitoring with data capturing software (LabVIEW).



Project Methodologies

The test rig on which the analysis was made consists of a commercial inverter air conditioner. Readings of the voltage, current and frequency that the inverter feeds to the compressor were taken. A number of circuits were built in order to take these readings which then were recorded using National Instruments LabVIEW. The air conditioner also monitors several temperatures such as ambient and room temperatures in order to vary the cooling capacity. These were also recorded using a temperature data logging device.



Results and Achievements

The motor being used to drive the compressor is a 3-phase induction motor and the motor drive strategy is VF control with a ratio of 0.3122. The motor is driven by a pulse width modulated (PWM) voltage signal with a switching frequency of 13 kHz. The range of frequency that the motor driving the compressor uses is between 90 Hz and 175Hz. The air conditioner reaches steady state conditions when operating within its capacity as shown below. The strategy in use for setting the operating frequency is also being investigated.

Three Phase High Power Factor Rectifier

Student: Lee Bullock
Supervisor: Dr. Maurice Apap

Introduction
The purpose of this project is to come up with an alternative to the conventional three phase high power factor rectifiers which uses low frequency inductors which are bulky and IGBT's and also the control is more complex. Therefore designing a high power factor rectifier which uses a switching MOSFET's and high frequency inductors to regulate the output voltage and line current, while also maintaining unity power factor. This would fill the gap between PWM rectifiers and cheap six pulse diode rectifiers.

Project Objectives
The aims of this project are to design and simulate a three phase high power factor rectifier circuit, while also designing and testing the form of control which will be used to regulate the inductor current to maintain the required output, at the same time ensuring unity power factor by keeping the inductor current in phase with the supply voltage.

Project Methodologies
Research was carried out into the functions of the different controllers to allow for design and then simulation. Also calculations were carried out to determine to rating of the power circuit components. This project was divided into the following steps:

- Simulation of power circuit with hysteresis and average current control using Simulink
- Design of power circuit and component selection
- Implementation of results of the design and simulation

Results and Achievements
Using the results from the simulations the controllers were compared in total harmonic distortion, switching frequency and current ripple of the two controllers. Both hysteresis and average current controllers achieved the task of controlling the power circuit in order to maintain the required output.

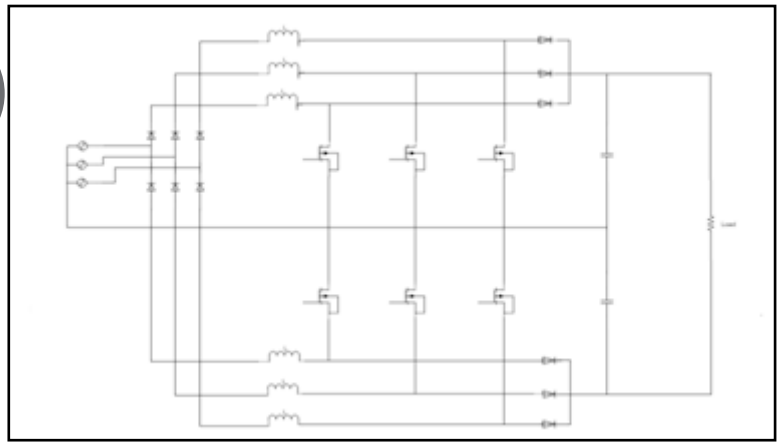


Figure 1 – Three Phase Boost Rectifier

Solar powered catamaran

Student: Ian Busuttil
Supervisor: Prof. Joseph Cilia

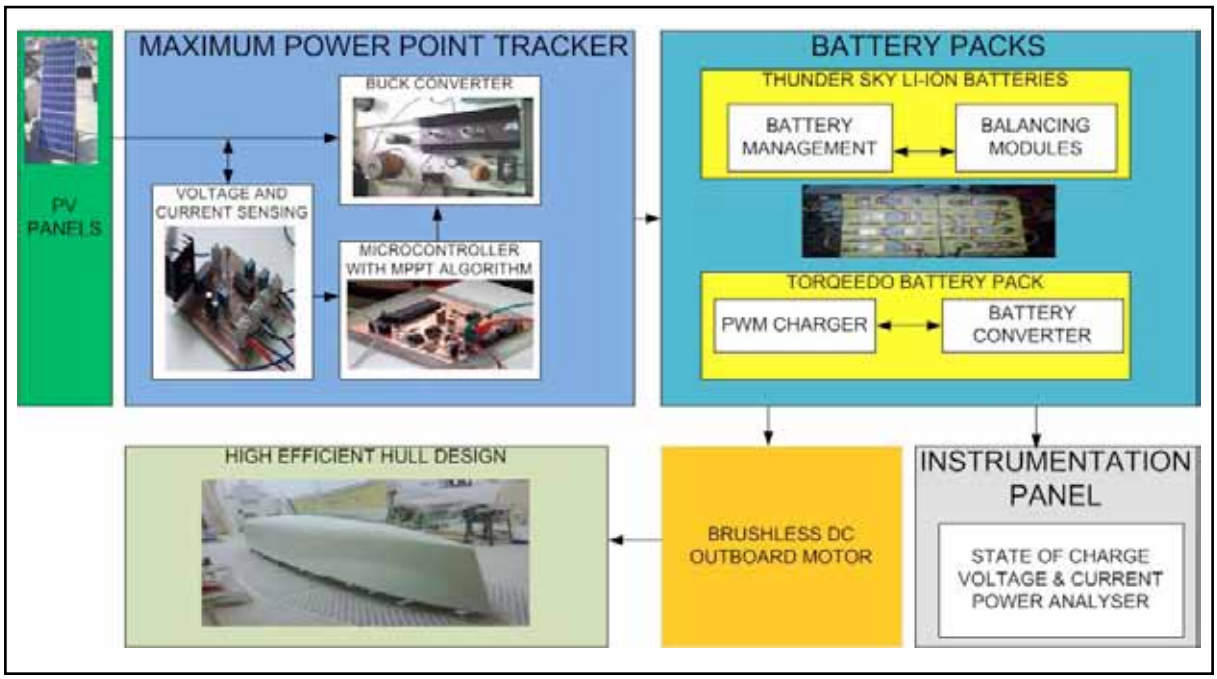
Introduction

The main motivation and aim behind this project has to do with renewable energies and its conservation. The former are becoming more popular with each passing day due to the need of reduction in green house gas emissions. Hence, the project related and based on this topic centres around building an environmentally solar boat which solar boat can be put to good use in our shores especially during the summer hot weather.

Project Objectives

- To design and build a high efficient hull for a catamaran.
- To implement a solar Catamaran having a sustained operating system which is capable of operating a whole trip around Malta.
- To analyse various Pv panels and undergo the study of their characteristics and their operation.
- To design, simulate and implement an efficient algorithm to achieve maximum power point of the PV panels.
- To design, simulate using PLECS and SIMULINK software, and implement power electronic circuits to achieve high efficiency DC/DC converters.
- To control and maintain Lithium-Ion Batteries in safe operating margins.
- To cascade the original battery system of the outboard with the electrical power circuit.
- To measure and display on consol critical values that are needed in such an application.
- To design a roof that can sustain the weight of the panels in those conditions.
- To backup the system by using Intelligent Li-ion batteries.

Project Methodology:



Catamaran system overview

Design and Implementation of a Hybrid Solar System

Student: Diane Cassar
Supervisor: Prof. Joseph Cilia

Introduction
Existing PV systems in Malta are grid connected. The disadvantage of these systems is that when there is a power cut and the grid is down one cannot make use of the system even though they have the solar panels installed which are producing power. In Malta we have sunshine almost all year round and it is a waste of energy to have a PV system installed while not being able to use it during a power cut. Grid-connected inverters need to be connected to the grid to work. Once a grid failure occurs the inverter will automatically sense this, trip and stop delivering power. The inverter checks the grid voltage and frequency continuously for its operation. In order to operate the inverter in off-grid mode these parameters must be simulated so that the inverter can sense them and operate.

Project Objectives
The aims of this project are:

- Understand the parameters of the inverter and see how they are affected when the inverter is operated in off grid mode
- Operate the inverter in off-grid mode by using a sinusoidal inverter instead of the grid
- Install a new set of photovoltaic panels to be used for the hybrid system and reposition the existing panels to achieve the maximum power output
- Implement the hybrid solar system which can be operated both grid connected and off-grid effectively.

Project Methodologies
The first step involved connecting the inverter to a computer so that its parameters can be monitored under different operating conditions. The inverter was set to off-grid mode and the parameters which were affected by this change were noted. It was found out that the off-grid setting widens the voltage and frequency ranges when compared to normal grid-connected operation. The second step was to connect the Sunny Boy inverter to a sinusoidal inverter which produced an output of 240V AC and 50Hz like the grid and monitor its operation. An array of PV panels was set up on the roof. Two existing PV systems were already set up in the past years and these needed to maintained and repositioned as to obtain the optimum position to avoid shading during all sunshine hours. The last step was to connect the loads so that the power which was being generated is consumed at all times since under off-grid conditions extra power generated can no longer be fed into the grid. No surplus power can exist in the system since this would trip the inverter.

Results and Achievements
The inverter was operated in off-grid mode and the hybrid system was set up. A fridge was used as the main load since this was considered the most important appliance to be kept operating in case of a power cut. The extra power was fed into a water heating element or used to charge up batteries needed to operate the sinusoidal inverter.

Figure 1: Hybrid System Testing Setup

An Investigation of the Failure Modes of Energy Saving Lamps

Student: Daniel Fenech
Supervisor: Dr. Ing. Cedric Caruana

Introduction
Climate change and global warming have led to campaigns throughout the world to replace inefficient incandescent bulbs with compact fluorescent lamps (CFLs). Rather than simply relying on a glowing metal filament to produce light, CFL technology goes a step further using gas discharge lamps. This makes CFLs more energy efficient and with lifetimes reaching fifteen times that of incandescent lamps. All in all they make the public save money and make the world greener. However, CFLs require an auxiliary apparatus called a ballast to run with them consisting of electronic materials. This makes CFLs more complex and hence there are more mechanisms of failure that needs to be investigated.

Project Objectives
The objective of this project is to investigate the failure mechanisms of energy saving lamps. A sample of lamps will be tested under different stresses and in a controlled way. Also, failed lamps together with a brief description of how they failed will be collected from the public and/or industry. The project aims to understand the typical causes of failure and possibly come up with recommendations for the better use of such lamps.

Project Methodologies
The project objectives were approached using the following methodology:

- Literature review and analysis of different types of electronic ballasts found in CFLs.
- Simulation of typical electronic ballasts using an electronic circuit simulator.
- Identification of the main issues that cause CFLs to fail prematurely.
- Literature review on how different research centres and organisations conduct testing on the identified failure issues.
- Design and building of three different setups to stress a sample of ten CFLs under elevated heat conditions, frequent switching, over-voltage, and under-voltage.
- Devise a test to analyse failed lamps.
- Analysis of electrical and light output results as lamps age.
- Analysis of failed lamps: those collected from the public and those coming from the test setups.

Results and Achievements
Three test setups were successfully built to test CFLs under different conditions which can lead them to fail prematurely. A test was also devised to check whether the CFL failure was due to the lamp or due to the ballast. From preliminary results it can be seen that the sample of CFLs being switched at a cycle of 5-minutes ON/ 5-minutes OFF are suffering from severe lamp-end darkening. Case operating temperature of CFLs found in the heat chamber can increase by as much as 25% when the lamp holder is in base-up position instead of base-down position.

Figure 1: Test setups used and data logging computer

Universal Dynamometer For Testing Electric Drives Part II

Student: Charlie Portelli
Supervisor: Dr. Ing. Cedric Caruana

Background
The function of a dynamometer is very important for Carlo Gavazzi that produces a vast range of soft-starters. The dynamometer allows them to emulate any particular type of load that they want to analyse. Moreover it allows them to investigate the effect particular loads will have when connected to a specific soft-starter, without the actual need of purchasing the physical load itself. Apart from this financial gain, an additional benefit is that the dynamometer provides a remote site testing, where the engineer does not have to physically go on-site to test the soft-starter.

Project Objectives
The parameters of the loads currently provide a big challenge to the engineer, since in most instances these are not known and not even provided by the manufacturer. The lack of having such parameters limits the effectiveness of having a dynamometer. Therefore if it is possible to obtain even just an approximation of such parameters, this would be of great value to the engineer who will be able to test and analyse such applications remotely.

Project Methodology
Carlo Gavazzi identified that one of the major applications of their soft starters, apart from induction motors to drive pumps, are compressors utilized in heat pumps. The use of the soft starter is to limit the inrush current. They also identified that the compressor is of a scroll type. Thus to emulate the scroll compressor and analyse the behaviour of the soft starters, four main objectives have to be reached. These are:

- To determine the range for the mechanical parameters describing the system such that these emulate a practical range of compressors.
- To identify the capabilities and limitations of the rig and determine the limits of emulated parameter variation, as this directly limits the range of actual compressors that can be emulated.
- To review soft starter operation and its intended range of operation.
- To analyse the effect on the soft starter starting transient of different load parameter variation.

Results and Achievements
The results include a set of Current-Time and Torque-Time characteristics that were obtained from the test rig. The achievements include the behaviour of the soft-starter when subject to different compressor loads.

Figure 1- Rig Setup

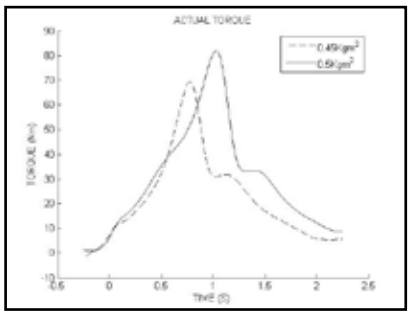


Figure 2 – Torque-Time Characteristic

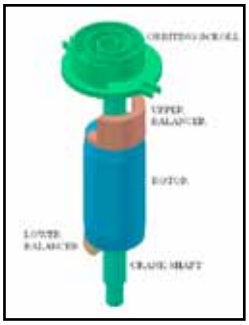


Figure 3 – Scroll Compressor design in Pro-E

Appreciation of Filter Systems

Student: Anabel Bonello
Supervisor: Prof. Carmel Pulé

Introduction

This work introduces a deeper illustration of the mathematical operators that may be used in multi dimensional filters or recognition systems, and provides the resultant waveforms, shapes and contours generated in various impulse functions that can select various parameters. Such concepts, in the areas of signal recognition and filtering would grow to produce observers as comparators which would operate continuously and supervise all activities and thus achieve corrective measures before disasters occur.

