

# **Department of Systems and Control Engineering**

## **Annual Report 2018 - 2019**



**L-Università ta' Malta**  
Faculty of Engineering

Annual activity report for the year 2018 - 2019 published by the

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## Key Descriptors

### Members of Staff

|                                                 |     |
|-------------------------------------------------|-----|
| Academics                                       | 8   |
| Visiting Academics (a total of T3 appointments) | 2   |
| Systems Engineers                               | 2   |
| Senior Laboratory Officer                       | 1   |
| Administrative Staff                            | 1.5 |

### Externally Funded Members of Staff

|                                                                           |   |
|---------------------------------------------------------------------------|---|
| Postdoctoral Researcher (also with the Centre for Biomedical Cybernetics) | 1 |
| Research Support Officer II                                               | 2 |
| Research Support Officer I                                                | 1 |

### Research Projects

15

### Research Funds

€249,700

### Students

|                                                          |    |
|----------------------------------------------------------|----|
| Supervision/Co-supervision of B.Eng. Final Year Students | 6  |
| Supervision/Co-supervision of M.Sc. by Research Students | 7  |
| Taught M.Sc. Students                                    | 2  |
| Supervision/Co-supervision of M.Phil./Ph.D. Students     | 10 |
| Interns                                                  | 5  |

### Peer-reviewed Publications

|                   |   |
|-------------------|---|
| Conference papers | 7 |
| Journal papers    | 7 |

### Teaching Activities

|                           |              |
|---------------------------|--------------|
| Postgraduate study units  | 14 (70 ECTS) |
| Undergraduate study units | 12 (90 ECTS) |

### Public Outreach

|                                         |       |
|-----------------------------------------|-------|
| Primary and secondary visiting students | ~ 470 |
|-----------------------------------------|-------|



## 1. Foreword

Over the past year the Department has continued consolidating its laboratories by refurbishing the space that was previously occupied by the Control Systems Laboratory. This space has now been re-purposed to provide teaching and research space for the areas of Transport Modelling, Signal and Image Processing, and Computer Vision, together with a closed space for biomedical data acquisition. This laboratory, called TrISP Lab, can now host students, projects and activities in these topics.

The Department has also run its full-time Masters in Signals, Systems and Control for the second time. We can now use the experience of these past two years together with the feedback from the external examiner to improve the Programme and possibly develop new offers.

The research portfolio of the Department was further consolidated and expanded, with most of the academics involved in funded research projects in some way or another. The research project areas include: multi-robot systems and robot control; robot and computer vision; computer vision for forensic analysis for child sexual abuse; vision-based eye-gaze tracking and eye-gaze tracking using the electro-oculogram; speech processing; music analysis and generation; brain signal processing and brain-computer interfacing; neuro-rehabilitation; bionic prosthetics; CT radiation dose optimisation; smart environments; transport modeling and control; cloud-based traffic light control; and satellite engineering. The research funding level of the Department over this academic year was close to a quarter of a million euros, raised through national and EU funding sources. This funding supports the Department's research students and its research activities, leading to a number of peer-reviewed publications in international conferences and journals.

It is also noteworthy that the link that was initiated with the University of Applied Sciences Nancy- Brabois, France, has led to the Carousel Week which gave an opportunity to the first-year students of the B.Eng. (Electrical and Electronic Engineering) degree programme to participate in a one-week international programme providing them with experience in teamwork, practical engineering work, industrial visits and socio-cultural events with their international counterparts. It is commendable that the Department's academics have been developing a number of international collaborations that encompass both the teaching and research domains.

The Department has remained very active in public outreach participating in a growing number of student events, and it has continued to co-ordinate the Faculty's Engineering Technology Clubs, attracting several hundreds of secondary school students.

Once again, the Department is grateful to all its academic, technical and administrative members who have continued to take initiatives and work together providing an excellent outreach and teaching experience, and advancing knowledge in its areas of expertise.

