University of Malta

L-Università ta' Malta

Annual Activity Report

2013 - 2014

Department of Systems and Control Engineering

SCE

Cover picture shows an eye-gaze tracking system.

Contents

1. Introduction

This sixth Annual Activity Report reports on the sustained effort of the Department of Systems and Control Engineering to provide high academic value to its members, its students, its community and the public at large.

The Department has continued to support its portfolio of research projects, providing focused research to its graduate and doctoral students in particular, and publishing in peer-reviewed international scientific fora on a regular basis. The Internal Research Seminar Series of the Department has now become a regular bi-monthly event attended by the Department's academics and students. The research student cohort made of research postgraduate students and doctoral students remains healthy and growing. The Department is also increasing its teaching contribution, in particular with new study-units being offered in Programmes outside the Faculty of Engineering. Last year's international collaborations have been consolidated and new ones created.

The work generated by the Department is also disseminated to the public through various outreach events that have become entrenched in the Department's calendar, such as Science and the City, Discover University and EU Robotics Week; several radio and television interviews and articles in the printed media complement this activity.

The multi-faceted high-quality activities of the Department are possible due to the harmonious co-operation and initiatives of the Department's academic, technical and clerical staff. I take this opportunity to thank each and every member of the Department for the dedication to the Department and to the pursuit and dissemination of knowledge.

30th September 2014 **Prof. Kenneth P. Camilleri**
Head of Department

2. Staff Members

Associate Professors
- Prof. Ing. Kenneth P. Camilleri, *B.Elec.Eng.(Hons.), M.Sc. (Sur.), Ph.D. (Sur.), MIEE, SMIEEE, ACIArb* – <u>Head of Department</u>

- Prof. Ing. Simon G. Fabri, *B.Elec. Eng. (Hons.), M.Sc. (Sheff.), Ph.D. (Sheff.), SMIEEE*

Lecturers
- Dr Kenneth Scerri, *B.Eng. (Hons.), M.S (Oakland), Ph.D. (Sheff.), MIEEE*

- Dr Ing. Marvin K. Bugeja, *B.Eng. (Hons.), Ph.D. (Melit.), MIEEE*

- Dr Tracey Camilleri, *B.Eng. (Hons.), Ph.D. (Melit.), MIEEE*

Assistant Lecturer
- Ms Alexandra Bonnici, *B.Eng. (Hons.), M.Phil. (Melit.), LLCM(TD), MIEEE*

Visiting Academics
- Ing. Andre Sant, *B.Eng.(Hons). M.Sc., MIEEE*

Research Support Officer II
- Ing. Stefania Cristina, *B.Eng.(Hons). M.Sc. (Melit.), MIEEE, MIET*

Systems Engineer
- Ms Lucianne Cutajar, *B.Eng. (Hons.)*

Senior Laboratory Officer
- Mr Noel Agius

## Clerk
- Ms Sanchia Lentini

3. Research Activities

3.1 Research Projects

- **Nonlinear, Adaptive and Intelligent Control**
  Main investigators: Prof. Simon G. Fabri and Dr Marvin K. Bugeja

  This research focuses on the development, design and application of modern methodologies for nonlinear, adaptive and intelligent control systems. The past year saw continuation of the collaborative investigation with Prof. Björn Wittenmark from Lund University in Sweden on dual control methodologies for adaptive control of extremum seeking Hammerstein systems. This work resulted in a conference paper at MED 2014 in Palermo together with a journal submission that is currently under review. In addition, the main investigators' past work on dual adaptive control for MIMO systems has been accepted for publication as a journal paper in the Transactions of the Institute of Measurement and Control and it is currently in press.

  In the meantime, Prof. Fabri has been concentrating on further research related to other aspects of the dual adaptive control systems paradigm.
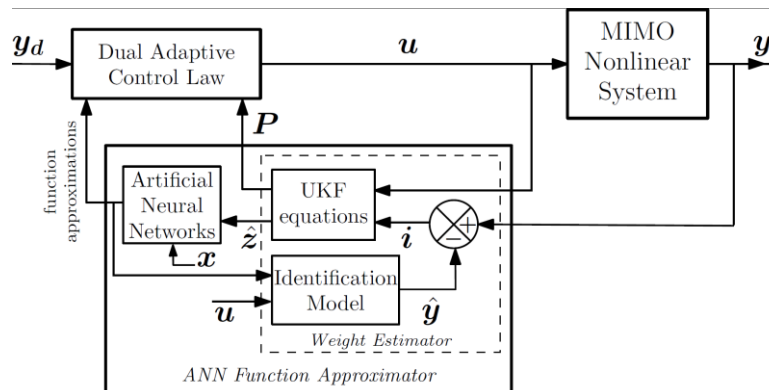
- **Nonlinear control of a ball and plate system**
  Main investigators: Dr. Marvin K. Bugeja and Mr. David Debono

  Primarily the aim of this research was to investigate and compare a number of sliding mode control schemes on a ball and plate balancing system. The control challenge is to balance a ball (or make it track a desired trajectory) on a flat plate, solely by tilting the plate. The problem is of particular interest to the control community because it is open-loop unstable and exhibits nonlinear and multivariable dynamics.

The research project included: a thorough literature review on the ball and plate problem and sliding mode control; the design and full implementation of a physical ball and plate experimental setup, which makes use of an intelligent camera (CMUcam4) to sense the ball's movement on the plate; the design, implementation and evaluation of various control schemes, ranging from linear full-state feedback controllers to nonlinear sliding mode algorithms. The work is fully documented in David Debono's Master's dissertation (University of Malta, 2014), and there are plans to publish the study and its findings in a conference paper.
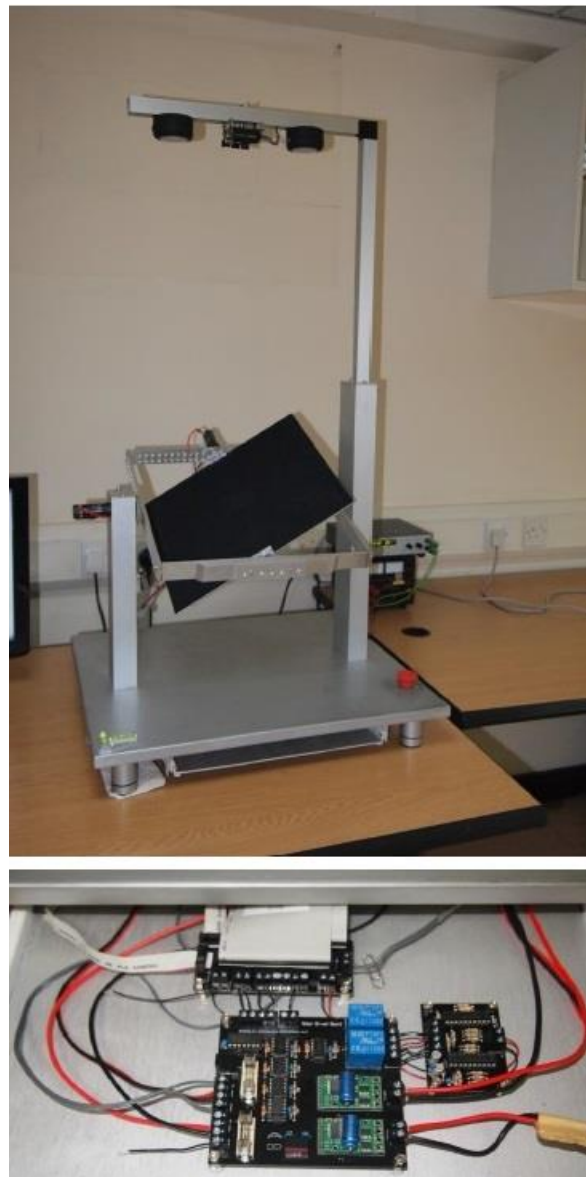