Project Objectives

- Mathematical analysis of the behaviour of systems for multidimensional signals.
- A General Recognition Function describing a Polarised filter system.
- Interpretation of the polarised Laplace Function and the Convolution Integral.
- Operation on the Impulse Function to create a more general recognition kernel.

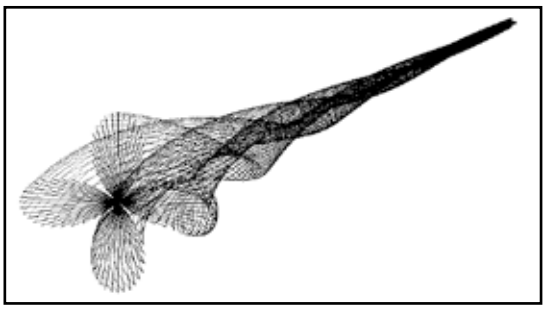
Project Methodologies

During this Project a fascinating world of space and time vector arrangement portrayed a marvellous understanding of the behaviour of signals. The following steps were carried out during the implementation of the project:

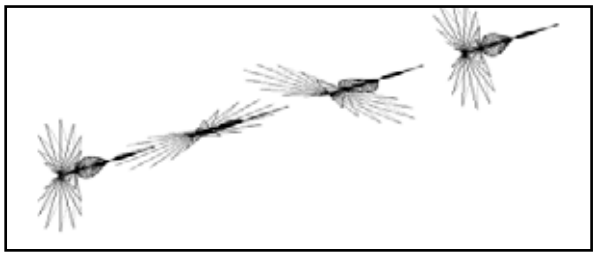
- Literature review of various analog and digital filters. Furthermore conventional results for the time and frequency responses through simulation were obtained and some characteristics and performances were observed through implementation.
- Analysing any system behaviour using important mathematical techniques, using the Laplace Transform and the Convolution Integral performed on multi dimensional signals.
- Presented an overall general recognition filter expression where it described the impulse function of a system as it selected space, position, timings, frequencies, and shapes. Futhermore polarisation in the space domain was performed on the 3 dimensional mathematical techniques.

Results and Achievements

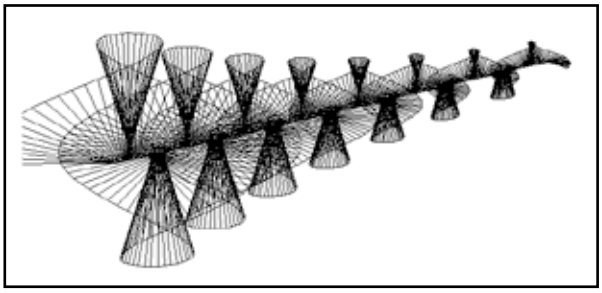
By knowing how to synthesis, the character of the system, many forms may be obtained such as the complete impulse function of vertical dipoles, lenses and optical filters. One may look upon the system kernel and the software/ideal kernel used in Laplace and Convolution Integrals to be as matrix, composed of individual elements that operate individually. These matrixes are located on a more complex non-conventional s-plane and by applying these mathematical techniques through comparing the real and software kernels, errors are found. The complex multiplication of these matrix components would produce products with and without a meaning, but it is predicted that the dot product of components of the matrix multiplication would have a useful meaning in signal and scenario recognition.



Polarised system in the space domain



Polarised system selecting timings



Polarised system selecting shapes

A maze solving robot

Student: Michaela Camilleri
Supervisor: Prof. Carmel Pulé

Introduction

The field of autonomous robotics has various applications ranging from game simulations to health and safety automations whereby such a system would be developed in order to locate the shortest route for a fire rescue operation in a building or the location of the shortest escape route during a mine explosion. As the name of this project suggests, a maze solving robot is a robot that can travel through a maze by changing its direction whenever any obstacle occurs in a particular direction. Thus such concept may be used to explore any particular hidden region without any human intervention.

Project Objectives

This project is intended to obtain experience in more than one area, including practical electronics handling information, power circuits, control systems and software engineering, which also includes a degree of activity which would be regarded as intelligence through a learning process.

A robot is required to enter an unknown maze virtually, learn to find the closed and the open paths, and decide to select on a way out of the maze to freedom. Learning through errors is permitted through the first trial and while the duration of the learning activity is monitored to see how quickly it learns, then the second trial would be covered directly without any errors. This information shall then be transferred onto the hardware version of the robot so that the maze is also solved in its hardware version.

Project Methodologies

The following is a list of the main tasks involved in this project:

1. Conduct research on the following topics:
   a. Maze creation and solving techniques
   b. Stability control
   c. Selection of an evaluation board
   d. The sensing devices available
   e. Robot building techniques (including the choice of the building components)
2. Design and development of a simulation in software for maze creation and maze solving.
3. Familiarisation with the evaluation board's features.
4. Robot hardware design and assembly – both electronic and mechanical aspects.
5. Robot software design and development.
6. Testing and improvements of the system.

Results and Achievements

The maze simulation software was implemented successfully. Figure 1 shows a 20x20 maze and its solution. Furthermore a hardware version of the robot was built as can be seen in Figure 2. The route taken by the virtual robot was then transferred onto the hardware version of the robot and this worked successfully.

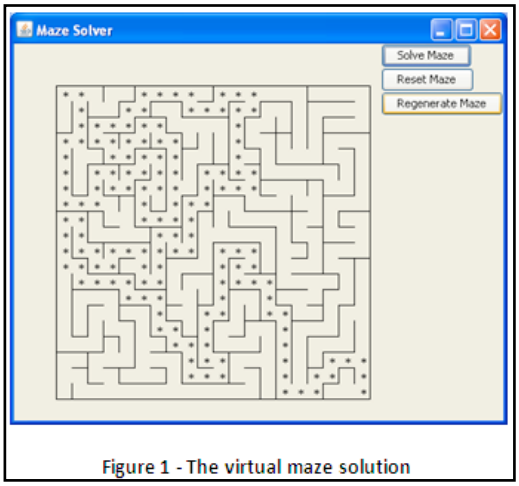


Figure 1 - The virtual maze solution

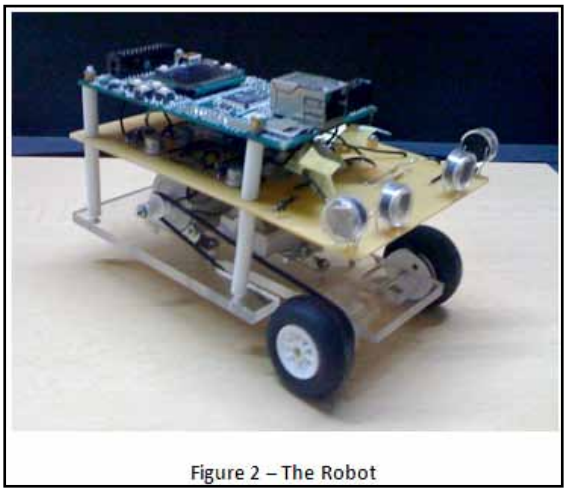


Figure 2 – The Robot

Platform Stabilization for Airborne Applications

Student: Stephen Grixti
Supervisor: Dr. Ing. David Zammit Mangion
Co-supervisor: Ing. Andrew Sammut

Introduction
Inertially stabilized platforms (ISPs) are used to stabilize a broad array of sensors, cameras, telescopes and weapon systems. Although requirements for ISPs vary widely depending on the application, they all have a common goal, which is to hold or control the line of sight of one object relative to another object or inertial space. The most widely known application of all is the use of inertially stabilized camera platforms mounted on moving vehicles such as aircraft [1].

Project Objectives
The objective of the project is the design of a single-axis stabilized platform for airborne applications and is the first departmental step towards achieving a stabilization system for a small unmanned aerial vehicle (UAV). The system should be able of isolating a light-weight payload from any pitch rotations undergone by the host aircraft.

Project Methodologies
The basic principle throughout the project was to sense the pitching angle using appropriate sensors for airborne applications and applying a counteracting torque to stabilize the payload. The project was divided into logical phases so as to ensure correct implementation at each stage:

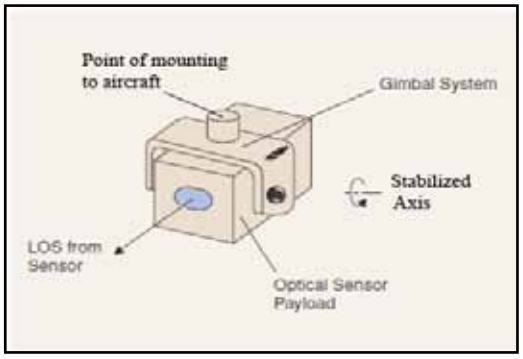
- Literature review and research of stabilized platform applications and technologies.
- Experimental setup of the gimbal-like structure and selection of components such as the driver motor and Microelectromechanical systems (MEMS) sensors.
- System modelling in Simulink® and through other analytical techniques.
- Implementation of the stabilization system using a potentiometer to sense aircraft pitch attitude.

Pitch sensing using appropriate MEMS sensors, evaluation of results and conclusions.

Results and Achievements
Satisfactory stabilization was achieved by sensing pitching attitude using a potentiometer. Formal testing and demonstration involved the use of a video camera mounted on the platform: camera line-of-sight along the pitch axis was correctly stabilized by the control system. The system is now to be further implemented and fine-tuned using the more appropriate MEMS sensors.

References
[1] J.M. Hilkert, "Inertially stabilized platform technology, concepts and principles", IEEE Control Systems Magazine, pp. 26-46, Feb.2008.
[2] M.K. Masten, "Inertially stabilized platforms for optical imaging systems, tracking targets with mobile sensors", IEEE Control Systems Magazine, pp. 47-64, Feb. 2008.

An example of a commercially available stabilized camera



The gimbal structure for single-axis stabilization [2]

UAV equipped with a stabilized camera system

Absolute positional head tracking systems

Student: Matthew Sammut
Supervisor: Mr. Marc Anthony Azzopardi

Introduction
Research is currently being carried out with regards to the design of advanced cockpit display systems, capable of presenting large amounts of data in a very short period of time. This type of cockpit display could be implemented as a Head Mounted Display (HMD) and would allow the pilot to scan a display much larger than his field of view by simply moving his head. For this to be possible the HMD has to allow the aircraft to calculate the position and orientation of the pilot's head within the cockpit. A previous project [1] involving the tracking of the orientation of the pilot's head has already been carried out however a system which tracks the absolute position is yet to be implemented. Such research is relatively new and thus allows for several innovative implementations.

Project Objectives
The objectives of this project are to design an ultrasonic absolute positional head tracking system which: processes data independent of previous knowledge so as to avoid any drift and abbe errors, is relatively cheap yet reliable and accurate with a fast update rate, is light weight and not a nuisance to the user and is able to cover a reasonable area so as not to restrict the user's movement.

Project Methodologies
The project deliverables were modularized into the following steps:

- Conducted a literature survey of different types of positional tracking systems where different systems were compared for their different pros and cons until a most suitable tracking system was decided
- After it was decided that an ultrasonic tracking system best fits the criteria, further research was carried out to determine a suitable algorithm to be used for the determination of the position of the user's head.
- Development of an ultrasonic head tracking system which involved the determination of the main subsystems required within the system, design of circuitry with the help of an electronic simulator, implementing and testing of prototype circuits, implementing the required code in microcontrollers and interfacing electronic hardware with microcontrollers.
- Production and analysis of results with varying parameters. This involves observing the accuracy of the computed position of the user's head and also analyzing the variation of the update rate of the system for different conditions.

Results and Achievements
Results include the analysis of the accuracy of the pilot's head position: while static, during movement and when subject to different temperatures. In addition to this the update rate is also to be analyzed at different conditions. Simulation results have shown that a satisfactory accuracy can be achieved. Future work is suggested involving the data fusion of the absolute position of the pilot's head together with its orientation in order to achieve a more accurate result.

References
[1] Fonk K., "Inertial measurement in light-weight head-mounted display systems", Unpublished, B. Eng. Dissertation, Department of Electronic Systems Engineering, University of Malta, Malta, 2009.

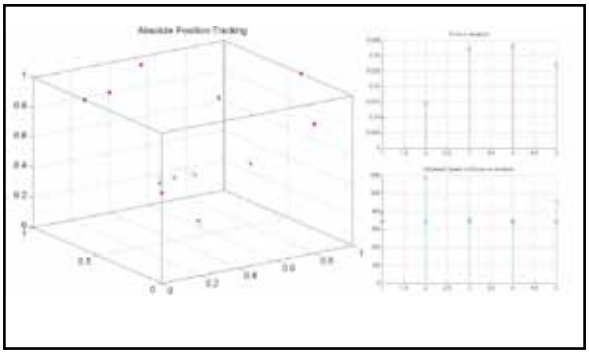


Figure 1: Typical Simulation Result

Person identification using brain signals

Student: Allister Bezzina
Supervisor: Ms. Tracey Cassar

Introduction

Throughout the years, several biometric systems have been developed. The goal of a biometric system is to identify a person from a known group of individuals. Traditional biometrics, such as those based on fingerprints and iris scanning, have been challenged since they are susceptible to forgery. A recent development is the use of brain signals, recorded non-invasively from the scalp through electroencephalography (EEG), leading to an EEG-based Brain-Computer Interface (BCI). Such a biometric is possible as it is known that brain signals are unique for each individual, and such an approach is advantageous as brain activity cannot be duplicated.

Project Objectives

The goal of this project is to develop a biometric system using EEG recorded data which is easy to implement and which can reliably identify the subjects being investigated.

Project Methodologies

The following steps were carried out to reach the goals of the project:

- A literature review of commonly employed techniques at each stage of the EEG-based biometric process (shown in Figure 1) was carried out to assess the benefits and limitations of each method and identify which approach is most suitable to implement.
- Analysis of the available EEG data was undertaken to determine the differences that exist across subjects.
- Autoregressive (AR) modelling was applied for the feature extraction stage followed by a Linear Discriminant Classifier (LDC). These were tested on simulated data and later applied on real EEG data. The advantages (if any) of a bivariate approach over a univariate approach were investigated and the use of more than one mental task for a possibly more robust biometric system was analyzed.