Prof Ing. Kenneth P. CAMILLERI  
Head of Department  
30th September 2019



## 2. Staff Members

### 2.1 Staff Members List

#### Full Professors

Prof. Ing. Kenneth P. Camilleri, *B.Elec.Eng.(Hons.) (Melit.), M.Sc. (Sur.), Ph.D. (Sur.), MIEE, SMIEEE*  
— **Head of Department**

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

#### Senior Lecturers

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

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

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

#### Lecturers

Dr Alexandra Bonnici, *B.Eng. (Hons.) (Melit.), M.Phil. (Melit.), Ph.D. (Melit.), LLCM(TD), MIEEE*

Dr Ing. Stefania Cristina, *B.Eng.(Hons) (Melit.), M.Sc. (Melit.), Ph.D. (Melit.), MIEEE, MIET*

#### Assistant Lecturers

Ing. Luana Chetcuti Zammit, *B.Eng. (Hons.) (Melit.), M.Sc.(Eng.), MIEEE*

#### Visiting Academics

Ing. Andre Sant, *B.Eng.(Hons.) (Melit.), M.Sc.(Eng.), MIEEE*

Mr David Debono, *B.Eng. (Hons.) (Melit.), M.Sc.(Eng.)*

#### Research Support Officer II

Ing. Rosanne Zerafa, *B.Eng. (Hons.) (Melit.), M.Sc.(Eng.)*

Mr Daniel Bonanno, *B.Sc. (Hons.) (Melit.), M.Sc. ICT (Melit.)*

#### Research Support Officer I

Mr Andre Tabone, *B.Eng. (Hons.) (Melit.) (from July 2019)*

#### Systems Engineers

Ing. Lucianne Gauci, *B.Eng. (Hons.) (Melit.)*

Ing. Rachael Duca, *B.Eng. (Hons.) (Melit.), M.Sc.(Eng.), MIEEE*

#### Senior Laboratory Officer

Mr Noel Agius

#### Administrators

Ms Sanchia Cilia Lentini

Ms Darleen Abela (*until May 2019*)

## 2.2 Staff Academic and Administrative Activities

### Prof. Ing. Kenneth P. Camilleri

#### Administrative

Prof. Camilleri is the the Head of the Department of Systems and Control Engineering and member of the Board of Studies of the Electrical & Electronic Engineering undergraduate programme, the Board of Studies of the M.Sc. by Research in Engineering, the Board of the Faculty of Engineering and the University Promotions Board, and chairs the Board of Studies of the taught M.Sc. in Signals, Systems and Control. He is also Director of the Centre for Biomedical Cybernetics and chairs the Centre's Doctoral Committee and its Board of Studies for the M.Sc. by Research programme, and he represents the Centre on the Board of the Malta Neuroscience Network of the University of Malta. Prof. Camilleri assists the European Union's Research Executive Agency in its evaluations of proposals submitted to various Horizon 2020 calls, and assists various international research agencies in their research proposal evaluations.

#### 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" as well as project co-ordinator for the Horizon 2020 project '4NSEEK'. He is the principal investigator for the MCST National R&I FUSION-TDP funded project R&I-2016-010-T 'WildEye' and the RIDT Malta Neuroscience Network Brain Fund Award 'DeepMotionBCI'. Prof. Camilleri is also co-investigator for the MCST National R&I FUSION-TDP funded projects R&I-2015-032-T 'BrainApp', R&I-2015-048-T 'FIHI', R&I-2017-002-T 'Deep-FIR', R&I-2017-028-T 'MAProHand', R&I-2018-012-T 'EyeCon', and for the MCST National R&I FUSION-CVP funded projects R&I-2018-004-V 'NIVS', R&I-2018-024-V 'ESC', R&I-2019-007-V 'Leggiero', R&I-2019-024-V 'PointACT', and R&I-2019-025-V 'VRSurge', as well as co-investigator in the TRAKE projects 'CAMVISM' and 'Eye-Design', and the RIDT Cancer Research Grant 2018 project entitled 'Combined Thermal and Visual Imaging for Early Detection of Skin Cancer'. Prof. Camilleri is a member on the Editorial Board of the Journal of Neuroscience Methods (Elsevier) and regular reviewer for several journals, including: IEEE Transactions on Image Processing; IEEE Transactions on Signal Processing; IEEE Signal Processing Letters; IEEE Computing in Science and Engineering; IEEE Access; SPIE Journal of Electronic Imaging; SPIE Optical Engineering; Elsevier Expert Systems with Applications; and Taylor & Francis Brain Computing Interfacing Journal. He is also International Programme Committee member of several international conferences, including: The Sixteenth International Conference on Intelligent Environments (IE 2019), the Eighteenth International Conference on Computer Analysis of Images and Patterns (CAIP 2019) and Applications of Intelligent Systems (APPIS 2019).