Ball & plate experimental setup

- **Robot Control**

   Main investigators: Dr. Marvin K. Bugeja and Prof. Simon G. Fabri

   Projects in this area study various aspects of robot control on different mobile robotic platforms. One particular thread of this research focuses on robotic exploration using active-SLAM. Simultaneous-Localization and Mapping (SLAM) algorithms enable a mobile robot to build a map of its environment and simultaneously (and continuously) estimate its location within this map. In the original SLAM problem, better known as *passive SLAM*, the robot is manually steered around the environment it is required to map. However a more challenging problem is that of autonomous exploration where the robot is required to drive itself around the environment in a way that aids the SLAM process, *i.e.* to acquire a more accurate map in less time (in comparison to random roaming). In literature this is known as *active SLAM.* This work investigates both passive and active SLAM algorithms via simulations and physical experiments using PowerBot, a commercial research mobile robot. This robot is fitted with several high-end sensors, including a laser range-finder and sonar belt.

PowerBot
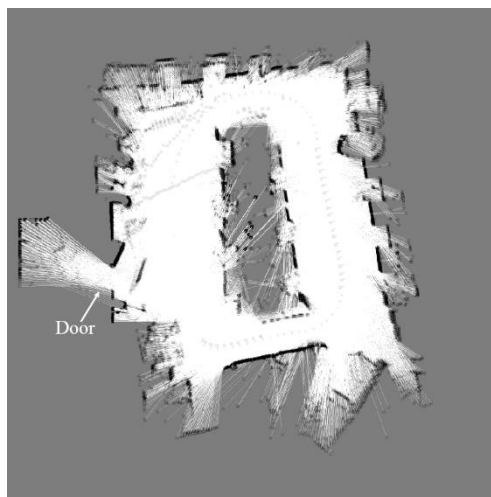
Map of the Control Systems Laboratory as obtained by EKF-SLAM on PowerBot
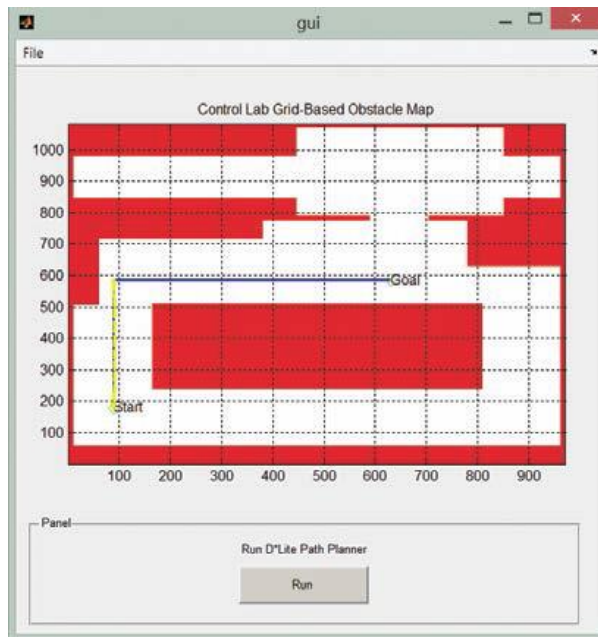
A working graphical user interface (GUI) designed and implemented by an undergraduate student (Ms. Claire Farrugia) during her studies on robotic path planning.

Another thread of this research is focusing on robotic search and target tracking. In this work the mobile robot is equipped with a single off-the-shelf camera and is commanded to autonomously search and track a particular target in an unknown, obstacle-clattered environment. Naturally, this research can have many applications in real-life including search and rescue, transportation and human-robot interaction. The Khepera III mobile robots available in the control laboratory are being used for the experiments. One of the vision-based robot tracking algorithms investigated is a direct results of the collaboration between the main investigators and Dr. Francois Guerin from the University of Le Havre in France. This particular algorithm has been published in a conference paper and presented at the IEEE Conference on Decision and Control in December 2013.

The Khepera III robot

- **Cognitive Vision for Sketch Understanding**
  Main investigators: Prof. Kenneth P. Camilleri and Ms Alexandra Bonnici

Human observers, can interpret sketches as 3D objects quite easily, using the artistic cues that are often introduced to the sketch to deduce the geometric shape of the sketched object. Replicating this interpretation on a machine is however, not a trivial task and the same artistic cues that humans use to aid the interpretation, increase the difficulties of the machine pre-processing required to identify these cues from the sketch strokes that define the shape of the object. The work carried out in this project is two-fold, namely, we investigate how the sketched object edges can be identified from the cues in which they are embedded and how the artistic cues can be used to aid the geometric interpretation of the sketch.