Results and Achievements

Autoregressive features to characterize the EEG data of each individual, followed by a linear discriminant classifier, resulted in an effective biometric system. The results show that the classification scores for the bivariate approach were substantially better than those for a univariate approach (Figure 2a), probably due to the functional connectivity that exists between different brain regions. Furthermore, the performance of the biometric system was enhanced when more than one task was considered (Figure 2b). The highest classification score was obtained for a bivariate 2-task system where an average classification of 97.78% was obtained.

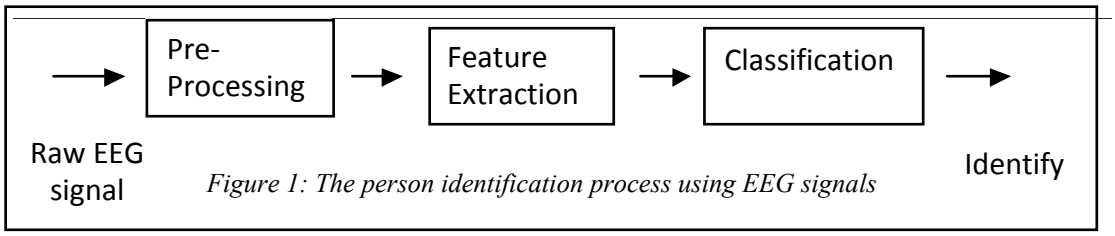


Figure 1: The person identification process using EEG signals

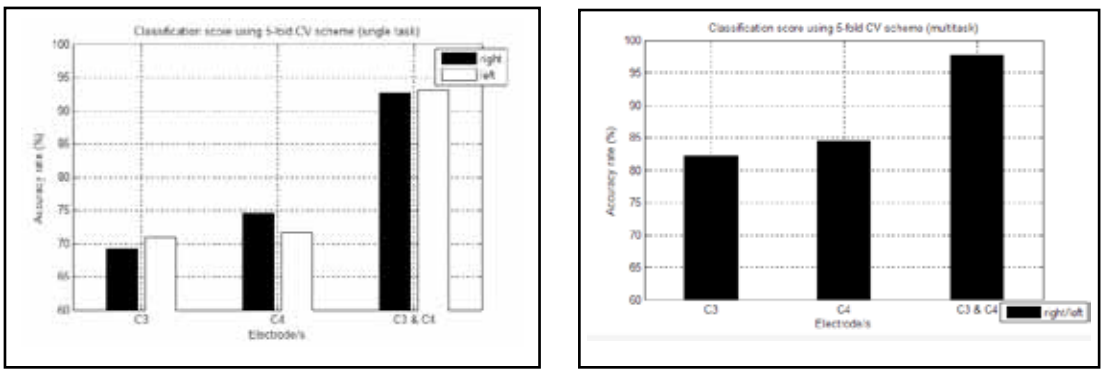


Figure 2: Percentage classification scores obtained for single tasks (a) and multiple tasks (b). Univariate and bivariate scenarios were investigated in both cases, with the bivariate models (C3 & C4) producing higher scores. Furthermore, a better accuracy rate was obtained in the multitask environment (b).

Simulation Models for Control using the Modelica®/Dymola® Environment

Student: Matthew Paul Cassar
Supervisor: Ing. Marvin K. Bugeja

Introduction
Different types of underactuated inverted pendulum systems were controlled using a modelling program named Dymola® that is a commercial front-end for Modelica®.

Project Objectives
The main objective of this project was a 3D animation of four different types of inverted pendulums. The pendulums were designed with a complete control algorithm, which was able to swing-up the pendulum from the downward natural pendant position to the upward inverted position. Once the pendulum was in a region close to the inverted mode, it was then stabilized and maintained inverted.

Project Methodologies
The fore mentioned objectives were tackled by:

- Modelling the plants using Modelica®/Dymola® - component based approach.
- Verification of results by comparing them using Modelica®/Dymola® - equation based approach and also using another modelling program called Matlab®/Simulink®.
- A swing-up control algorithm was designed that swings the pendulum from the downward pendant position towards the inverted position.
- A stabilizing controller was designed to stabilize the pendulum around the neighbourhood at the upper equilibrium point.
- A transition algorithm was designed that switches from the swing-up controller to the balancing controller and vice versa.
- The complete control algorithm was implemented using Modelica®/Dymola®.

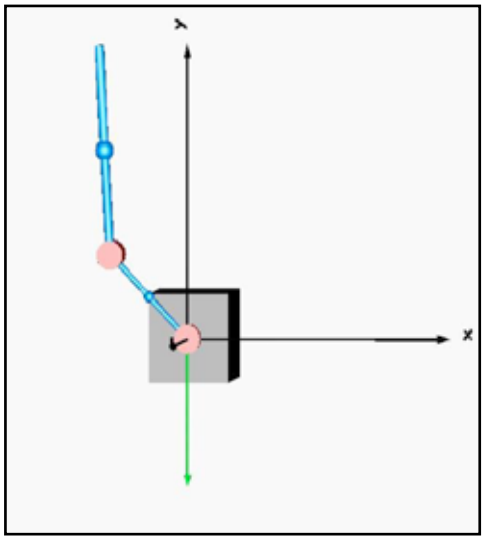


Figure 1: Dymola-Modelica visualization of Pendubot

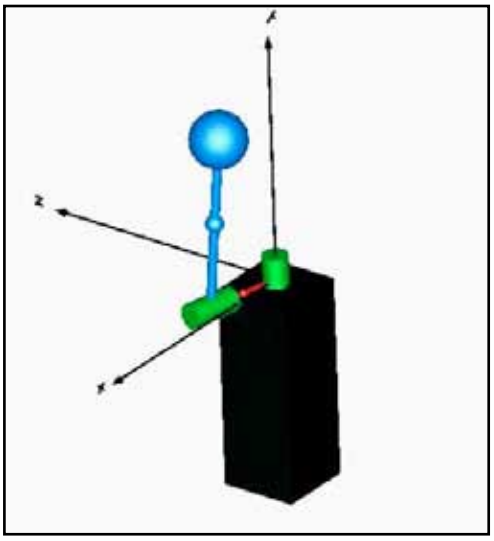


Figure 2: Dymola-Modelica visualization of Furuta

Control of a Robotic Finger using Shape Memory Alloy Actuation

Student: Mario Cauchi
Supervisor: Prof. Ing. Simon G. Fabri
Co-supervisor: Dr. Ing. Michael A. Saliba

Introduction
This project presents a complete redesign of the 1-link robotic finger done in a previous final year project "Control of a Robotic Finger with Non-Conventional Actuators" [1]. The current project aims to achieve a compact 3-link robotic finger using Shape Memory Alloy (SMA) actuation. This 3-link robotic finger will eventually form part of a complete robotic hand that can be used for various applications such as prosthesis and humanoid mechanical robots.

Project Objectives
The aims of this project are to: (i) Review previous dissertations and published papers on the control of robotic fingers using SMA actuators. (ii) Familiarization with the mechanics of robotic fingers. (iii) Extension of last year's 1-link robotic finger into a 3-link robotic finger. (iv) Design, development, testing and implementation of the finger's actuation and interface electronics. (v) Design, development, implementation and testing of variable structure control schemes for the control of the robotic finger.

Project Methodologies
The project's methodology adopted was as follows:

- Literature review on SMA non-conventional actuators, review of previous dissertation [1], and review of published papers on robotic fingers using SMA actuation.
- Design and fabrication of the 3-link robotic finger.
- Modelling of robotic finger's model, building and verification of electronic circuits, and familiarization with dSPACE© 1104 Control Board and Control Desk interface system.
- Design and simulation of an automatic position control system, using variable structure control.
- Acquisition and analysis of simulation and experimental results from simulation model and actual robotic finger setup.

Results and Achievements
The robotic finger was fabricated and set up at the lab for testing. The results obtained from both system modelling and from the actual robotic finger setup using variable structure control for automatic position control, show that the output angles track and follow the reference angle input applied to the system. Satisfactory results from trajectory control were also obtained. Therefore when position coordinates are input into the system, the robotic finger will successfully follow the path to that desired position.

[1] N. Aquilina, "Control of a Robotic Finger with Non-Conventional Actuators," B. Eng(Hons) dissertation, 2009.

Simulation of Flight Control for an Autonomous Helicopter

Student : Luana Chetcuti Zammit
Supervisor : Dr. Kenneth Scerri

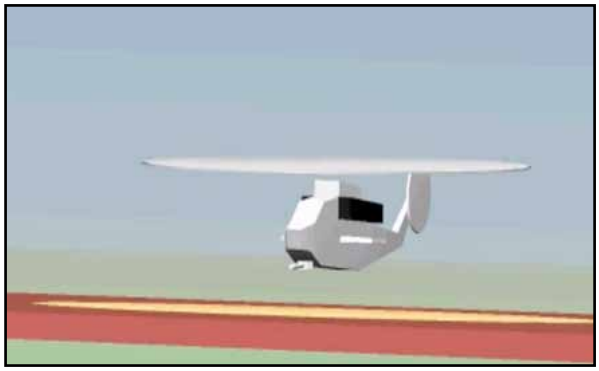
Introduction
The main objective of the thesis was to model the behaviour of an autonomous helicopter, the Yamaha R-50 model helicopter, using Mathworks Simulink™ and to build controllers to stabilize the system under different flight conditions. My motivation in helicopters resulted from their advanced capabilities and great flexibility. Besides having the ability to hover, an autonomous helicopter can perform tasks which would be difficult or hazardous for a manned vehicle. Furthermore, the aircraft flying qualities are very much affected by the pilot's actions as a controller as he is a key element in the system. Even the most skilled pilots make fundamental errors when confronted with real-life scenarios. Therefore an autonomous helicopter was designed to ensure flight safety during all flight conditions.

Project Objectives
The project proposal describes a four point plan to attain autonomous flight in a helicopter, which includes the design of a detailed simulation model including the helicopter dynamics, kinematics and aerodynamics, linearization of the model, comparison of the linear and the nonlinear model, and the design and implementation of control strategies for the desired flight envelopes.

Project Methodologies
The flying task of a helicopter, was visualized as a closed loop feedback system with the pilot as the key sensor being highly trained and experienced. Pilots get the data from the outside world and instruments displays. They are able to judge the quality of the flight performance through the received data, and control inputs are applied to produce the required corrections. Various outside disturbances are also present including wind and humidity which affect the flight performance. In the case of autonomous helicopters, the pilot is replaced by a controller. Furthermore, the helicopter was considered to be an arrangement of multiple interacting subsystems. The main rotor element, the fuselage, the powerplant, the flight control system, the empennage and the tail rotor elements and the resulting forces and moments all contributed to this system. Physical principles and laws were used to describe the system behaviour. To create a simulation environment, that can be used for real flight testing, a high accuracy level was required. For the development of controllers, simplifications were required without deteriorating the final result. The observed outputs of the system included the position in the x, y and z direction, the linear velocity in the x, y and z direction, the rotation about the x, y and z axis and the angular velocity in the x, y and z direction of the helicopter. These are fed back, to get the required input to make the system remain stable during all flight conditions, without the presence of a pilot. Simulation results were observed using the Matlabs Virtual Reality toolbox in Matlab and the Flight Gear Animation Block [1].

Results and Achievements
The derived nonlinear equations for each block, were linearized about hovering to get the linear behaviour of the system. State space modeling was used to model the dynamics of the system, and eventually optimal controllers were implemented for hovering, using this derived state space model. The optimal controller, working on the linear model, managed to stabilize the helicopter in this condition, getting the states from their initial value, reaching asymptotically the zero, equilibrium point of the helicopter. The basic limitation of the optimal controller design was that the controller was guaranteed to work only in the neighbourhood of hovering. Gain scheduling was implemented to extend the validity of the linearization approach to a range of other operating points. In all, a total of five controllers were designed for hovering, landing and takeoff, carrying out a soft changeover between controllers, depending on its flight behaviour, while still ensuring stability to the system at different flight envelopes. Fuzzy logic will be implemented next, to ensure stability of the system during changeover of controllers.

References
[1] http://www.flightgear.org/



The following is a screenshot taken during one of the animation results for takeoff.

Active control of vibrations in a cantilever beam

Student : Wanda Gauci Minuti
Supervisor : Prof. Ing. Simon G. Fabri

Introduction
Active control of mechanical vibrations is mainly concerned with low frequency vibrations in the range of 0.3Hz to 500Hz and is investigated in a variety of fields and applications with the aim of achieving safe operation of machine tools, reduced human discomfort in helicopters and super yachts, improved performances of precision industrial processes such as in the semiconductor industry, as well as in large space structures and bridges. As technology develops it makes it cheaper and simpler to build intelligent structures with actuators and sensors highly integrated into the structure, instead of traditional bulky damping techniques [1].

Project Objectives
The objectives of this project are to:

- Review Active Vibration Control systems and work done in 2009 project [2].
- Obtain a more accurate mathematical model of the beam using Timoshenko Beam Theory
- Design, code and simulate an active vibration control algortihm.
- System implementation and performance evaluation, also by comparing with results obtained in last year's project.

Project Methodologies
A smart structure, in this case an aluminium beam with piezoelectric transduces, is employed experimentally to sense an external disturbance and respond to that with active control in real time to reduce the unwanted vibrations. The following steps were carried out during the implementation of the project:

- Literature review on Active Vibration Control, and its implementation on flexible smart cantilever beams and review of the work done in last year's dissertation by Dimech [2].
- Plant modelling using Timoshenko Beam Theory and implementation in MATLAB®.
- Controller Design and simulation using Sliding Mode control technique for vibration suppression.

Implementation on hardware setup and comparison of results for new controller and beam model with those in [2], where Euler-Bernoulli Beam Theory and Optimal Control techniques were investigated.

Results and Achievements
Simulation results obtained so far has shown that Sliding mode control achieves better vibration suppression than the best performance achieved previously by Model Predictive control. Further tuning is required for results on actual setup implementation to be obtained.

References
[1] Andre' Preumont. 'Vibration Control of Active Structures An Introduction',2nd Edition. Kluwer Academic Publishers, Dordrecht, 2002.
[2] S.Dimech. 'Active Noise and Vibration Control'. B.Eng Dissertation, University of Malta, Malta, 2009.