### Prof. Ing. Simon G. Fabri

#### Administrative

Prof. Fabri is a member on several University boards and committees including the Academic Resources Funds Committee, the Board of the Institute of Linguistics, the Board of the Institute for Climate Change and Sustainable Development, the Quality Assurance Committee, the Doctoral Academic Committee, the Board of Studies of the M.Sc. in Signals, Systems and Control, and the M.Sc. Board of Studies and Doctoral Committee of the Centre for Biomedical Cybernetics. Prof. Fabri is coordinator of the department's Internal Research Workshop Series and the M.Sc. course on Signals, Systems and Control. He is a member of the Malta Government Engineering Profession Board and the Executive Board of the Mediterranean Control Association.

#### Academic

Prof. Fabri is the project leader of the ERDF Project "Modernising the University of Malta's Control Systems Engineering Laboratory". He is a member on the Editorial Board of the International Journal on Advances in Intelligent Systems and Associate Editor of the International

Journal of Systems Science published by Taylor & Francis. Prof. Fabri is co-investigator in the MCST National R&I funded projects (FUSION) R&I-2015-042-T 'Speechie', R&I-2016-035T 'HDMS' and R&I-2017-003T 'Ride+Safe'. He is a reviewer for several journal submissions, including: the International Journal on Advances in Intelligent Systems, Transactions of the Institute of Measurement and Control, the International Journal of Control, the Journal of Vibration and Control, Mathematical Problems in Engineering and IEEE Transactions on Systems, Man and Cybernetics and reviewer committee member or associate editor for several international conferences.

### **Dr Kenneth Scerri**

#### **Administrative**

Dr Scerri chairs of the Faculty of Engineering International Affairs Committee, which during this academic year has established four new Erasmus agreements and has both sent and welcomed numerous students and academics on various placements, internships and visits. He is currently finalising the establishment of the Intelligent Transportation Research Laboratory at the Faculty of Engineering. He has also been awarded the MCST Commercialisation Voucher Programme (CVP), for the project entitled "An Internet of Things Solution for Urban Traffic Control" (IOT4UTC). During this academic year, Dr Scerri has joined the EU COST actions CA18232 - Mathematical models for interacting dynamics on networks. He has also worked to establish and launch the Data Science Research Platform at the University of Malta and establish research collaborations with local IT companies and start-ups.

#### **Academic**

Dr Scerri is a reviewer for the International Journal of Systems Science and various international scientific conferences. He is also a member of the Transportation and Data Science research platform at the University of Malta.

### **Dr Ing. Marvin K. Bugeja**

#### **Administrative**

Dr Bugeja is the national representative on the general assembly of the European Control Association (EUCA). He is also the Faculty's representative on Senate (until July 2019) and a member of the University of Malta Scholarship Selection Board; a member of the Board of Studies of the M.Sc. in Language and Computation offered by the Institute of Linguistics and Language Technology; a member of the Board of Studies of the M.Sc. in Signals, Systems and Control offered by the Faculty of Engineering; and a member of the Faculty of Engineering IT affairs committee.