Sketched edges are typically extracted from an image by means of vectorisation algorithms. These however, assume that the drawing can be easily binarised and as shown in the figures below, this is clearly not the case in images containing shading cues. For this reason we investigate alternative vectorisation and junction identification algorithms by sampling the sketched image sparsely with families of concentric circles and using the intersection of the straight lines with the circles to identify junction points in the image. The line orientations at the identified junction points allows us to determine the junction geometry and this can be used to create a graph structure representation of the drawing. This graph structure can then be used to drive the placement of new sample circles and hence complete the vectorisation process.
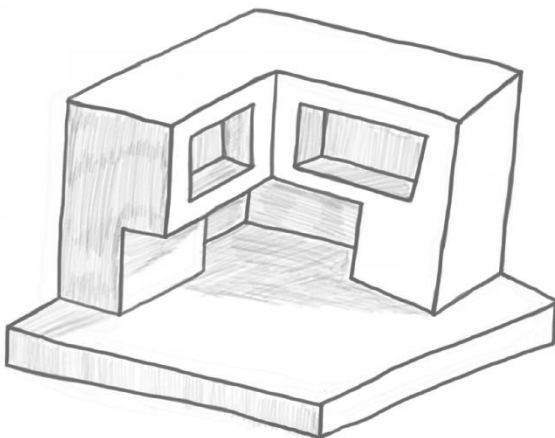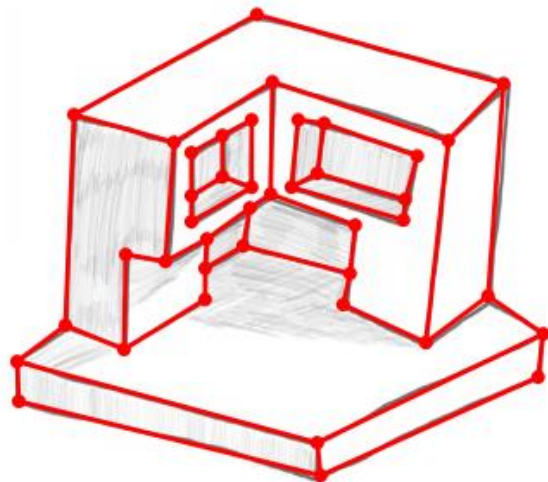
| Original drawing | Binarised image |

Features describing the cues acting on the identified edges are then extracted and these cues are used as constraints on the geometric interpretation of edges, in a cue-constrained edge labelling algorithm.

- **Eye-Communicate - Robust, Cost-Effective Eye-Gaze Technology for Assisted Communication**
  Main investigators: Prof. Kenneth P. Camilleri and Ing. Stefania Cristina

  The prospect of communicating by eye gaze to provide an alternative communication channel for disabled persons is becoming increasingly appealing. Although this approach has generated worldwide interest, eye-gaze technology is presently hampered by various open issues which slow down its widespread use. One limitation which remains prevalent is the prohibitive cost associated with eye-gaze tracking systems, hindering access by those persons who may potentially benefit from this technology from actually affording it. This project, therefore, proposes to investigate suitable methods to address open issues associated with eye-gaze tracking, while at the same time seeking low-cost solutions that may be afforded by the individual consumer and which permit the user to move naturally without demanding additional equipment other than the required cameras.

  Specific algorithms developed so far within this project and their performance were presented at, and published in the proceedings of the 8th International Conference on Advanced Engineering Computing and Applications in Sciences (ADVCOMP 2014) in Rome, Italy, during August 2014. This work has also received a 'Best Paper' award and an invitation to submit an extended article version as a journal paper.
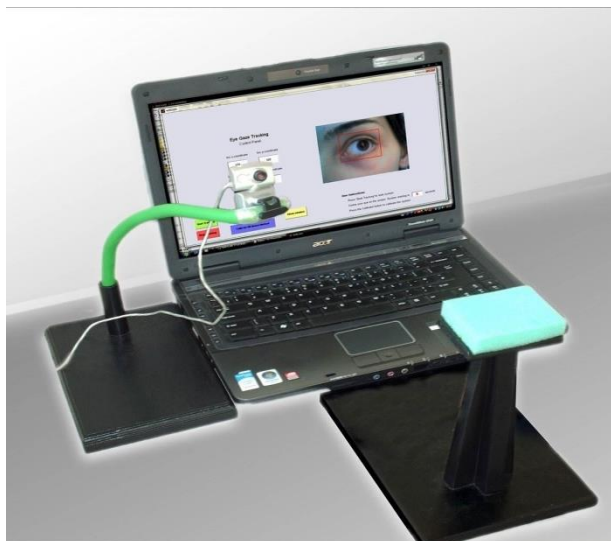
Low-cost eye-gaze tracking platform

- **Development of EEG Signal Processing Methods**
  Main investigators: Prof. Kenneth P. Camilleri, Dr Owen Falzon, Dr Tracey Camilleri, Prof. Simon G. Fabri

  The Department continued its research in electroencephalograpic (EEG) signal analysis, working on the identification of spindles and K-complexes in sleep EEG data, and the detection of mental states in EEG data to be used for brain computer interfacing (BCI).

  The Department continued to develop a method to distinguish mental states without prior training, work which was published in an international peer-reviewed journal in March. In the context of brain-computer interfacing (BCI) using flickering stimuli, it was shown that by using stimuli of different colours the information transfer rate of the BCI may be improved; the group is also studying the robustness of detecting the brain potential evoked by such flickering stimuli when the subject is in the distracted visually or by own movements. Collaboration with Dr Fabio Cuzzolin of Oxford-Brookes University on the use of multilinear classifiers to factor out such distracting nuisance factors has also started this year. Further work is also ongoing to develop the analytic common spatial patterns (ACSP) method that was developed by the Department and which is receiving increasing attention from the international EEG signal processing community.

- **Real-time Brain-Computer Interface Platform**
  Main investigators: Dr Tracey Camilleri, Dr Owen Falzon, Prof. Kenneth P. Camilleri,

  During this year, an important milestone for the Brain-Computer Interfacing (BCI) research activity of the Department has been achieved with the development of a real-time BCI platform which allowed the control of a music player using brain signals. Part of this work was published in a peer-reviewed international conference, and has also received wide media coverage and national awards such as the 'Premju Innovazzjoni Malta 2013'. Furthermore, funds from the TAKEOFF scheme were awarded in order to develop a proof-of-concept mobile device of the Brain-Controlled Music Player which bring the device to a commercialization-ready level. Further work has been ongoing throughout this year to develop new concepts for real-time BCI with the aim of developing a brain controller interface for home-care equipment.

Brain Controlled Music Player

- **Transport Modelling Applied to the Maltese Traffic Network**
  Main investigators: Dr. Kenneth Scerri, Ms. Nicolette Formosa, Ms. Luana Chetuti Zammit and Prof. Simon G. Fabri

  This work focuses on the development of cost effective intelligent traffic management systems in an urban environment. Through the use of off-the-shelf inexpensive sensors and a novel modelling methodology, various control strategies have be adopted for the online switching of traffic lights timing. Such switching is shown to minimize queue lengths at congested junctions, thus reducing both the travel time through the junction and the emission of hazardous pollutants. Different developments based on these ideas have been well received at 3 international conference when presented by various member of this research team.