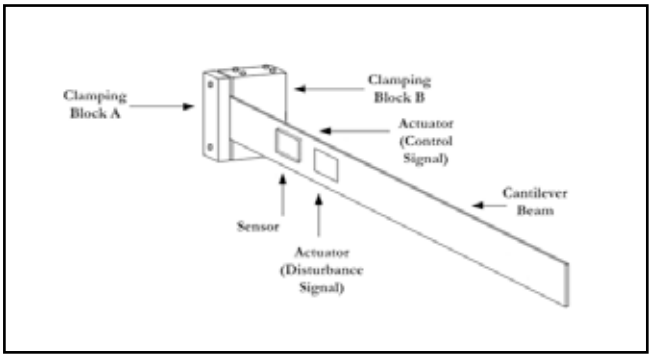


Figure 1: Mechanical Experimental setup of cantilever beam [2]

Nonlinear Control of a Rotational Inverted Pendulum

Student: Martin Micallef
Supervisor: Ing. Marvin Bugeja

Introduction
Nonlinear control techniques are very important when it comes to the design of practical systems, since real life problems are inherently nonlinear. Nonlinear control has proved to be very challenging since different techniques can prove to work on some systems but not on others. Critical issues, like checking the stability of the system are not routine task anymore but become very complex due to the nonlinear dynamic equations. In real life situations it's not always possible to linearize the model around some equilibrium point and work with very limited range. Other challenging situations involve parameter uncertainties. If parameter uncertainty is not taken into consideration the system's stability may be compromised. In such situations nonlinear control can provide wider range of operation and robustness to parameter uncertainties.

The Furuta pendulum is an excellent test-bed for control algorithms, because it involves stabilization issues which are common to a number of real-world problems. This setup has attracted a lot of research because:

1. It has a complex nonlinear dynamic model
2. It is an under-actuated system
3. It is a non-minimum phase system

Project Objectives
The main aim of this thesis is to study different nonlinear controller design techniques and apply them, to the Furuta pendulum when possible.

The challenge of controlling inverted pendulums is usually approached in a two-fold manner: swinging the pendulum and stabilizing it once it is up. Traditionally, controllers for the stabilization region operate within a very limited range (e.g. 15 degrees) since they are designed on a linearized model. If a pendulum is disturbed beyond this small range it would fall. Nonlinear control should provide better range of operation in both pendulum angle and speed with respect to the previous linear controllers implemented.

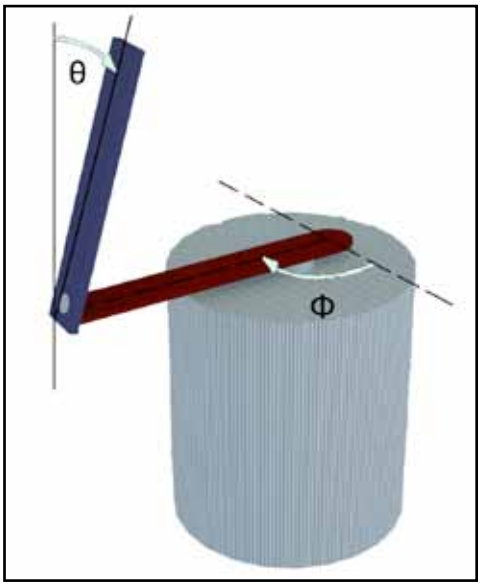
Project Methodologies
The study and implementation of the following project attained to the following procedure:

- Literature review was carried out to study different nonlinear techniques. Some techniques that seemed appropriate to be used on the Furuta pendulum were selected and thoroughly studied.
- The mathematics behind these algorithms was worked out for the Furuta pendulum. Some techniques were discarded during this stage either because of their mathematical complexity or because they were not possible to be implemented on system.
- Controllers were designed with the techniques that were successful. These controllers were then implemented on simulation and tuned to give the best results.
- After simulation the controllers were then tested on the plant itself and tuned heuristically to achieve satisfactory performance on the physical setup itself.

The different nonlinear controller design techniques studied include:

- Input-state linearization
- Input-output linearization
- Lyapunov redesign
- Sliding mode control
- Gain scheduling control
- Inverse dynamics controller

Results and Achievements
Nonlinear control yielded excellent results. In simulation one of the controllers namely the Input-output linearization coupled with an LQR controller managed to catch the pendulum from a starting angle of 65degrees. Improvement was also noticed on the plant itself however such large angles cannot be achieved due to the limited torque in the motor of the Furuta pendulum plant.



Robot Manipulator Control

Student: Raymond Muscat Micallef
Supervisor: Prof. Ing. Simon G. Fabri

Introduction
Robotic manipulators are used in industrial applications for a wide range of tasks including assembly, welding, pick-and-place applications, and other manufacturing applications, and even in more critical situations such as surgery. It is the controller that gives the robot its utility and adaptability. Hence the controller must accurately direct the robot to perform its specified task. As robots increase in complexity, they become more difficult to model and this poses a problem to control them effectively and accurately. Robot dynamics are highly coupled and nonlinear. Their dynamics may also change when handling object of different weight. Intelligent controllers can be used to estimate any time-varying parameters and to adapt to different situations.

Project Objectives
This project is a continuation of other projects. Previous projects evaluated the use of Radial Basis Function (RBF) Artificial Neural Networks to estimate nonlinear and unknown parameters to implement a real-time Adaptive Control Scheme. However, RBF neural networks suffer from the 'curse of dimensionality'. As the robot becomes more complex, increasing the degrees-of-freedom, the number of neurons needed increases exponentially. The adaptive control scheme could not be implemented in real-time due to processor and memory limitations. It was also concluded that the use of Multi-Layer Perceptron (MLP) Neural Networks might be a solution since typically MLP networks require less neurons with respect to RBF networks.

The main objectives set out for this project are:

- Design and implementation of a 2-finger gripper for the 3 degrees-of-freedom robotic manipulator available in the laboratory.
- Mathematical modelling of the modified plant using Simulink©.
- Design of an Adaptive Control Scheme employing MLP Neural Networks for the arm and the gripper.
- Interfacing the controller with the actual plant using the dSPACE© hardware environment.

Project Methodologies
The following plan was formulated for the project:

- Research, design and fabrication of the 2-finger gripper and wrist for the manipulator.
- Review of previous dissertations and literature on the use of Neural Networks for Robot Manipulator Control.
- Review of the Extended Kalman Filter for training MLP Neural Networks.
- Selection of motors for new joints and evaluation of available motors to assess if they meet torque requirements of the new modified plant.
- Mathematical dynamic modelling of the plant including the gripper and wrist.
- Design and simulation of Proportional Integral (PI) Controllers for the new motors.
- Design and simulation of the Adaptive Position Controller using MLP Neural Networks.
- Simulation of a non adaptive Inverse Dynamics Controller to verify the correctness of the plant model.
- Design of the electronics to interface the manipulator with the dSpace© environment.

Results and Achievements
MLP Neural Networks have the potential of requiring a significantly lower number of neurons when compared to RBF Neural Networks. Thus MLP Neural Networks can be used in real-time adaptive control for complex plants. However, tuning the networks, especially the initial unknown parameters, can prove a difficult task, also because the Extended Kalman Filter is not an optimal estimator and so it can quickly diverge leading to an unstable system.

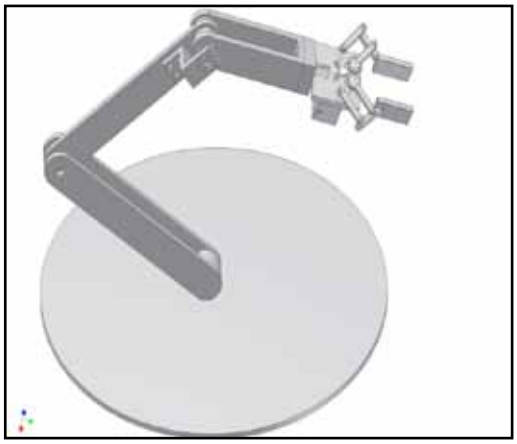


Figure 1: Model of the modified manipulator

Model predictive control for a ball-balancing system

Student: Peter Spiteri
Supervisor: Dr. Kenneth Scerri

Introduction
The Ball-Balancing System is a popular control system project. This is mostly due to its use in learning about applying control to stabilize an otherwise unstable system, and also to its interesting aesthetics. The setup mainly consists of the wheel and the ball, and several electronic boards where the wheel is set to stably hold the ball in one dimension. This system is extremely unstable and so it is a good case in point to test controllers, where in this case a model predictive controller was implemented. This controller is an interesting one since it is very intuitive and is related to the human behaviour whereby we select the control actions which we think will lead to the best outcome now and in the predicted future [1]. Moreover, Multiple-Input Multiple Output (MIMO) systems can be handled very easily [2].

Project Objectives
This project is a continuation of two previous undergraduate projects [3], [4], where the main objective is to balance a ball on a wheel as shown in Figure 1, using a suitable controller. The ball is free to roll on the outside circumference of the wheel. Prior to designing the model predictive controller, all the boards available needed extensive servicing and so the boards had to be tested separately to get the system back to work in a satisfactory manner.

Project Methodologies
The subtasks carried out to reach the final aim include:

- Familiarization with the existing system
- Research on ball-balancing systems and their controller, mainly model predictive control
- Testing and tuning of the existing hardware and repair if necessary
- Model predictive control development
- Simulation of the set-up using previous controllers and model predictive control
- Implementation of the controller on the actual set-up
- Analysis of the practical results

Results and Achievements
Results have shown that the controller designed is capable to handle the desired task. The controller manages to stabilize the system with certain initial conditions. Once the ball is stabilized on top of the wheel, it can handle as well external disturbances such as manually hitting the ball.

References
[1] Rossiter J. A., "Model-Based Predictive Control: A Practical Approach," CRC Press, 2004
[2] Camacho E. F. and Bordons C., "Modern Predictive Control," Springer, 2007
[3] Camilleri A., "Design of a Linear Quadratic Regulator for a Ball-Balancing System," Thesis, University of Malta, 2003
[4] Spiteri R., "Robust Control for a Ball-Balancing System," Thesis, University of Malta, 2004

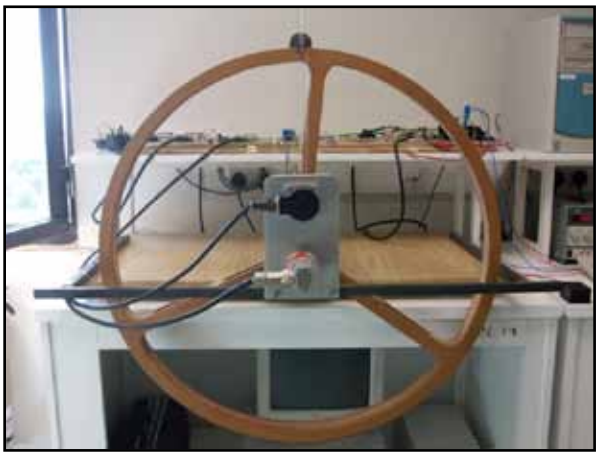


Figure 1: The Ball-Balancing System

Classification of Physical Movement Based on Human EEG Data

Student: Ingrid Vella
Supervisor: Dr. Kenneth Scerri

Introduction
Electroencephalography (EEG) is the electrical neural activity of the brain. It represents brain function and status of the whole body and can thus be used in Brain Computer Interfaces (BCI) with the aim to energize paralyzed organs or bypass the disabled parts of the human body.

Project Objectives
The main goal of this project is to allow the development of BCI systems to distinguish between left and right limb movement in people.

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

- Literature review of current BCI techniques
- Preprocessing of the EEG data to remove data at very low frequencies attributed mainly to breathing, data at frequencies higher than those known in literature to be attributable to movement, and ocular artifacts.
- Epoching of the data to identify sections during which the subject moves the left or right hand.
- Fitting univariate AutoRegressive (AR) and SpatioTemporal AR (STAR) models to the filtered data
- Model validation
- K-means clustering of AR parameters

Results and Achievements
Univariate AR models applied to each epoch of the filtered data for the first subject gave the AR2 parameters during left and right hand movement shown in Figure 1. The '+' markers represent the parameters estimated during left limb movement while the 'o' parameters represent the parameters estimated during right limb movement. Figure 2 shows the estimated parameters from AR2 parameters classified into two clusters.

The percentage proportions of correctly classified parameters in each cluster are given in the following table.

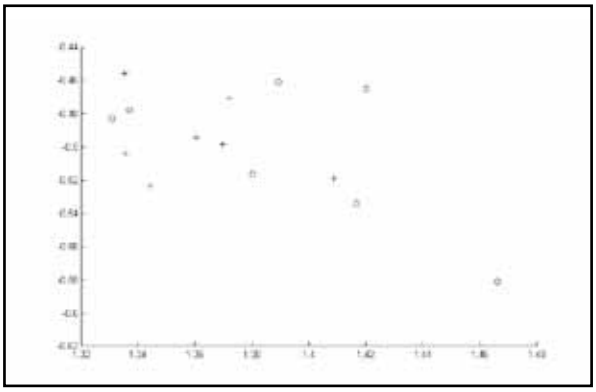


Figure 1: AR(2) parameters during left(+) and right(o) movement

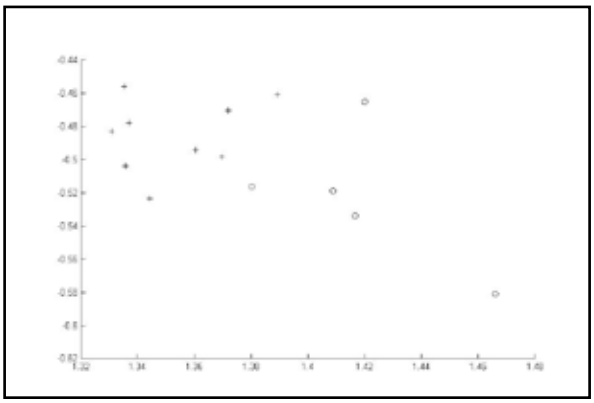


Figure 2: AR(2) parameters clustered as left or right limb movement

The final part of the project involved clustering of parameters for a wide range of people, and using higher order models.

	Cluster 1	Cluster 2
Left	57%	43%
Right	14%	86%

Implementation and Control of a Ball and Plate System

Student: Minette D. Vella
Supervisor: Ing. Marvin Bugeja

Introduction
The Ball and Plate control system is a two dimensional extension of the traditional ball and beam system whereby the objective is to balance a free moving ball on a flat plate. This is achieved by tilting the plate, by means of two motors, accordingly. The problem is of particular interest because the system is nonlinear and open-loop unstable, meaning that once the ball is moving, it will roll off the end if no action is taken. Among the interesting challenges of the problem is the indirect control of the ball via the plate tilt angles. This balancing problem is a good control test bed for applications in robotics, mobile vision systems as well as transportation systems.