#### **Academic**

Dr Bugeja is a reviewer or programme committee member for several conferences and journal submissions, including the IEEE Transactions on Cybernetics, the International Journal of Systems Science, Neurocomputing, the International Journal by Elsevier and the International Conference on Informatics in Control, Automation and Robotics among others. In addition Dr Bugeja is a member of the Astrionics research group (Astrea), and a member of the Particle Detector and Accelerator research group, both of the University of Malta, as well as a regular invited lecturer at the ISMMB, Dept. of Mechatronics, Faculty of Mechanical Engineering, Brno University of Technology, Brno, Czech Republic.

### **Dr Tracey Camilleri**

#### **Administrative**

Dr Camilleri is a member of the Faculty's M.Sc. by Research Board of Studies, the Faculty's representative in the Malta Neuroscience Network, the academic advisor for first year electrical engineering students, the counselor of the IEEE Malta student branch, the secretary of the IEEE Women in Engineering and a member of the IEEE Malta Section committee.



**Academic**

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. Dr Camilleri is the principal Investigator of the National R&I Fund Award R&I-2015-132-T 'BrainApp' and the National R&I Fund Award R&I-2018-012V 'EyeCon', and co-investigator of the RIDT Malta Neuroscience Network Brain Fund Award 'DeepMotionBCI'.

**Dr Alexandra Bonnici****Administrative**

Dr Bonnici is a member on the Faculty's Board of Studies (B.Eng. electrical stream) as well as the Doctoral Board of Studies for the Centre of Biomedical Cybernetics. Dr. Bonnici coordinates the Faculty of Engineering Technology Clubs, the Job Shadowing Week, and is the coordinator of the Carousel Week. Dr Bonnici is also the Program Coordinator of the new Certificate in Engineering Sciences being offered by the Faculty of Engineering.

**Academic**

Dr Bonnici is a reviewer or committee member for international conferences and journals, including: The Eurographics Workshop on Sketch Based Interfaces and Modelling, Computer and Graphics Journal, The International Symposium on Document Engineering and The Eurographics Conference on Visualization. Dr Bonnici is also a member of the Steering Committee of the ACM International Symposium on Document Engineering, a topic editor for the research topic Music and AI for Frontiers, and is an associate editor on Xjenja, the journal of the Malta Chamber of Scientists. Dr Bonnici is a co-investigator on the '4NSEEK' project co-financed through the H2020 ISFP-2017-AG-CYBER call and the TRAKE 'EyeDesign' project.

**Dr Ing. Stefania Cristina****Administrative**

Dr Cristina is a member of the Faculty's PR committee. She serves as a project proposal evaluator for Horizon 2020 project proposals and is Hon. Secretary of the Malta Group of Professional Engineering Institutions (MGPEI).

**Academic**

Dr Cristina is a reviewer for several conferences and journal submissions, including the International Workshop on Assistive Computer Vision and Robotics (ACVR), the ACM Symposium on Eye Tracking Research and Applications (ETRA), the ACM Symposium on Document Engineering (DocEng) and the ACM Transactions on Multimedia Computing, Communications, and Applications (TOMM). Dr Cristina is the principal investigator of the National R&I Fund Award R&I-2019-024V 'POINTact' and part of the Project Management team of the National R&I Fund Award R&I-2016-010T 'WildEye'. She is also a principal investigator of the TRAKE 'EyeDesign' project, and a co-investigator of the '4NSEEK' project co-financed through the H2020 ISFP-2017-AG-CYBER call.

**Ing. Luana Chetcuti Zammit****Administrative**

Ing. Chetcuti Zammit is an IEEE member. She is currently helping in the establishment of the Intelligent Transportation Research Laboratory at the Faculty of Engineering.

**Academic**

Ing. Chetcuti Zammit is a reviewer for several international conferences such as the Australian Control Conference.