- **Spatio-temporal Analysis of Pollution Data**
  Main investigators: Dr. Kenneth Scerri, Ms. Luana Chetcuti Zammit and Ms Nicollette Formosa in collaboration with Dr. Maria Attard and Ms. Therese Bajada at the Institute of Sustainable Development at the University of Malta.

  The work on this project over the last 12 months has focused on extending the work previously carried out on air pollution to another dataset measuring marine pollution. Marine pollution models were thus developed based on novel spatio-temporal methodologies. The aim is to obtain computationally efficient models capable of analyzing pollution dispersal and predict future behaviour. These marine pollution models have being tested, with excellent results on data gathered by autonomous marine vehicles in the Norwegian Fjords. It is envisaged that these models will also be applied to study the marine pollution patterns in the Mediterranean focusing on

measures gathered around the Maltese islands. Work is also underway to develop simple add-ins to a standard GIS packages to make these methods available to non-technical users.

3.2 Internal Research Seminar Series

IRSS 2013-2014

Dual Adaptive Control of Stochastic MIMO Nonlinear Systems

Marvin Bugeja   25 Oct 2013

The ever-increasing scale and complexity of modern machines and processes, coupled with a tightening of performance specifications, necessitate control systems with higher levels of intelligence. To this end, intelligent control aims to endow systems with the key features of adaptation, learning and autonomy. The work presented in this talk is a step in this direction. The first part presents novel dual adaptive, neural-network-based control schemes for a general stochastic class of multivariable nonlinear systems. In contrast to conventional adaptive controllers, a dual adaptive scheme aims to strike a balance between estimation and control at all times, in order to accelerate adaptation and minimize the errors simultaneously. To aid in bridging the gap between theory and practice, the second part of the work deals with the design and implementation of dual adaptive neuro-control schemes for the dynamic control of nonholonomic mobile robots with unknown or uncertain dynamics.

Data-driven Modelling of Traffic and Air Pollution

Luana Chetcuti   6 Dec 2013

Human activities are responsible for the release of various polluting gases and particles into the atmosphere which diffuse into the environment with damaging consequences to both the natural environment and the health of living organisms. Recently, this has led to a great interest in pollution modelling with the aim of improving the air quality of the human habitat including the Maltese Islands. Modelling of the air quality around us can be too complex to be described by known natural or physical laws. In such situations mathematical models can be inferred directly from observed spatio-temporal data. This study uses the air pollution measurements mostly associated with heavy traffic, that is nitrogen dioxide and benzene. The main objectives in this study include the development of i) a statistical

based model that estimates the road network traffic assignments in Malta, based on origin-destination flows and traffic counts and ii) the development of statistical based models to describe air pollution behaviour on the Maltese islands with or without considering the estimated traffic flow information. Another advantageous deliverable of this research is the development of computationally efficient methods to estimate model parameters. Analysis of the results will show that traffic has a predominant effect on the air pollution behaviour, resulting in very improved air pollution predictions for Malta.

SSVEP-based Brain-Computer Interface (BCI) System for a Real-Time Application

Rosanne Zerafa   21 Feb 2014

A BCI system creates a new communication channel between the human brain and a computer by issuing commands to specific equipment based on the brain activity of an individual. Electrical brain activity can be recorded non-invasively through an electroencephalogram (EEG) where EEG electrodes are placed on specific locations of the scalp. The BCI system effectively allows for the conversion of patterns of electrical brain activity into commands to control specific equipment without requiring particular physical effort. The neurophysiological phenomena known as steady state visually evoked potentials (SSVEPs) are electrical potentials evoked in the occipital region of the brain in response to repetitive visual stimulation. This response can be utilized in BCIs by having various visual targets flashing at specific frequencies, each associated with a particular command or with a piece of equipment that may be activated. This talk presents the work done on developing a real-time SSVEP-based BCI system. An offline study was primarily conducted to investigate the influence of various characteristics on SSVEP detection and to determine optimal subject-specific parameters that enhance the performance of SSVEP-based BCIs. This lead to the design and implementation of a real-time SSVEP-based music player application that works in an asynchronous mode, giving the user the flexibility of issuing a command independently of any cues. The tests conducted demonstrated high accuracy and information transfer rates of the music player application, highlighting the potential of using the BCI system as an assistive application for people suffering from motor impairments and even as an entertainment application for healthy users.

Improving Urban Traffic Flow Through Modelling and Control

Kenneth Scerri   2nd May 2014

The high car ownership rates coupled with the limited space for infrastructure expansion seen on the Maltese islands, elicit an efficient use of our current road network. Towards this aim, the developments on urban traffic modelling and junction control done during the last year at the Department of Systems and Control

Engineering will be presented. A novel model describing vehicle behaviour at urban junctions controlled by traffic lights will be introduced. While other competing models suffer from high computational demands due to a quadratic increase in the model dimension with increasing junctions, the proposed model will be shown to obtain comparable results with only a linear increase in the model complexity. This model is also the first reported successful attempt in literature to describe the important phenomena of junction block-back in an urban environment. Furthermore, the model lends itself well to dual techniques for model parameter estimation and control, resulting in an online adaptation of the traffic light timings to varying traffic conditions. Results based on simulated implementations of this model together with model based control strategies will be given to highlight the significant improvements attainable through this implementation.

3.3 Technical Reports in Systems and Control Engineering

This year the department launched the series Technical Reports in Systems and Control Engineering. The aim of this series is to provide documentation that compliments the research work published in peer-reviewed journals and conference proceedings by members of the SCE department. The first report in this series, Fasthpe: A recipe for quick head pose estimation documents the work of Michael Sapienza and Kenneth Camilleri on the problem of head pose estimation.