Project Objectives
- Literature review on the control of the ball and plate problem.
- Design and implementation of a simulation model of the ball and plate system.
- Design and implementation of the actual ball and plate setup.
- Implementation of the necessary control algorithms.
- Design and implementation of the necessary electronics for data acquisition and computer interface
- Testing and evaluation of both simulation and experimental results.

Project Methodologies
The following steps were carried out during the implementation of the project:
- Literature review regarding suitable modelling techniques.
- Identification of a suitable mathematical model to represent the physical Ball and Plate Structure
- Verification of suitable algorithms on the simulation model emulating the actual setup.
- Construction and fabrication of the actual Ball and Plate Structure.
- Design and implementation of all the necessary electronics to interface the mechanical setup to the computer-embedded data acquisition card for a complete hardware-in-loop system.

Results and Achievements
The results obtained show that all the designed controllers involved to complete the control task work as desired.

References
[1] Cheng Char Ker, Chin E.Lin, Rong Tyai Wang, "Tracking and Balance Control of Ball and Plate System", Journal of the Chinese Institute of Engineers Vol. 30, No. 3, pp 459-470 (2007).
[2] Shorya Awtar, Kevin C.Craig, "Mechatronic Design of a Ball and Plate Balancing System".
[3] Greg Andrews, Chris Colasuonno, Aaron Herrmann, "Ball on Plate Balancing System", Final Year Project Report, Rensselaer Polytechnic Institute, April 2004.
[4] Steve Zahra, "Control of a Rotational Inverted Pendulum", B.Eng (Hons), thesis, University of Malta, Msida, Malta, 2009.

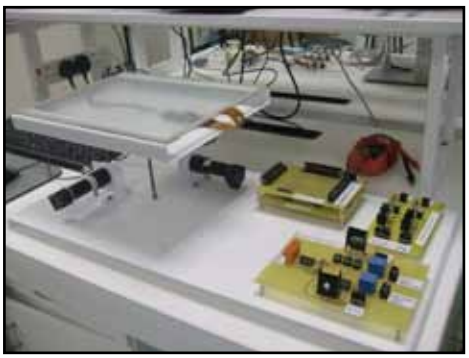


Figure 1. Ball and Plate Setup

Error Concealment Techniques in Multi-view Video

Student: Paula Aquilina
Supervisor: Dr. Ing. Carl James Debono

Introduction
3D video is expected to revolutionise home and mobile entertainment. 3DTV requires a standardised codec that can support multi-view, this standard is still being developed. Multi-view video has other applications apart from 3DTV, it can be used for tele-presence (video-conferencing in 3D), free-view point video, medical purposes and gaming.

Project Objectives
The objective of this dissertation is to emulate a real-time wireless multi-video system and to perform error concealment on the frame information that was corrupted during transmission.

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

- Search for the latest version of the Joint Multi-video Coding software (JMVC ver. 5.05) which mimics the latest version of the standard available when work on this dissertation commenced.
- Literature review of the following areas:
  1. Overview of the main features of H.264/AVC.
  2. Study of various error resiliency tools.
  3. Study of the H.264/AVC bitstream.
  4. Errors in a wireless channel and their effects.
  5. Study of the various types of error concealment techniques available.
- Study of the JMVC software model to understand how it works and its current capabilities.
- Modification of the encoder in order to allow the division of a frame into various slices and to provide a coding structure which is suitable for real-time transmissions.
- Modification of the assembler to cater for the division of a frame in a number of slices.
- Simulation of the wireless channel was using MATLAB.
- Alteration of the decoder to allow the acceptance of corrupted slices and perform error concealment to replace the erroneous information received.
- Testing the effectiveness of the concealment methods used.

Results and Achievements
Error resiliency tools were implemented to make concealment possible. A wireless channel to create both random and burst errors was simulated. The decoder was modified in order to accept corrupted slices. The macroblocks whose information is lost are first filled with zero and later concealed. Temporal concealment was used, where applicable. This technique exploits information from past frames to conceal the lost information. Inter-view concealment was also implemented on anchor frames for views 1 and 2, where information from neighbouring views is used. A third type of concealment, spatial concealment, which estimates the value for every pixel lost by averaging the value of the nearest available pixels was also implemented.

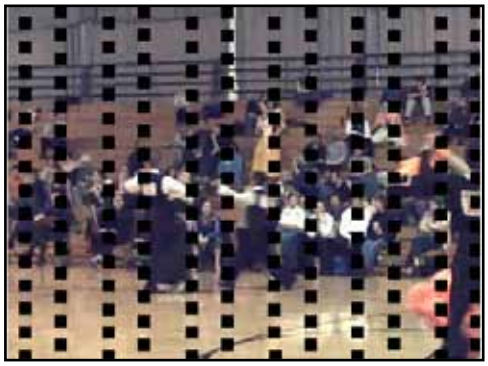


Figure 1: Corrupted image with no concealment

Figure 2: Corrupted image after concealment

Vision-Based Surveillance System

Student: Leanne Attard
Supervisor: Dr. Ing. Reuben Farrugia

Introduction
Due to the numerous amounts of surveillance cameras available, security guards seem to be ubiquitously watching over us. However, the number of existing cameras exceeds the number of humans to monitor them and the supervision of all the sensors' output is costly. Thus, video footage from cameras is most often only used as a forensic tool after the fact. This suggests the need of an intelligent video surveillance system providing continuous 24-hour monitoring, replacing the traditional ineffective systems. In this dissertation, a vision based surveillance system is implemented.

Project Objectives
The main aim of this project is to investigate the use of computer vision algorithms for the implementation of a surveillance system. Initially, motion detection for obtaining the moving objects in the scene is carried out. An object classification technique is then used to recognise the category to which the detected moving components belong. The last step involves the determination and recording of the location of humans or vehicles in the scene throughout a set of consecutive frames.

Project Methodologies
The work involved in this project was conducted as follows:

- Literature review in the area of Motion Detection, Object Classification and Object Tracking
- Design of the algorithms to achieve the aims mentioned in the previous section
- Acquisition of image datasets for the classification section of the system
- Implementation of each part of the system using MATLAB
- Verification of the proper behaviour of the system by testing the algorithms on video sequences previously used in computer vision workshops

Results and Achievements

- Motion detection was achieved by background subtraction. A shadow removal technique was implemented. Post-processing was applied to suppress noise and label connected components.
- The HOG feature was used to characterise the objects. Support vector machines were used for classification, achieving an average of 97% accuracy.
- Colour and distance cues were used to track objects with high accuracy.

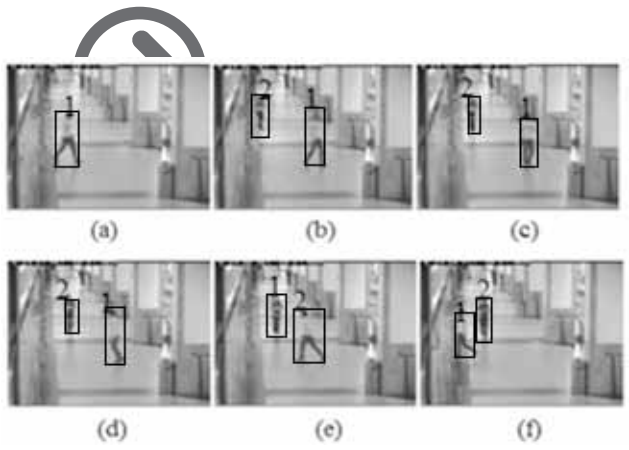


Figure 1: Frame sequence showing identity of two persons before and after they intersect.

Figure 2: Trajectory information of the centre coordinates of the tracked objects.

Investigation of the Body Coupled Communications Channel for Body Area Networks

Student: Simon Attard.
Supervisor: Dr. Ing. Saviour Zammit

Introduction.
As time goes by, powerful portable consumer electronics surrounding the human body are always becoming more popular. Miniaturization of complex electronics into small devices has reached a remarkable level. These two facts have created a need for Body Area Networks (BAN), which are networks that connect together devices placed in, on, or in close proximity to the human body. There are various applications for BANs, for example connecting on body sensors for wireless health monitoring of patients and for fitness monitoring of athletes. Other uses of BANs are in gaming, entertainment and other consumer electronics applications [1].

The motivation behind investigating the Body Coupled Communications (BCC) channel is that it offers a very good alternative to traditional wireless RF communications for connecting BANs. Some good characteristics of BCC channels are low attenuation, low signal variability due to body movement and the signal energy is mostly kept in human body proximity [2].

Project Objectives.
The main objectives of this study were to obtain a better understanding of how the capacitive BCC channel behaves under various different circumstances and afterwards obtain a model for this channel.

Then the physical layer issues are tested. Such tests include the comparison of the performance of different modulation schemes. A physical layer system for capacitive body coupled BAN is developed.

Project Methodologies.
First an extensive literature review was done on the basic principles behind the BCC mechanism and on the several requirements and challenges of BANs. Then the measurement setup was prepared. Various experiments were conducted and the results obtained were recorded. The BCC channel was investigated under static body conditions and also under moving body conditions. The results obtained were used to derive a model for the capacitive BCC channel.

When all the channel characteristics measurements were taken, a setup which was used to investigate the physical layer issues was developed. This setup was used to test the performance of several different modulation schemes and measure the bit error rates for different transmitted powers.

After obtaining an understanding about the capacitive BCC physical layer, it was decided to develop a Frequency Hopping Spread Spectrum (FHSS) system, because such as system had several properties which were ideal for BANs. When the system was ready, it was tested.

Results and Achievements.
Several interesting results were obtained from the experiments, such as the propagation loss under static conditions, the effect of movement and the amount of off-body radiation. It was found that the best frequency band for communication was between 250MHz and 500MHz and that it was possible to use small couplers and still obtain a good performance. In the second part of the study, it was found that Minimum Shift Keying was the best performing modulation scheme. The FHSS system which was designed worked according to plan.

References.
[1] Maulin Patel et al., "Applications, Challenges, and Prospective in Emerging Body Area Networking Technologies", IEEE Wireless Communications, February 2010, pp. 80 – 88.
[2] N. S. Mazloum, "Body Coupled Communications: Experimental Characterization, Channel Modeling and Physical Layer Design", M.S. Thesis, Chalmers University, 2008.
[3] M. A. Hanson et al., "Body Area Sensor Networks: challenges and Opportunities", The IEEE Computer Society, January 2009,vol. 42. No. 1, pp. 58-65.

An Autonomous Cognitive Radio

Student: Therese Attard
Supervisor: Dr. Ing. Adrian Muscat

Introduction

Cellular calls do not always result in the cheapest calls. From the results of a survey that was carried out, it was noted that most people make use of expensive cellular rates without taking into consideration cheaper technologies, such as VoIP and fixed line calls. In this project, a mobile application that estimates the cheapest calling rate for a particular contact is designed. The algorithm considers the call priority and the call log statistics (the average call duration and the probability of the contact answering the call) to select the best available technology for the user at a given time instant. The call statistics are generated by the algorithm from time domain call log data and the call priority is defined by the user. The algorithm transforms the mobile phone into an autonomous cognitive phone that negotiates and takes action on behalf of the user [1]. The limitations of the proposed autonomous cognitive radio are discussed, including seamless handover setup from the user's side.

Project Objectives

The main project objectives are to:

- Collect data on current services available, including local tariffs schemes for cellular and fixed line calls;
- Develop conceptual architecture/s for the Autonomous Cognitive Radio (ACR);
- Calculate gain at the user's end, given the ACR architecture;
- Identify limitations, restrictions and gaps in the proposed system;
- Demonstrate a sample of the ACR functions on a smartphone.

Project Methodologies

The project considers solutions for the lowest call rate system that can be implemented from the user's point of view. During the implementation of the project, the following steps were carried out:

- Literature review of current technologies and concepts, such as VoIP and cognitive radio;
- Analysis of survey results to understand user profiles and call patterns;
- Development of the ACR as a mobile phone application, which considers a user's call pattern in order to predict the lowest rated call;
- Discussion of the limitations of the ACR and the possibility of a seamless handover from user's side.

Results and Achievements

The ACR algorithm described above has been designed by keeping the user's interest as the main point of interest. Three priority call types (Cheapest, Balanced, and Fastest) have been successfully deployed on the mobile device. Further functions, including handovers, have been projected and discussed.

References

[1] J. Mitola. Cognitive Radio Architecture: The Engineering Foundations of Radio XML. Hoboken, NJ: Wiley, 2006.

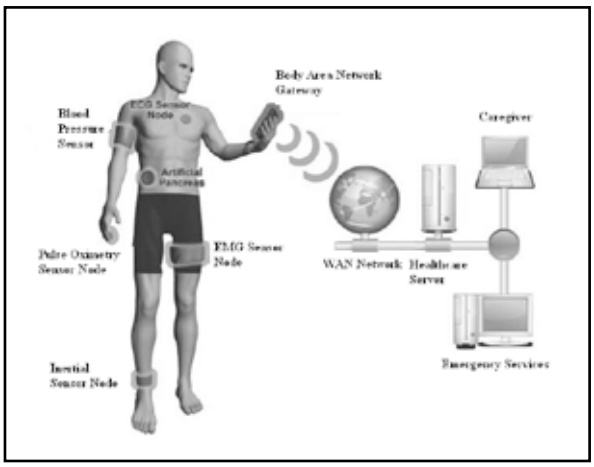


Fig.1. Typical BAN for health monitoring [3].

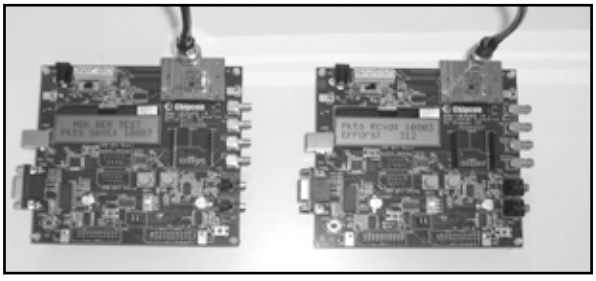


Fig. 2. Hardware used for BER testing and FHSS system.