## 3. Academic Activities

### 3.1 Research Activities

#### Research Projects

##### Coordination and Control of Multi-Robot Systems

MAIN INVESTIGATORS: Dr Ing. Marvin Bugeja

RESEARCH STUDENTS: Ing. Rachael Duca

For several decades, the robotics community has focused its research on the design of optimal and robust algorithms that enable a mobile robot to individually and autonomously perform a specific task. However there are times when it is very difficult, if not impossible, for a single robot to execute the given task on its own. For instance, the task at hand can be too complex for a single agent, or it might involve a large physical space. Moreover, a system of multiple robots working together to achieve some common goal, often leads to a quicker, more robust and more efficient solution. However such systems can only be designed if the task at hand is split and distributed in a manner that maximizes efficiency and enhances robustness, based on the capabilities of the individual robots in the team. Such systems have several real-life applications such as in: persistent surveillance, disposal of hazardous waste, warehouse management, and autonomous exploration. To this end, this doctoral research programme (started Oct 2016) is investigating how the coordination and cooperation between autonomous agents in a multi-robot system can be made more efficient, robust, and reconfigurable. This work aims to contribute an optimal framework that allows for task division, allocation and execution for multi-robot systems. This framework shall then be applied to address a real-life relevant problem. The results of the reviewing stage of this project has been published in a review paper<sup>1</sup> at an international peer-reviewed conference in July 2017. More recently, a novel solution to the energy-restricted coverage problem, where a team of robots with energy restrictions is required to optimally cover an environment with time-varying importance regions, has been submitted for peer-review to one of the major conferences in the field.

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<sup>1</sup>R. N. Duca, M. K. Bugeja, "A review on multi-robot systems categorised by application domain," in Proc. of the 25th Mediterranean Conference on Control and Automation (MED), Valletta, Malta, July 2017, pp. 701-706.

### **Robotics, Control and Automated Systems**

MAIN INVESTIGATORS: Prof. Ing. Simon G. Fabri, Dr Ing. Marvin Bugeja

RESEARCH STUDENTS: Various

FUNDING BODY: University of Malta Research Grants

FUNDING AMOUNT: €4,400

AWARDEE: Prof. Ing. Simon G. Fabri, Dr Ing. Marvin Bugeja

Projects in this area study various aspects of robot control on different platforms, including mobile robots, and other control systems.

A particular robotics project was carried out by undergraduate student Ms Rebecca Spiteri, under the supervision of Dr Ing. Marvin Bugeja. Industrial robots are widely used in the manufacturing and construction industries. The robotic industry generally aims at having a light system capable of achieving high precision and accuracy in the shortest possible duration. Vibrations are induced within a flexible system, if either the system involves inherently flexible parts or the system involves light-weight construction. The main objective of this dissertation, is to address vibration issues in systems with multiple vibration modes, due to presence of more than one flexible components. For computer controlled systems, one effective feed-forward technique is Input Shaping which makes use of the constructive cancellation principle. Input shaping is basically done by convolving a sequence of impulses with a desired base command, which in turn creates a self cancelling command signal. The input shaping techniques considered in this dissertation are Positive Zero-Vibration shapers, Specified Negative Amplitude Zero-Vibration Derivative-Derivative shapers and the S-curve command function. A rotary multiple-link flexible manipulator was used to analyse and validate the effect of different input shaping. A virtual model of the multiple-link flexible manipulator, along a model of the PM DC motor and an angular positional controller was implemented in a realistic simulation environment provided by MATLAB<sup>®</sup> Simscape Multibody<sup>™</sup>. Different input shaping techniques were implemented and their effect on the virtual model was analysed through three dimensional animations and vibration graphical representations. Furthermore, the input shaping techniques were digitally implemented on the DS1104 control board using MATLAB<sup>®</sup> Simulink<sup>®</sup> and ControlDesk D-SPACE software. One can conclude that the most effective and robust input shapers are those that consist of a higher number of impulses namely, the positive convolved shapers, the SNA-ZVDD shaper and the S-curve command as a base function to positive input shapers. The analysis carried out in this dissertation is based on vibration reduction, settling time reduction and robustness of the input shaping techniques.