4. Student Projects and Supervision

4.1 B.Eng Students

Project Title	Student	Supervisor
Reducing Vibration in Flexible Mechanical Controlled Systems via Input Shaping	Joseph Agius	Dr. Ing. Marvin Bugeja
EMG Signal Analysis of the Gait Cycle	Vanessa Azzopardi	Dr. Owen Falzon Prof. Kenneth P. Camilleri

Analysis of EOG Signals for Human Computer Interaction	Alison Baldacchino	Dr. Tracey Camilleri
Object Recognition and Approach for Mobile Robots	Antonella Camilleri	Dr. Ing. Marvin Bugeja
Virtual Object Manipulation in an Augmented Reality Setup	Daniel Camilleri	Prof. Kenneth P. Camilleri
Electroencephalographic Analysis of the Effect of Pharmaceutical Drugs on Epilepsy	Janice Camilleri	Dr. Kenneth Scerri
Active-SLAM for Autonomous Exploration using a Mobile Robot	Claire Farrugia	Dr. Ing. Marvin Bugeja
Controlling a Robotic Arm in 3D Space using Surface EMG Signals	Sean Kenneth Grech	Dr. Tracey Camilleri Dr. Ing. Marvin Bugeja
Infra-Red Reflectography for the Analysis of Historical Paintings	Adrian Grima	Dr. Kenneth Scerri
Autonomic Control of Traffic Networks	Daniel Magri	Dr. Kenneth Scerri
Gesture Recognition with Single and Multiple Kinect Sensors	Anne Marie Muscat	Prof. Kenneth P. Camilleri
Machine Learning of Buy and Sell Signals for Equity Investment	Clive Zahra	Prof. Kenneth P. Camilleri

4.2 M.Sc. Students

Project Title	Student	Supervisor
3D model based object recognition using assembly of discrete primitives	Mr. David Paul Agius	Prof. Ing. Kenneth P. Camilleri
A Study of Autonomic Control for Intelligent Traffic Junctions	Ms. Dora Lee Borg	Dr. Kenneth Scerri

Project Title	Student	Supervisor
Non-linear Control of a Ball and Plate System with Visual Feedback	Mr. David Debono	Dr. Ing. Marvin Bugeja
Spatial Modelling for Marine Pollution	Ms. Nicolette Formosa	Dr. Kenneth Scerri
Assistive Environmental Control based on VEPs	Mr. Norbert Gauci	Dr. Owen Falzon Dr. Tracey Camilleri
Residual Vibration Reduction and Control of Flexible Systems	Ms. Diandra Simiana	Dr. Ing. Marvin Bugeja

4.3 M.Phil. / Ph.D Candidates

Project Title	Student	Supervisor
Vectorisation and interpretation of Drawings with Artistic Cues	Ms. Alexandra Bonnici	Prof. Ing. Kenneth P. Camilleri
Modelling Spatial Context in Maltese Sign Language Recognition from Video Sequences	Mr. Mark Borg	Prof. Ing. Kenneth P. Camilleri Prof. Marie Alexander
Autonomic Control for Road Network Management using Geocomputational Tools	Ms. Luana Chetcuti Zammit	Dr. Kenneth Scerri Dr. M Attard
Eye-Gaze Tracking for Human-Computer Interaction, Behaviour Analysis and Communication	Ing. Stefania Cristina	Prof. Ing. Kenneth P. Camilleri
Representation and Knowledge Extraction from Multiview Image and Video	Ing. Clifford De Raffaele	Prof. Ing. Kenneth P. Camilleri

5. External lectures and Visitors

From the Oxford-Brookes University, UK

In July 2014, Department academics and PhD students together with staff from the Centre for Biomedical Cybernetics hosted Dr Fabio Cuzzolini for a one-day workshop where the application of tensorial modelling to electroencephalography (EEG) signals was investigated. Dr Cuzzolin delivered a presentation on his work on multilinear classifiers which was followed by discussions and presentations on the EEG data collected for this study which was specifically collected in such a manner to emulate real-life EEG data 'in the wild'. This study aims to investigate the application of multilinear classifiers to EEG signal analysis and classification.

From the University of Le Havre, France

In November 2013, the Department hosted three staff members from the University of Le Havre in France: Dr. Francois Guerin, Dr. Florence Lecroq and Mr. Hervé Pelvillain. Dr. Guerin presented a mini course on the programming of FPGAs and their application to control engineering. Dr. Lecroq and Mr. Pelvillain provided technical support for the installation and networking of PLC equipment in the Control Systems Engineering laboratory. This visit was funded under the EU Socrates-Erasmus programme. Dr. Guerin and Dr. Lecroq briefly returned in June 2014 in order to follow the progress of their two intern students who were being hosted by the department's Control Systems Laborartory for a two month internship programme.

From the Brno University of Technology, Czech Republic

In April 2014, the Department hosted Prof. Robert Grepl, the head of Department of Mechatronics of Brno University of Technology in the Czech Republic. Prof. Grepl, delivered a lecture and a number of laboratory sessions to second year mechanical students (as part of the SCE2210 study-unit) on the use of Matlab and Simulink to model and simulate linear dynamic systems.

6. Teaching Activities

The Department is responsible for teaching several study-units within the B.Eng.(Hons) programmes in Electrical and Electronic Engineering, Mechanical Engineering and the B.Sc.(Hons) ICT course in Communications and Computer Engineering. It participates in the M.Sc. course on Sustainable Environmental Resource Management that is jointly offered by the University of Malta and James Madison University (JMU) from the USA. With the help of the Centre for Biomedical Cybernetics, the Department also offers two-study units in the M.Sc. in Medical Physics course offered by the Medical Physics Unit in the Faculty of Health Sciences.

A Selection of study units offered by the Department in 2013/2014		
SCE1201	Dynamic Systems and Signals 1	5 credits
SCE2111	Automatic Control Systems 1	5 credits
SCE2213	Automatic Control Systems 2	5 credits
SCE2112	Control Systems 1	5 credits
SCE2210	Introduction to Control Systems	5 credits
SCE3113	Automatic Control Systems 3	5 credits
SCE3216	Automatic Control Systems 4	5 credits
SCE3112	Control Systems Technology and Automation	5 credits
SCE3101	Dynamic Systems and Signals 2	5 credits
SCE3205	Dynamic Systems and Signals 3	5 credits
SCE3204	Image Analysis and Computer Vision	5 credits
ENR3008	Team Project	5 credits
SCE4101	Computational Intelligence 1	5 credits
SCE4102	Systems Theory	5 credits
SCE5107	Principles of Biomedical Signal Processing for Medical Physics	5 credits
SCE5108	Principles of Biomedical Image Processing for Medical Physics	5 credits

7. Staff Publications (October 2013 - September 2014)

C. Formosa, K. Cassar, A. Gatt, A. Mizzi, S. Mizzi, K.P. Camilleri, C. Azzopardi, C. Deraffaele, O. Falzon, S. Cristina, N. Chockalingam, "Hidden Dangers revealed by Misdiagnosed Peripheral Arterial Disease using ABPI Measurement", Diabetes Research and Clinical Practice, ISSN 0168-8227, October 2013.