Wireless Online Paying System

Student: David Busuttil
Supervisor: Dr. Ing. Carl James Debono

Introduction
Nowadays, mobile phones are not just used for voice and text but come along with an always increasing portfolio of applications, such as Global Positioning System (GPS) navigators, Internet and multimedia players. Performing real-time transactions from a mobile phone is only a recent concept. The idea was to design an architecture which allows real-time transactions to be performed from a mobile phone.

Project Objectives
The project involved the designing of an embedded system using Field-Programmable Gate Array (FPGA) technology that interfaces a mobile phone to a Point of Sales (POS) through a wireless link. This enables clients to perform real-time fund transfers through their accounts. Various techniques were employed to ensure that data is transferred securely.

Project Methodologies
The development of the project was broken down as follows:

- Design, implementation and testing of the wireless protocol stack
- Interfacing the protocol stack with a Personal Computer (PC) and a mobile phone
- Implementation and testing of the software suite:
  - Mobile phone, POS and transaction server applications
  - Client and bank web applications

Results and Achievements
Using a combination of security techniques, a secure environment for performing real-time transactions has been developed. The system can be regarded as being safer then existing POS fund transfer systems. All the hardware and software have been subjected to various testing conditions, where the system behaved as expected. The prototype works as expected and serves as a proof of concept.

Figure 1: Concept behind the Wireless Online Paying System

Figure 2: Snapshot of the prototype model

Speech Annotation System

Student: Roberta Camilleri
Supervisor: Prof. Ing. Paul Micallef

Introduction
Speech recognition of Maltese is a research area that needs investigation. Phonetically annotated and labelled corpora are very important and useful in building a speech recognition system. The task of partitioning a speech utterance into a set of phonemes is known as speech annotation. The manual phonetic annotation of speech corpora is a tedious and time-consuming task and thus an automatic speech annotation system is built in this project.

Project Objectives
The main aim of this project is to annotate Maltese sentences with the highest degree of accuracy possible.

Project Methodologies
Several algorithms exist for building the phoneme models namely, Neural Networks, Hidden Markov Models (HMM), Wavelets and Dynamic Time Warping (DTW). However the HMM is the mostly used since it gives the best results and also due to the fact that the HTK software suite [1], which is based on the HMM algorithm, is readily available. In this project, the annotation system was built using HTK. This is done in mainly two stages: the Training stage and the Decoding stage. The following steps were carried out during the implementation of the project:

1. Training Stage:
   - Data Preparation – The training and testing speech utterances are converted into the appropriate parametric form and any associated transcriptions are converted to have the correct format and use the required phone or word labels.
   - Initialisation – The topology of the HMM is defined at this stage and an HMM is initialised for each phoneme. All phone models are initialised to be identical and have state means and variances equal to the global speech mean and variance.
   - Re-estimation- One of the HTK tools is used to perform a single re-estimation of the parameters of a set of HMMs using an embedded training version of the Baum-Welch algorithm. This re-estimation procedure is repeated several times.
2. Decoding Stage:
   - Evaluation – Now that each HMM represents its corresponding phoneme, the testing utterances are used to evaluate the performance of the system. This is done using one of the HTK tools which is based on the Viterbi algorithm.

Results and Achievements
The testing speech signals were also manually annotated and these were compared with the output of the system. The start time and end time errors of each phoneme are found. Initially the average sum of the start time and end time errors of all phonemes summed to 1.402 frames (1 frame = 25ms). This result was not so satisfying and various amendments were made to the system, mainly in the HMM itself, to minimize the errors. The final system till now gave an average error of 1.2 frames. Other tests are being done on the system to improve further the results.

References
[1] S. Young, G Evermann, T. Hain, D. Kershaw, G. Moore, J. Odell, D. Ollason, D. Povey, V. Valtchev, and P. Woodland. 'The HTK Book,' Cambridge University Engineering Dept, Cambridge, UK, 2002

Live Internet Streaming Using Scalable Video Coding

Student: Lucianne Cutajar
Supervisor: Dr. Ing. Reuben Farrugia

Introduction

The use of video streaming is increasing abruptly due to the wide variety of devices and applications which enable the streaming and viewing of video clips. Due to the variety of devices at the end points with different viewing capabilities and buffer space as well as the varying transmission channel conditions, transmitting one stream with a fixed spatio-temporal video format to all the end points will not guarantee successful video viewing at all the end devices.

By using Scalable Video Coding, the video stream transmitted is encoded in layers each of which define particular spatial and temporal values starting with the minimum resolution at the base layer 0 and enhancing the video display with each layer, the top most layer having the highest resolution and frame rate of the streaming end devices present in the network. Using SVC would mean encoding the video only once, at the highest resolution required (base layer plus all enhancement layers) and then adaptations would be made by the user at the receiving end, by choosing an adequate number of enhancement layers in order to achieve the required spatio-temporal resolution.

Project Objectives

The project's aim is to build a network topology with both wired and wireless connections over which the transmission of SVC bitstream is simulated for different networking scenarios from which a study of the data rates and quality of the received video is concluded.

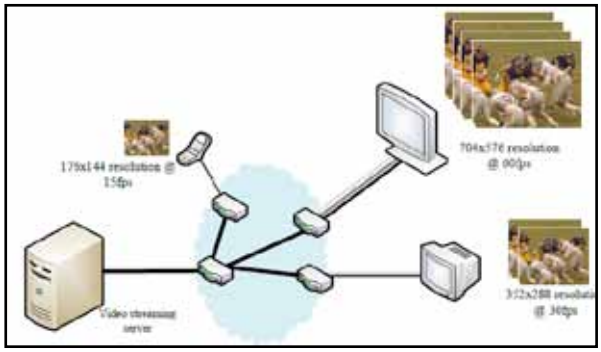
Project Methodology

In conducting the project, the following steps were taken:

- Literature review of picture encoding methods, video structure and compression standards in particular the H.264/AVC standard, the SVC technique and familiarisation with the NS3 environment
- Adapting the right variable values and creating the general and layer configuration files which are then used by the JSVM encoder for encoding videos in a scalable stream.
- Extracting trace files of the encoded video bit stream.
- Simulating bit stream errors and packet loss by dropping packets from the trace file and observe the corresponding decoder performance, PSNR values and visual effects on the decoded video.
- Designing a network topology and implementing it in the NS3 environment.
- Testing the network performance for the transmission of a scalable video stream over different networking scenarios.
- Evaluation of the NS3 generated results, using Wireshark and other statistics obtained by the NS3 simulations.

Results and Achievements

A simulation of a network of devices with different video requirements for viewing was setup and a SVC bitstream was transmitted over the network using unicast and multicast transmissions. By the completion of this project, errors in transmission of the SVC bitstream over the network would be simulated and the resulting effects on the transmitted video analyzed. A study of the resulting data rate statistics and respective PSNR values for the different modes of transmission is performed.



Development of a steerable mirror panel in order to reflect the sun's rays of light into a building for lighting purposes

Student: Albert Falzon
Supervisors: Dr. Ing. Saviour Zammit
Co-supervisor: Prof. Joseph Cilia

Introduction
The cyclic energy crisis and environmental concerns, foremost of which global warming, have resulted in a movement towards alternative resources of energy. Solar energy is a very attractive solution in Malta, however the high cost of PV panels and storage systems, and the inefficient conversion from solar to electricity and then to light or heat energy means that more cost effective systems are required. This thesis deals with a closed loop sun tracking system which reflects the sunlight by tilting reflectors on two different axes at a particular location. This idea will be of utmost importance in sustainable living as in eco-villages, which avoids energy storage and conversion.

Project Objectives
The first step was to calculate the solar Azimuth and altitude angles for a given date, place and time. These were coded in Matlab and the corresponding graphs were plotted covering a 24 hour time window. These were verified by comparing the zero crossing (rise and dawn) with those of local newspapers. This showed that the DiSeQC rotators could be used. The angular position of the shafts has to be be controller through an electronics interface to the motor which require the superposition of the 22Khz signal onto the DC supply voltage.

The 650mV chopping system results in a square type waveform as opposed to the sine wave specified by Eutelsat documentation. The Fourier analysis of a square wave shows that the amplitude and frequency of the fundamental (sine wave) component of a square wave is the same as that of the original square wave. The use and analysis of a 10nF filter (Low Pass filter) removed the higher frequency components of the square wave to produce the signal specified by Eutelsat.

A thrust bearing set was designed to allow two DiSEqC motors to rotate the mirror in two mutually perpendicular planes. The mechanical setup was manufactured at the faculty's workshop.

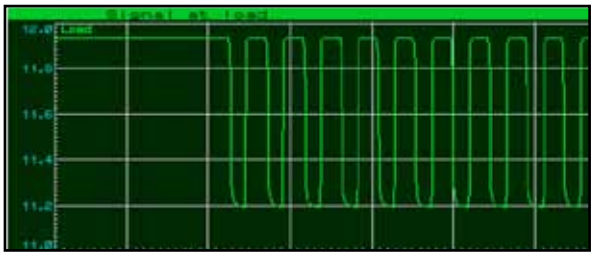


Figure 1: The DiSEqC signal System Deisgn and Implementation

Figure 2: The complete setup

Wireless Audio Transmission

Student: Nicholas Frendo
Supervisor: Dr. Ing. Saviour Zammit

Introduction
In a typical modern home, tens of multimedia sources are present, all of which have their own media formats, connections and other technical details. This project aims at focusing all multimedia sources, particularly audio sources, at a central point irrelevant of their technical differences and made available in a wireless fashion, under the home's Wi-Fi coverage in a client-server model form being an infrastructure based system as described in figure 1. Thus exploiting the increasing availability of smart devices, such as smart phones and net books, equipped with wireless data communication technologies in meeting today's ever-increasing multimedia demand.

Project Objectives
This project aims at studying the protocol stack involved in real-time audio streaming together with the conversation process during the setting up and tearing down stages. Also, this project studies the wireless link characteristics and the effect upon the quality of service of real time audio streaming with varying signal-to-noise ratio (SNR) of the information signal and average packet size in bytes.

Project Methodologies
- Research previous work related to wireless audio streaming over WLANs and Bluetooth technologies;
- The packet loss rate measurement for one hour of real time audio streaming with variable signal-to-noise ratio of the information signal and average packet size sent;
- Objective analysis of the received media by computing the mean square error of the original media against the received media;
- Subjective analysis of the quality of service of the audio streaming experience with variable signal-to-noise ratio of the information signal and average packet size sent.

Results and Achievements
The quality of the live audio streaming experience is principally tied to the packet transmission loss rate. In turn, the packet loss rate is mainly dependent on two components, namely the SNR of the information signal and the average packet size in bytes. The packet loss rate increases both with the SNR degradation of the information signal and with the decrease in data encapsulation per packet. Decreasing the amount of data encapsulated implies an increase of sent packets from server to client. An increase in header overhead due to the increase in sent packets overloads the transmission system leading to the mentioned increase in packet loss rate. Both scenarios were observed to aid in the deterioration of the quality of service of the wireless real time audio steam both from a subjective and an objective point of view.

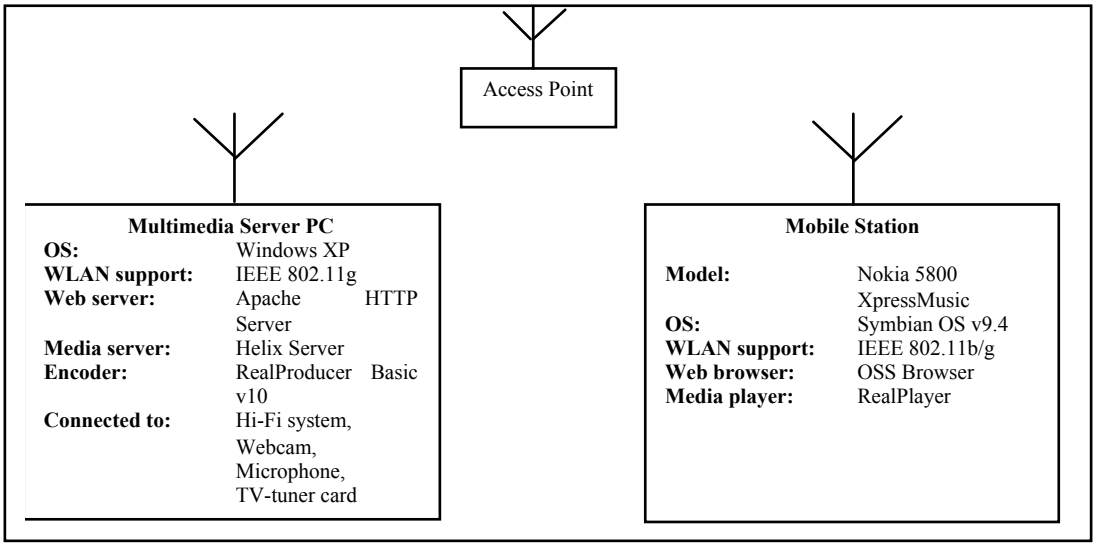


Figure 1: Multimedia Server Setup

Intelligent home control

Student: Steven Galea
Supervisor: Dr. Ing. Saviour Zammit
Co-supervisor: Prof. Joseph Cilia

Introduction
The main focus of the project deals with load monitoring of most important appliances in our homes. Load profiles are the fingerprint of a household's energy demand. Through this project, the collection of this challenging information constitutes is attempted with minimum effort for installation.

Project Objectives
The recent upward trend in electricity prices has made households more aware of their demand on electricity and on their previous consumption patterns. This project is especially designed to provide households with a mechanism whereby they can monitor their consumption and thus rectify their habits. The primary ambition however remains to make electricity consumers and households in particular aware of their consumption patterns and to help them better understand what they are paying for in electricity bills.

Project Methodologies
The primary aim of this project was to monitor the whole load at short intervals from a single point. Hence the project objectives comprised:
Performing research on the following topics:

- NILM techniques [1]
- Load Profiling
- Load Generator [2]
- Load Analyzer [3]
- Mobile Monitor [4]

Deriving and implementing a simulation model of load generator. Verifying the accuracy of the Load Generator and comparing such results with actual values. Designing an analyzer, to distinguish load profiles. Designing and implementing of the link between the computer and mobile phone.

Results and Achievements
From the load analyzer it is detected which load is on at a particular time. From the plots it can visually be detected. The data produced by the load analyzer is than passed to a mobile for mobile monitoring.