L. Chetcuti Zammit, M. Attard, K. Scerri, "Bayesian Hierarchical Modelling of Traffic Flow - with Application to Malta's Road Network", Proceedings of the 16th International IEEE Annual Conference on Intelligent Transportation Systems, The Hague, Netherlands, October 2013

R. Zerafa, T. Camilleri, O. Falzon, K. P. Camilleri, "Comparison of Plain and Checkerboard Stimuli for Brain Computer Interfaces based on Steady State Visual Evoked Potentials", presented at the *6th International IEEE/EMBS Conference on Neural Engineering (NER)*, San Diego, California, Nov. 2013.

O. Falzon, K.P. Camilleri, "Multi-colour stimuli to improve information transfer rates in SSVEP-based brain-computer interfaces", in Neural Engineering (NER), 2013 6th International IEEE/EMBS Conference on, San Diego, California, November 2013.

F. Guérin, S.G. Fabri and M.K. Bugeja, "Double Exponential Smoothing for Predictive Vision Based Target Tracking of a Wheeled Mobile Robot", *Proceedings of the 52nd IEEE Conference on Decision and Control - CDC2013*, pp. 3535-3540, Florence, Italy, December 2013.

T.A. Cassar, K.P. Camilleri, S.G. Fabri, "Automatic Detection of Spindles and K-complexes in Sleep EEG Using Switching Multiple Modes", *Biomedical Signal Processing and Control*, Elsevier, vol. 10, pp. 117-127, Mar. 2014.

S. G. Fabri, B. Wittenmark and M.K. Bugeja, "Dual Adaptive Extremum Control of a Hammerstein System", in *Proc. of the 22nd Mediterranean Conference on Control and Automation – MED'14*, pp. 61-66, Palermo, Italy, Jun. 2014.

S. Cristina, K.P. Camilleri. "Identifying gaze gestures from noisy image-based eye movement data", in *I see you, you see me: Inferring cognitive and emotional processes from gazing behaviour*, P. Gamito and P. Rosa, Eds. Newcastle-upon-Tyne: Cambridge Scholars Publishing, 2014, ch.12, pp.232-257.

S. Cristina, K. P. Camilleri, "Cursor Control by Point-of-Regard Estimation for a Computer With Integrated Webcam", *8th International Conference on Advanced Engineering Computing and Applications in Sciences* (ADVCOMP), pp. 126-131 Rome, Italy, Aug. 2014.

P. Farrugia, K.P. Camilleri, J.C. Borg, (Aug. 2014) "A language for representing and extracting 3D geometry semantics from paper-based sketches", *Journal of Visual Languages &*

Computing, [Online], vol. 25, no. 5, pp. 602-624, Available: http://www.sciencedirect.com/science/article/pii/S1045926X14000640 [Oct. 2, 2014]

P.C. McGuire, A. Bonnici, K. R. Burner, C. Gross, J. Ormo, R.A. Smosna, S. Walter, L. Wendt, "The Cyborg Astrobiologist: Matching of Prior Textures by Image Compression for Geological Mapping and Novelty Detection", *International Journal of Astrobiology*, 13 (3): 191–202, 2014.

K.P. Camilleri, O. Falzon, T. Camilleri, S.G. Fabri, "Phase Variants of the Common Spatial Patterns Method", in *Neuromethods,* pp. 1-17, Humana Press, 2014.

D.L. Borg, K. Scerri, "Efficient Traffic Modelling and Dynamic Control of an Urban Region", in *Proc. of the 4th International Symposium of Transport Simulation*, Ajaccio, Corsica (France), Jun. 2014.

D.L. Borg, K. Scerri, "Constrained Dynamic Control of Traffic Junctions", *Procedia Computer Science*, vol. 32, pp. 293-300, Jun. 2014.

M. Sapienza, K.P. Camilleri, "Fasthpe: A recipe for quick head pose estimation", Dept. of Systems and Control Eng., University of Malta, Msida, Malta, TR-SCE-**2011-01, June 2011. Available:** www.um.edu.mt/__data/assets/pdf_file/0015/230361/Fasthpe_A_recipe_for_quick_head_pose_estimation.pdf [Nov. 24, 2014]

8. Staff Academic Activities

Ms A. Bonnici
<u>Academic</u>
Ms Bonnici is a reviewer or committee member for international conferences and journals, including: The Eurographics Workshop on Sketch Based Interfaces and Modelling and Computer and Graphics Journal.

Dr Ing. M. K. Bugeja
<u>Administrative</u>
Dr Bugeja is a Faculty representative on Senate. He is also a member on the Faculty's Board of Studies (electrical stream) and a member of the Faculty's IT affairs committee. Dr Bugeja

is a member of the Faculty's ad hoc Committee on Assistant Lecturer Loading and a member of the Board of Studies for the new MSc in Language and Computation/Human Language Technology, by the Institute of Linguistics. Also, he is the coordinator of the EU Robotics Week on behalf of the SCE department.

Academic

Dr. Bugeja is a reviewer for several conference and journal submissions, including the IEEE Transactions on Systems, Man and Cybernetics, the International Journal of Systems Science and Neurocomputing, the International Journal by Elsevier.

Prof. K. P. Camilleri

Administrative

Prof. Camilleri is the Head of the Department of Systems and Control Engineering. He is also the Director for the Centre for Biomedical Cybernetics and occupies the post of Chairman in the Support Staff Work Resources Committee. Prof. Camilleri serves as an evaluator for Horizon 2020 project proposals.

Academic

Prof. Camilleri is the project leader (Biomedical Engineering Sub-project) of the ERDF Project "Strengthening of the Analytical Chemistry, Biomedical Engineering and Electromagnetics RTDI Facilities" and also a Principal investigator for the National R&I Fund Award R&I-2012-057 'Eye Communicate'

Prof. Camilleri is a member on the Editorial Boards of the International Journal on Advances in Intelligent Systems and of the Research Journal of Information Technology. and a reviewer for several journal submissions, including: IEEE Transactions on Image Processing, IEEE Transactions on Signal Processing, IEEE Signal Processing Letters, IEEE Computing in Science and Engineering, IEEE Transactions on Systems, Man and Cybernetics: Part A, Journal of Electronic Imaging, Optical Engineering, Expert Systems and the International Journal of Systems Science. He is also a Reviewer or International Programme Committee member of several international conferences, including: The Eleventh IASTED International Conference on Biomedical Engineering (BioMED 2014), The Eighth International Conference on Advanced Engineering Computing and Applications in Science (ADVCOMP 2014) and The Eleventh International Conference on Intelligent Environments (IE 2014).