References
[1] Hart, G.W., Nonintrusive Appliance Load Monitoring, Proceedings of the IEEE, December 1992, pp. 1870-1891. [2] Jean-Pierre Ebert, Andreas Willig, A Gilbert-Elliot Bit Error Model and the Efficient Use in Packet Level Simulation, Berlin, March 1999. [3] H S Matthews, Automatically disaggregating the Total Electrical Load in Residential Buildings: a Profile of the Required Solution.2008 [4] Sarah Darby, The Effectiveness of Feedback on Eenergy Consumption, April 2006

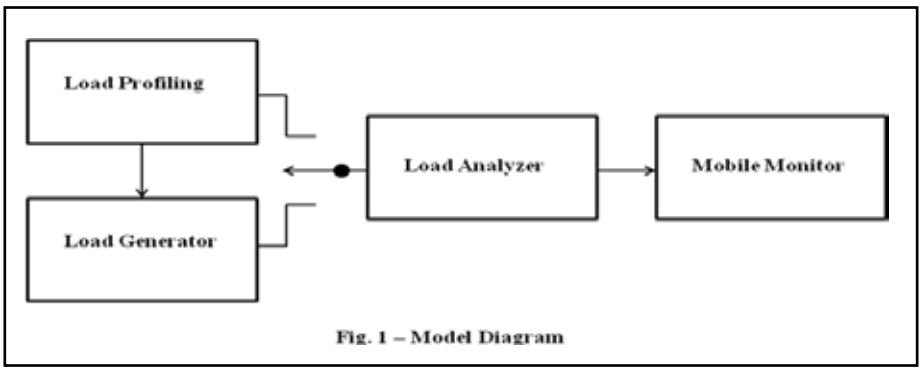


Figure 1: Model Diagram

Simualtion of Routing Protocols in Mobile Ad-hoc Networks (MANETs)

Student: Andrew Tonna
Supervisor: Dr. Ing. Reuben A. Farrugia

Introduction
A Mobile Ad-hoc Network (MANET) is a mesh of mobile devices being able to communicate with others using the peers. Due to the increased availability of laptops and wireless devices, MANETs have become a popular area of research. Although ad-hoc networks hold several advantages over infrastructure networks, several problems and limitations lie in the way of the growth and development of such networks. These limitations are caused by the nature of MANETs, which consist of mobile devices that are:

- small and lightweight - limited resources such as battery power and processor speed
- mobile - highly dynamic topology
- wireless communication - a wireless medium provides a lower reliability and more constrained bandwidth than wired mediums, and is also susceptible to interference from other nodes.

Therefore when designing routing protocols for MANET environments, it is necessary ensure that these limitations are taken into consideration.

Project Objectives
- To develop an understanding of the most popular routing protocols available for MANETs.
- To choose and improve on one of these protocols, which will be evaluated through a series of simulations.
- To become familiar with the NS3 network simulator.
- To perform simulations of MANET routing using NS3 network simulator.
- To implement a Genetic Algorithm to optimize the routing algorithm.
- To analyse the performance of the different MANET routing strategies.

Project Methodologies
This project describes the different ad-hoc routing protocols, optimization techniques which are suitable for MANETs. One of the ad-hoc routing protocols is chosen and described in greater detail, after which further modifications are suggested for this protocol and then implemented. The project was carried out in the following steps:
- Literature review of the different ad-hoc routing and optimization techniques available.
- A detailed analysis of the operation of one of the chosen routing protocols.
- Proposition of the different modifications.
- Simulation of the unmodified and modified routing protocols in MANET environments, which are then compared and analysed in detail.

Results and Achievements
The results obtained so far showed a great improvement in data throughput, especially over longer paths, however a dramatic increase in delay was observed which may be too significant for some applications. In order to further improve on these modifications, a genetic algorithm is also being implemented in order to find the optimal path in fewer iterations, and to provide load balancing across the network in order to help reduce congestion levels within the nodes and therefore help reduce the delay.

Hardware Facial Image Based Expression Recognition

Student: Joseph Azzopardi
Supervisor: Dr. Ing. Edward Gatt

Introduction
The human face provides one of the most powerful, versatile and natural means of communication. Facial expression analysis deals with visual recognition of different facial motion and facial feature changes and being able to classify them in set of expressions classes. Facial Expression Recognition is important for the future of Human-Machine Interaction, in order to develop an intellectual form of communication between people and machines, and also for behavioural studies and psychological rehabilitation [1].

Project Objectives
This study aims to develop an automatic system which is able to identify the expression of a person from static images and then implement the classification stage on hardware using an FPGA. The study aims further to develop the classifier in hardware which is able to produce similar results to its software counter part. Several architectures are presented and discussed. Optimisation in the management of the limited resources of the FPGA at hand is also important. Improving accuracy and speed, whilst also using the least amount of area is another major objective of this dissertation. The best trade-off in terms of area, speed and implementations losses is sought for the classifier.

Project Methodologies
Face images are complex and multi dimensional. The method of Principal Component Analysis (PCA) and the Eigenface approach developed by Turk and Pentland [2] are used to represent face images in a lower dimensional space, which is better suited for a pattern recognition task. Instead of creating a single subspace that represents all the training images, a subspace for each expression is created, capturing the variations of that particular expression only [3]. Such variations are represented in a mathematical way using the eigenvectors of the covariance matrix which have the largest eigenvalues. A testing image is first transformed into each expression space. Reconstruction of the image from each subspace is then performed and finally all 7 reconstructed images are subject to a similarity measure with the original image. The reconstructed image which is most similar to the original is then declared as winner. The following steps were also carried out during the implementation of the project:

- Literature review of current state of the art Automatic Analysis of Facial Expressions.
- Detailed description of PCA used as a holistic approach for feature extraction. Such feature extraction deals with information theory and is not necessarily directly related to the general notion of face features such as the eyes, nose, mouth etc,
- Use of JAFFA image database to train and test the system, and use of confusion matrices to show the accuracy of the system and to examine how expression classifications were confused. The classes considered include the 6 universal expressions: happy, sad, surprise, anger, fear, disgust and the neutral.
- Identify the optimum parameters namely image size, and number of Principal Components to give the maximum recognition rate.
- Development of 4 different hardware architectures to implement the classification stage, namely the Euclidean Distance. Correct functionality was achieved in Design 1; Designs 2-4 aim to maximise performance and reduce circuit size.

Results and Achievements
The facial expression classification system managed to obtain an average recognition rate of 85.8% using image sizes of 32x32 and taking the first 40 Principal Components. Design 3 implements the best hardware solution using the Spartan 3E-100 and can classify 7 expressions in 92.22µs using 69% of slice resources. Performance is particularly important in a fast changing system such as a real time system and thus the serial-parallel system was proposed in Design 4. Design 4 is a brute force towards performance ignoring hardware size – classifying an image in 71.68µs using 166% slice resources.

References
- G.Donato, M. S. Bartlett, J.C. Hager, "Classifying Facial Actions", IEEE Trans. Pattern Analysis and Machine Intelligence, Vol. 21, 1999, pp. 974-989
- Matthew A. Turk and Alex P. Pentland, "Face Recognition Using Eigenfaces," IEEE Computer Society Conference, pp. 586-591, June 1991.
- G.R.S Murthy and R.S.Jadon, "Effectiveness of Eigenspaces for Facial Expressions Recognition", International Journal of Computer Theory and Engineering, Vol.1, No. 5, December, 2009.

A Dynamic Element Matching Technique for Phase Interpolation Direct Digital Synthesis Applications

Student: Darren Cutajar
Supervisor: Dr. Owen Casha

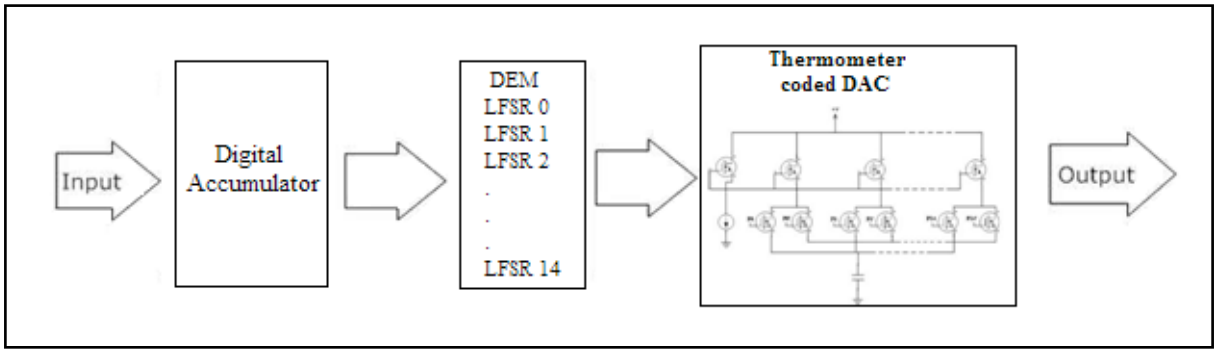
Introduction:
Frequency Synthesis has undergone major changes according to the necessities of society. Fine frequency tuning, fast frequency switching and high frequencies are the main factors that produce an ideal synthesizer. At high frequencies, spurious tones may be seen at the output. This project focuses on diminishing these tones as much as possible[1]

Project Objectives:
To design and simulate a phase interpolation Direct Digital Synthesizer comprising a method to compensate for the spurious tones. Dynamic Element Matching is proposed to be implemented in the DAC. The limiting frequency of the whole architecture is to be found and increased as much as possible.[2] This can be done by using advanced components and pipelining techniques.
Project Methodologies:

- Literature review on DDS, DEM, pipelining techniques and DAC system. [3]
- Integrate the 1-bit integrator in a 4-bit pipelined integrator
- Obtain simulation results and locate delay bottlenecks, which limit the maximum frequency
- Use TSPC logic to improve the operating frequency. [4]
- Introduce DEM techniques in the proposed DAC
- Simulate the LFSR code using VHDL/Verilog [5]

Results and Achievements:
The synthesizer was operated at a frequency of 1.25 Ghz using a technology of CMOS 0.35µm. The produced results were as expected. However, the Flip flops were the main components limiting the operating frequency. Furthermore, the LFSR technique was a success and thus, the DAC element matching techniques were improved.

References:
1 Owen Casha, Franck Badets, Ivan Grech,Edward Gatt,Joseph Micallef, "Spurious Tone Analysis of Phase Interpolation Direct Digital Synthesis", Grenoble, France, 2009.
2 Owen Casha, Ivan Grech, Franck Badets. "CMOS Phase-Interpolation DDS for an UWB MB-OFDM Alliance Application", Grenoble, France, 2009.
2 Razavi, Behzad. "RF Microelectronics." University of California, Los Angeles, 1998. pp. 247-296.
3 Uyemura, John P. "CMOS Logic Circuit Design." Georgia Institute of Technology, 2001. pp. 419-429.
4 Doshi N. A., Dhobale S. B., and Kakade S. R. "LFSR Counter Implementation in CMOS VLSI",World Acadamy of Science,Engineering and Technology 48, 2008.



Design of an FPGA-Based ECU for a spark ignition engine

Student: Simon Ellul
Supervisor: Dr. Ing. Ivan Grech

Introduction

An electronic control unit (ECU) is an embedded device that controls one or more systems in a motor vehicle. The most critical area managed by such a system is the fuel mixture strategy. All ECUs work in a similar manner. By referring to multidimensional tables relating various parameters, the system is able to manage an engine efficiently and in real time. Using feedback obtained through various onboard sensors, an ECU can refine the management strategy still further in with the aim of maximising power and torque whilst reducing emissions and boosting efficiency by improving fuel economy.

This approach allows an engine's operation to be controlled in great detail, allowing greater fuel efficiency, better power and responsiveness and much lower pollution levels than earlier generations of engines. As the ECU is dealing with actual measured engine performance every clock period, it can compensate for many variables, something that traditional systems cannot do. In addition, the electronic system is able to a large degree to compensate for the gradual wearing of the engine as it ages, which in practice allows engine life to be extended.

Project Objectives

The aim of this project was to design an embedded system (using an FPGA) having a robust engine management strategy that in response to continually changing parameters, can adopt corrective action in order to maintain the combustion cycle for as long as desired. Hence, the FPGA (Spartan 3E), configured as an ECU, would then control a commercially available internal combustion engine. Another equally important aim of this project was to conduct research into the integration of mechanical and electrical systems in modern internal combustion engines.

Project Methodologies

In order to accomplish the numerous tasks required for the development of an effective engine management strategy, the following project methodology was adhered to :

- Analyse onboard sensors and identify critical ones
- Design and prototype interface boards
- Design and prototype power supply circuits
- Test sensor interfaces using an oscilloscope or other available means
- Develop and simulate engine management source code using HDL
- Upload verified source code to FPGA, programming it to operate as an embedded system
- Connect all sensor interfaces to the FPGA, thereby integrating hardware and software portions of the project

The most critical components for the engine management strategy were deemed to be the camshaft and flywheel position sensors. Using signals from these components, the piston positions could be established and their relative motion could be gauged. Through the use of interface blocks, the FPGA was then able to identify the correct instant when to inject fuel or fire the spark plugs. Once the actuation instances were known, the injector pulse width and spark plug dwell angle had to be determined in order to guarantee the smooth running of the engine (avoiding misfire).

In order to interface the hardware portion with the engine management source code, ModelSim was used for HDL simulation purposes. The next step involved using the Xilinx ISE programming suite in order to map the software defined ports to the hardware connections of the FPGA. The synthesized code was also uploaded to the board's PROM, allowing it to operate as an embedded system. Once all the sensor, power or interface circuits were connected accordingly the system could be powered up and the engine started.

Once the basic engine management strategy had been tested and shown to be working correctly, the feedback of various other non – critical but important engine sensors can be monitored in order to provide a more accurate picture of the factors affecting the engine. To interface these sensors would require an ADC, as these components are analogue whereas the FPGA is a digital device. This involves additional circuitry and complex software polling procedures.

Results

With the basic interface boards functioning correctly, a steady and stable power supply guaranteed through regulators and the engine turning over, the focus of the project lies with the ECU programming portion. The engine management software is currently being simulated and evaluated. In addition, a minor portion of the pre – starting engine checks and procedures have already been uploaded to the FPGA.