Dr T. Camilleri

<u>Administrative</u>

Dr Camilleri is a member of the Faculty's MSc by Research Board of Studies. She assisted in the organization of the Biomedical Engineering Exhibits for Discover University and was a Coordinator for the Faculty's third year study unit ENR3008 - Team Project. Dr Camilleri is a Member of the IEEE Malta Section committee.

<u>Academic</u>

Dr Camilleri is a reviewer for journal submissions including: Journal of Selected Topics in Signal Processing, Journal of Biomedical Engineering and Control and IEEE Transactions on Biomedical Engineering. She is also an adviser for the IEEE Malta Student Branch.

Prof. S. G. Fabri

<u>Administrative</u>

Prof. Fabri is a member of the Administrative Council of the European Control Association (EUCA). Also a member on the University Academic Resources Funds Committee and the boards of The Institute for Sustainable Development and The Institute of Linguistics. Prof. Fabri coordinates the department's *Internal Research Seminar Series*.

<u>Academic</u>

Prof. Fabri is the Project Leader of ERDF Project 082: "Modernizing the University of Malta's Control Systems Engineering Laboratory".

Prof. Fabri is also a member on the Editorial Board of the International Journal on Advances in Intelligent Systems and a member on the Editorial Board as well as associate Editor of the International Journal of Systems Science. He is a Reviewer for Springer book submissions and for several journal submissions, including: Transactions of the Institute of Measurement and Control -Robotics and Autonomous Systems, the International Journal on Advances in Intelligent Systems, the International Journal of Adaptive Control and Signal Processing and IEEE Transactions on Robotics.

Prof. Fabri is a Reviewer Committee Member for several international conferences, including: 8th International Conference on Advanced Engineering Computing and Applications in Sciences, 2014, 13th European Control Conference, 2014, International Conference on Informatics in Control, Automation and Robotics, 2014 and the 13th International Conference on Control, Automation, Robotics and Vision (ICARCV 2014)

Dr K. Scerri

<u>Administrative</u>

Dr Scerri is a member of the Faculty Board and a member of the Board of the Institute for Climate Change and Sustainable Development. He also occupies the post of Chairman of the Faculty Doctoral Committee.

Academic

Dr Scerri is a member of the cross faculty *Transport Information Systems and TelemAtics* (TISTA) Research Group. He is a reviewer for submissions to the IEEE Transactions on Signal Processing and for the Eight International Conference on Advanced Engineering Computing and Applications in Science (ADVCOMP 2014).
Dr Scerri is a collaborator with the Institute for Sustainable Development and the Faculty of ICT at the University of Malta on the project of Geoinformatics and Transport Modeling.

9. Prizes, Awards and Appointments

Malta Innovation Awards

In February 2014, the Department of Systems and Control Engineering was awarded second place for Scientific Innovation at the Malta Innovation Awards 2013. The Department participated with the 'Brain-Controlled Music Player', an M.Sc. by Research project developed by Ms. Rosanne Zerafa under the supervision of Dr. Tracey Camilleri and co-supervisor Dr. Owen Falzon, led by Prof. Kenneth Camilleri. The Malta Innovation Awards is held by the Ministry for the Economy, Investment and Small Business with the aim to recognize the effort and work by individuals or companies which took a step further in their work and created a unique, feasible product or concept.

TAKEOFF funding Award

After several years of research in brain-computer interfacing, the recent work of a group of researchers from the department in collaboration with others from the Centre for Biomedical Cybernetics led to real-time brain-controlled music player which received widespread international interest and recognition. The group, made up of Rosanne Zerafa, Tracey Camilleri, Owen Falzon and Kenneth Camilleri, was awarded seed funding from the TAKEOFF Seed Fund in June 2014 to develop a product prototype of this brain-controlled device with the objective of making brain control more accessible.

Best Paper Award

The paper entitled *Cursor Control by Point-of-Regard Estimation for a Computer With Integrated Webcam*, authored by Ing. Stefania Cristina and Prof. Kenneth P. Camilleri, and published in the proceedings of the 8th International Conference on Advanced Engineering Computing and Applications in Sciences (ADVCOMP 2014) in Rome, Italy, during August 2014, received a 'Best Paper' award and an invitation to submit an extended article version as a journal paper.

10. Participation in courses, meetings and overseas visits

Research visit at Brno University of Technology, Czech Republic

In April 2014 Dr. Ing. Marvin Bugeja visited the Department of Mechatronics at Brno University of Technology, hosted by the head of department Prof. Robert Grepl. Dr. Bugeja delivered lectures and practical sessions on "Introduction to Nonlinear Systems Analysis". Moreover, he discussed possibilities of joint research projects and lecturing visits between the two departments. As a result of these discussions the two parties agreed to start collaborating on a particular research project. Part of this collaboration entails a PhD student from Brno University of Technology spending a few weeks working in the Control Laboratory of the University of Malta under the guidance of Dr. Ing. Marvin Bugeja and Prof. Ing. Simon G. Fabri. This visit will be taking place between October and November 2014.

Attendance at meeting of the General Assembly of the European Control Association

In June 2014 Professor Simon G. Fabri attended the annual General Assembly meeting of the European Control Association (EUCA) which was held at Strasbourg in France. Prof. Fabri is the Malta representative on the General Assembly of EUCA.

Participation at MED 14

In June 2014 Professor Simon G. Fabri presented a paper at the 22nd Mediterranean Conference on Control and Automation (ECC13) in Palermo.

11. Collaboration with Third Parties

International collaboration...

Dr. Ing. Marvin Bugeja and Professor Simon G. Fabri collaborated with Dr. Francois Guerin from the University of Le Havre in France on Vision Based Target Tracking of Wheeled Mobile Robots. Results from this work were presented at the International Conference on Decision and Control CDC held at Florence in December 2013.

Professor Simon G. Fabri and Dr. Ing. Marvin Bugeja also collaborated with Professor Bjorn Wittenmark from Lund University in Sweden on Dual Adaptive Extremum Control Systems. Results from this collaboration were presented at the 22nd Mediterranean Conference on Control and Automation held at Palermo in June 2014.