ECU of an Electric Car

Student: Francarl Galea
Supervisor: Dr. Ing. Edward Gatt

Introduction
The Internal Combustion Engine in a vehicle has met our requirements for more than a hundred years. Presently engineers have begun to shift from this technology to electric cars because of a number of reasons mainly that fuel is becoming scarcer and therefore more expensive, and because of the harmful emissions left by fuel powered vehicles.

Project Objectives
The aim of this project is to control a system by an Electronic Control Unit (ECU) from the driver's inputs: Accelerator and Brake pedals. The designed system can obtain even better efficiencies than current Electric Cars by including a Continuous Variable Transmission (CVT) in the Power Train. A CVT is a Transmission with an infinite amount of gear ratios and so it is capable to keep the Electric Car's Motor running continuously at a speed which giving its maximum efficiency at all time. Another feature available in this system is Regenerative Braking which means that the batteries in the vehicle will be charged when the driver hits the Brake Pedal thus saving a lot of energy back for future usage.

Project Methodologies
A project model was built in order to test and show that the ECU and proposed system actually works. In order to model the Momentum of the car, a flywheel was fitted and so its Rotating Kinetic Energy models the Kinetic Energy present in a moving vehicle. The following steps were carried out during the implementation of the project:
Literature Review of current ECUs used in vehicles and on all components which were used in the Project Model (Motors, Batteries, Transmissions, Flywheels and Regenerative Braking)Model Building which involves all the Mechanical Parts, Electrical Parts and the Programming of the ECU which programmed on an FPGA shown in Figure 1.Testing and analysing final performance of the model with the designed ECU. Displaying FPGA's output signals on an Oscilloscope.
The ECU was designed using a programming language called Hardware Description Language (HDL). This program was then loaded to an FPGA. An FPGA is one of the fastest methods used for prototyping and testing. The source code is synthesised and converted to a physically realisable gate net-list. The circuit is implemented by the FPGA which in turn uses ports specified in the net-list as inputs and outputs.

Results and Achievements
The FPGA was programmed and all the system worked successfully. At the time tests are being done on the system and touches to the programming code so that it will make it run even better in all modes of operation which are Accelerating, Cruising and Deceleration.

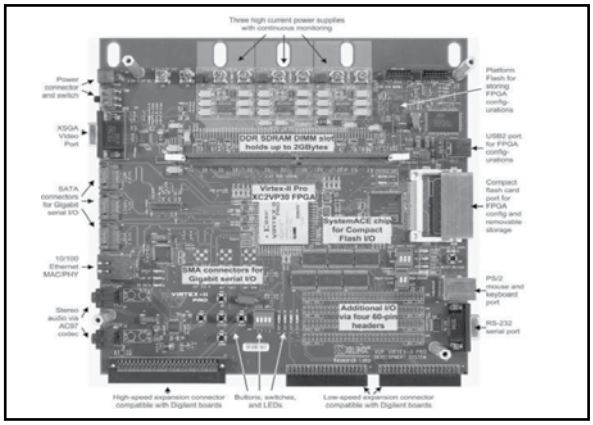


Figure 1: Xilinx Virtex-II Pro

Design of an embedded greenhouse management system

Student: Neil Mallia
Supervisor: Dr. Owen Casha
Co-supervisor: Dr. Ing. Edward Gatt

Introduction:
The idea behind greenhouses is to enable the production of vegetables, fruit and flowers all year round. This is because these products grow only during a specific period of the year, when the weather is optimal for them. Therefore the idea of greenhouses is to create an environment which is optimal for the crops in order to be able to grow the crops all year round.

Project Objectives:
- To control the light intensity within the greenhouse depending on the natural light available [1]
- To monitor and control the humidity within the greenhouse by reading the inside and the outside humidity levels and trying to keep the inside level within an adequate range [6]
- To control the air temperature within the greenhouse by the use of ventilation and also heaters and coolers [2] [3]
- To control the ventilation within the greenhouse to help in the control of humidity and temperature and also to keep the internal CO_2 levels adequate [4] [5]
- To control the irrigation system within the greenhouse [7]
- To implement and embed the above control systems via VHDL code on a single FPGA board

Project Methodologies:
The project simulates the internal climate of a greenhouse and studies the best possible ways to automate the climate control of the greenhouse. The following steps were carried out to implement the project:
- Literature review of what is being controlled in greenhouses
- Identify the parameters which need to be controlled within the greenhouse
- Develop boards to capture data and pass the data to the central board
- Program the FPGA in order to control the greenhouse as required

Results and Achievements:
The greenhouse's most important aspects, which are the environmental conditions, are being controlled as required. By implementing this system in a greenhouse, one would be ensuring that the greenhouse environment would be optimal all the time without the risk of damaging the product.

References:
1 Alberta Agriculture, Food and Rural Development, Commercial Greenhouse Production in Alberta, Alberta, Canada, 2001, pp. 1-31
2 How it Works, How Greenhouses Work – Greenhouse Gardening at it's Best!, [accessed 25th February 2010] http://www.howitworks.net/how-a-greenhouse-works.html
3 Ibrahim A. Hameed, Seong-in Kim, A System With PSuedo-derivative feedback control for short-term Greenhouse Operation, Korea University, Korea, 2006.
4 NSW Department of Primary Industries, Ventilation in Greenhouses, [accessed 1st March 2010] http://www.dpi.nsw.gov.au/agriculture/horticulture/greenhouse/structures/ventilation
5 Ontario Ministry of Agriculture Food & Rural Affairs, Carbon Dioxide in Greenhouses [accessed 6th April 2010] http://www.omafra.gov.on.ca/english/crops/facts/00-077.htm
[6 Peter Kincaid Willmott, Scientific Greenhouse Gardening, Butler & Tanner Ltd., Frome, Somerset, 1982, pp. 10-16
[7 University Of Florida IFAS Extension, "Irrigation of Greenhouses Vegetables – Florida" in Greenhouse Vegetable Production Handbook, Vol 3, Florida, USA, 1990

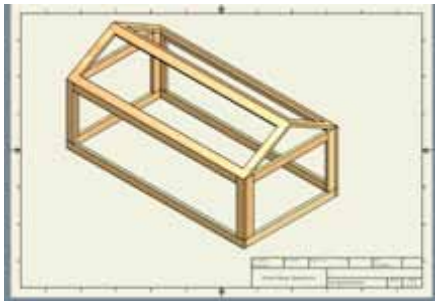


Figure 1. Greenhouse Model

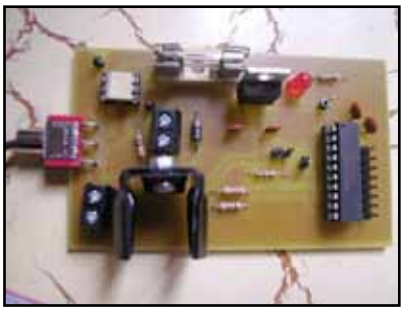


Figure 2. Light Control Circuit

Mitigation Of Radiation Induced Single Event Transients In Integrated Circuits

Student: James Spiteri
Supervisor: Prof. Ing. Joseph Micallef

Introduction
The need for radiation hardened integrated circuits arises from the many situations where electronic components are used in radiated areas. On earth, electronics aren't effected by radiation because background radiation is insignificant but in space radiation levels are very high. Therefore electronics on satellites and spacecrafts need radiation protection of some sort so that their integrated circuits won't fail when the need arises. Radiation exposure isn't limited to space. On earth radiation intensive machinery is used in medicine like the MRI or the X-Ray which can emit enough radiation in order to effect its own electronic components. Nuclear power stations and nuclear waste treatment facilities provide high levels of radiation and potential health hazards, thus electronics to withstand these levels of radiation need to be used in controlling and monitoring these facilities.

Project Objectives
The aim of this project is to design a solution to the single event transients induced by space radiation. At present no one solution exists to mitigate these effects.

Project Methodologies
In order to understand and mitigate the effects of radiation on integrated circuits, simulations have to be done. Research for valid simulations was done and a number of papers were found. One of these papers studied the effects of single event transients due to a radiation source on an op amp (the LM124) and matched the results with simulations done with the SPICE program. This paper [1] was useful so that to validate the simulations of the anomalies. Once these simulations were validated the design of the mitigation circuit could be done.

Results and Achievement
By studying the results achieved from the simulation of the anomalies, a pattern emerged. The effects are temporary and are very fast (have high frequency), therefore a high pass filter could be used to filter out these anomalies. The drawback of this method is that the high frequency performance of the circuit are compromised. In the diagram on the right the light blue signal is the input while the green signal is the output of the circuit after it is effected by an anomaly. The purple signal is the mitigated signal. This is a preliminary result and more studies need to be done.

References
[1] Ronald L. Pease, "Modeling Single Event Transients in Bipolar Linear Circuits," IEEE transactions on Nuclear Science, August 2008.

DLL-Based Frequency Multiplier for GSM Applications

Student: Karen Vella Mulvaney
Supervisor: Dr. Owen Casha
Co-supervisor: Dr. Ing. Ivan Grech

Introduction

In many communication systems, frequency synthesizers are the main building blocks to generate the desired output frequency. Their performance over the whole system is greatly affected by phase noise, spurious tones and power consumption amongst other specifications [1]. PLLs have been the most commonly used synthesizer, however a delay-locked loop (DLL)-based frequency multiplier has the advantage of an improved phase noise due to a clean reference input compared to the noise accumulated in the voltage controlled oscillators [2].

Project Objectives

In this project, a study of DLL-based frequency multipliers must be carried out, followed by the design and implementation of adequate synthesizer architecture to generate a 900MHz signal from a 100MHz reference input. The required signals must be generated with low phase noise and spurious tone specifications dictated by the GSM900 standards.

Project Methodologies

CADENCE platform version 5.0.41 with AMS 0.35µm CMOS kits was used to design the various building blocks of the DLL-based frequency multiplier and simulations were carried out using SpectreS Simulator to obtain the desired results. The project was organized in the following way:

- A literature survey to familiarize the reader with the operation and existing architectures of DLL-based frequency multipliers.
- Selecting the appropriate architectures for the building blocks that make up the frequency multiplier
- Designing and testing of the individual blocks by dc biasing, dc sweeps to generate control voltages, using different analysis such as transient response and ac analysis. Then obtaining sufficient results for each block.
- Combining the blocks and thus closing the DLL loop, and simulating to obtain results for the phase noise and spurious tone.

Results and Achievements

The reference clock and the VCDL output signal must be in phase to get the desired frequency as shown in Figure 1. For this to be true, the DLL must be locked. The locking range was worked out and appropriate delays were achieved by the VCDL implemented in this project. A charge pump is currently being tested so then the transfer function of the closed-loop could be achieved.

References

[1] Owen Casha, Ivan Grech, Franck Badets, Dominique Morche, and Joseph Micallef, "Analysis of the Spur Charecteristic of Edge-Combining DLL-Based Frequency Multipliers," IEEE Trans. On Circuits and Systems, vol. 56, No. 2, pp. 132-136, February 2009

[2] Jingcheng Zhuang, Qingjin Du, Tad Kwasniewski, "A -107dBc, 10kHz Carrier Offset 2-GHz DLL-Based Frequency Synthesizer"

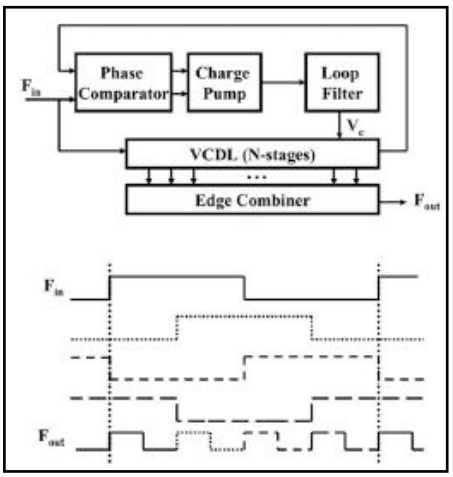


Figure 1 [1]

Performance of IC Standard Cells Radiation-Hardened Through Layout Techniques

Student: Nadine Xerri
Supervisor: Prof. Ing. Joseph Micallef

Introduction

In situations such as aerospace systems integrated circuits (ICs) can be exposed to radiation. This radiation can lead to errors in the operation of ICs. One solution that has been used is to modify the fabrication process of ICs so that the effects of the incident radiation are eliminated. However, this radiation-hardened fabrication process results in very expensive ICs due to the limited demand. Furthermore, as the commercial ICs technology developed further, resulting in ever-decreasing dimensions, the cost and time required to modify the fabrication process to take care of radiation effects have become prohibitive. New Radiation-Hardness-By-Design (RHBD) techniques have been developed which make use of standard IC fabrication technologies, but minimize the effects of incident radiation through circuit and/or layout design.

Project Objectives

The main objectives of the project are researching layout techniques that have been developed for RHBD ICs , design various layout cells with radiation-hardening properties using Cadence layout design systems, and then compare the performance characteristics of the different layouts. Three approaches to radiation-hardening by layout design are investigated here: the introduction of guard bands , bus widening and edgeless transistors. Layouts for a standard inverter, an inverter with guard rings, and an inverter with bus widening, using AMS 0.8 µm CMOS technology, are shown in Figure 1. The different layouts have been simulated and various characteristics noted in order to compare the difference in performance between the standard cells and the radiation tolerant cells.

Project Methodologies

In this project, three main RHBD Layout Design techniques were identified and implemented in order to observe how these techniques affect the performance characteristics of the device. The following work has been done:

- Literature review of the various RHBD layout techniques
- Designing the layout of various standard cells using Virtuoso Layout Design in two different CMOS technologies
- Implementing the RHBD layout techniques for these standard cells
- Simulation of the various layout approaches
- Comparison of the performance characteristics of the RHBD cells compared to their standard equivalent cell

Results and Achievements

It has been found that when implementing different layouts that lead to radiation hardness, trade-offs need to be done. The main problem is the silicon area used, which for a RHBD cell is three times as much as its standard equivalent cell. Other characteristics are also affected, such as power dissipation which increases when adding the guard rings and the bus widening.

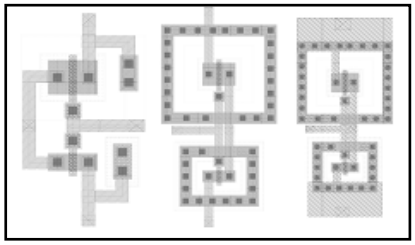


Figure 1: Layouts of a (a)standard inverter (b) inverter with guard rings and (c) Inverter with guard rings and bus widening

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