Ms Alexandra Bonnici in collaboration with Dr. Johann Habakkuk Israel from the Fraunhofer Institute for Production Systems and Design Technology in Berlin, Germany, applied for two projects under the VisionAir program, allowing two students, namely Mr Daniel Camilleri and Ms Anne Marie Muscat to each participate in a two-week visit at the Fraunhofer institute. Through this collaboration, the paper sketch-based interface developed by Ms Bonnici and Prof. Kenneth Camilleri was integrated with the immersive sketching environment developed at the Fraunhofer institute, creating a new sketch-based interface that allows for two sketching modalities, namely online and offline sketching. A user study was conducted to determine the usability of such a hybrid interface, which was found to be practical and useful by all participants.
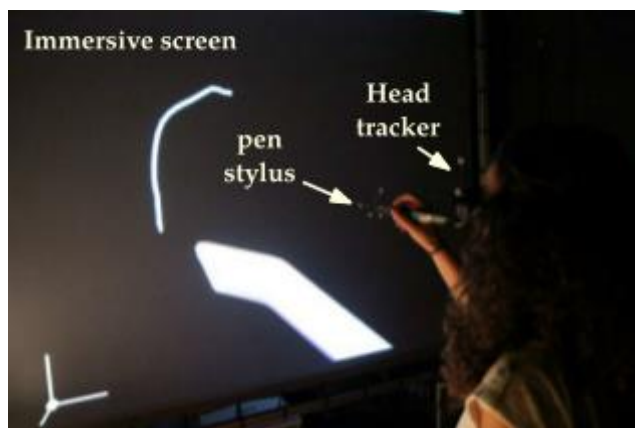
The immersive sketching environment

Professor Kenneth Camilleri together with Dr Tracey Camilleri, Dr Owen Falzon and Ms Rosanne Zerafa have recently started collaborating with Dr Fabio Cuzzolin from Oxford-Brookes University, UK on multilinear classification of brain signal data.

12. Public Outreach

European Robotics Week

The department led the Faculty's participation in the local activities of the European Robotics Week which was held from the 24th to the 30th November. This European-wide innovative event was coordinated by the European robotics community and supported by the European Robotics Coordination Action (euRobotics) which is funded by the Seventh Framework Programme on Information and Communication Technology. Activities took place simultaneously over sixteen European countries, including Malta, to engage robotics technology stakeholders such as manufacturers, universities and research institutes, to organize outreach activities targeted to students and the general public on the theme of robotics. The objective is to highlight the importance of robotics as an emerging technology in modern application areas, and to use the robotics platform as a vehicle to encourage students in taking up careers and educational programmes in science, technology, engineering and mathematics (STEM). The turnout at the Faculty of Engineering was very encouraging, where a total of about 50 secondary school children visited the robotics set ups and demonstrations over three mornings. These included hands-on mobile-robot programming workshop sessions organized and delivered by the Systems and Control (SCE) department and demonstrations with various robotic manipulators in the Industrial Automation Laboratory of the Department of Industrial and Manufacturing Engineering.

Press articles, TV and magazines

The Department has kept a very active public outreach agenda featuring in various magazine programmes on all local TV stations as well as on a number of radio stations and print media. This year's public outreach was dominated by presentations related to the real-time brain-controlled music player which was launched in a press release in January 2014 on the national news and various print media, and which was rapidly taken up by several tech page webmasters around the world.

Kids on Campus Summer School

The department participated in the Kids on Campus summer school by giving three interactive workshops on the 5th, 7th and 12th August for children aged between five and six years. In these workshops, the children were introduced to the various robots used for research within the Department, giving a brief overview on practical use of robots. The Lego Mindstorm robots were then used to introduce the concepts of obstacle detection and avoidance, ball throwing and path following.
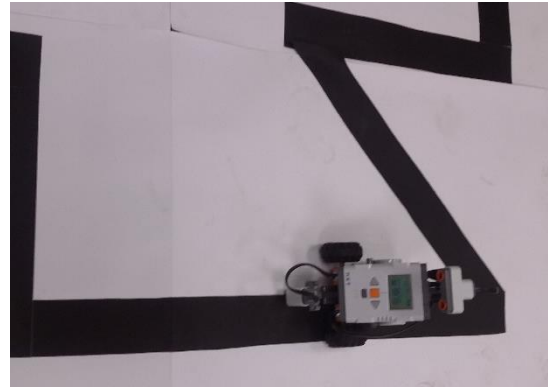
Lego Mindstorm applications programmed in the Kids on Campus Workshops

Foreign Student Placements and Internships

The Department hosted two intern students from the University of Le Havre in France on a two month internship. One of the students worked on a project involving the design, implementation and supervision of an industrial sequence control system using PLCs. The second student focused on a project concerned with vision-based control of mobile robots. Furthermore, in collaboration with the Centre for Biomedical Cybernetics, the Department hosted four interns this year. The first was a biomedical engineering undergraduate student from the Universite de Franche-Comte, France, and was responsible for tuning a Kalman Filter designed to process signals obtained from accelerometers for the purpose of motion tracking. The next two students were two undergraduate students from L'Ecole Superieure D'ingenieurs De Rennes, France. The first was tasked with improving the visual interface of a real-time brain controlled music player. The second was tasked with segmenting and registering visual images and thermal images of the hand, and automatically extracting the temperatures from the finger tips.

The last student was a graduate student from Bern University of Applied Sciences, in Switzerland, who was tasked with developing a 3D spatial EEG activity map for signals acquired from the scalp using a wireless Enobio EEG amplifier.

Discover University

During the Discover University week, the department organized a series of two hands-on workshops in the Systems and Control laboratory 'Programming with Lego Mindstorms' was attended by 60 students from three different schools. Through this workshop, the students were introduced to concepts of robot control via the Lego Mindstorms robots. 'What! No Photoshop' was attended by 60 fifth formers from three different schools. This workshop introduced the students to the basic image processing algorithms that drive common imaging apps on smart-phones. In addition, a talk entitled 'Machine Interpretation of Sketches' was given in the main pavilion on campus.

Various setups, namely the thermal camera, the Emotiv EPOC headset and the eye-gaze tracking platform, were also displayed to students and the general public in the main pavilion on campus. The attendees were given an introduction to the concepts behind thermography, brain-computer interfacing and eye-gaze tracking, and encouraged to interact and operate the setups with the help and guidance of departmental staff. All three setups received considerable interest from the attending students and public.

Science in the City

For Science in the City which was held on the 26th of September 2014, the department in collaboration with the Centre for Biomedical Cybernetics and Moveo Dance Company put up a performance at St. James Cavalier, Valletta entitled MindSet. The show featured a member of the audience being setup with a brain to computer interface through which his brain activity could be recorded and analysed in real time whilst he is seeing the dance show. The particular brain activity recorded would then be used to determine the dance, song and theatre lights to follow. In this way, the member of the audience had total control of the performance flow including dance, song and lightning arrangements. The four performances presented were very well attended.

Testing subject brain signals from MindSet performance