### **Eye-Gaze Tracking**

MAIN INVESTIGATORS: Dr Ing. Stefania Cristina

FUNDING BODY: University of Malta Research Grant

FUNDING AMOUNT: €2,200

AWARDEE: Dr Ing. Stefania Cristina

This project builds upon our long-standing track record on eye-gaze tracking, whereby the eye movements are tracked from image frames captured by a webcam and used to control the

mouse cursor on a monitor screen. The aim of this project is to investigate eye-gaze tracking methods that reduce further the constraints imposed on the user, such as on the head and face movements, in order to allow for more natural user interaction. It is also envisaged that the interaction space is expanded to encompass the user's living environment, hence allowing interaction by means of the eye-gaze with objects of interest within a smart environment, based on image information captured by suitably placed cameras within the environment.

### **WildEye - Eye-Gaze Tracking in the Wild**

MAIN INVESTIGATORS: Prof. Ing. Kenneth P. Camilleri and Dr Ing. Stefania Cristina

RESEARCH SUPPORT OFFICER: Mr Daniel Bonanno

FUNDING BODY: FUSION R&I Technology Development Programme 2017

FUNDING AMOUNT: €141,313 (out of the total project funding €193,943 for the consortium)

AWARDEE: Prof. Ing. Kenneth Camilleri

Eye movements have long been recognised to provide an alternative channel for communication with, or control of, a machine such as a computer, substituting traditional peripheral devices. The ample information inherent to the eye movements has attracted increasing interest through the years, leading to a host of eye-gaze tracking applications in several fields, including assistive communication, automotive engineering, and marketing and advertising research.

This project has been awarded funding under the FUSION R&I Technology Development Programme 2017, and has commenced on the 31st of July 2017 with the collaboration of Seasus Ltd as the commercial partner. The project proposes a passive eye-gaze tracking platform aimed to provide an alternative communication channel for persons with physical disabilities, permitting them to perform mundane activities such as to operate a computer, hence improving their quality of life and independence, or for normal individuals as an additional access method, permitting an auxiliary control input for computer applications, such as games.

In the proposed platform, eye and head movements will be captured in a stream of image frames acquired by a webcam, and subsequently processed by a computer (and possibly mobile devices) in order to estimate the gaze direction according to the eye and head pose components. Mapping the eye-gaze to a computer screen will permit commands to be issued by the selection of icons on a suitably designed user interface. This project will be addressing challenges associated with eye-gaze tracking under uncontrolled daily life conditions, including handling of head and non-rigid face movements, and reduction or elimination of user calibration for more natural user interaction.

The research work carried out during the past year has finalised the development of a method for the estimation of head pose under non-rigid face movement, and has now progressed towards the development of a method for mapping the 3D gaze information onto a 2D point-of-regard on the monitor screen. Aspects of our research work have also been published in a paper submitted to the 27th European Signal Processing Conference (EUSIPCO 2019).

### Visual object recognition based on textual descriptions

MAIN INVESTIGATORS: Dr Albert Gatt<sup>2</sup> and Prof. Ing. Kenneth P. Camilleri

RESEARCH STUDENTS: Mr Marc Tanti<sup>3</sup>

This research project, undertaken in collaboration with the Institute of Linguistics and Language Technology, combines the computer vision expertise of the Department with linguistic description of images provided by the Institute. Specifically, the aim of the project is to generate linguistic captions for images and seek methods that can generate descriptions of objects by recognition of its parts. This research has led us to study the use of deep neural networks to this problem. In this context, typically, a convolutional neural network (CNN) extracts image features and a recurrent neural network (RNN) encodes linguistic information. The most common architectural model “injects” the CNN-extracted visual features directly as an input to the RNN, thus making it part of the linguistic encoding process, as shown in Figure 3.1b. An alternative architecture that we have investigated encodes the visual and linguistic features separately, with these being “merged” at a subsequent feed-forward stage, as shown in Figure 3.1a. Our work suggests that the “merge” architecture is superior to the “inject” approach, leading not only to architectures that are more suitable for this task but also to an insightful interpretation on the role of the RNN and CNN processes. Recent work investigated the sensitivity of the various architectures of neural image caption generators to the visual input. This work showed that the extent to which image captioning architectures retain and are sensitive to the visual information depends on the type of word being generated and its position in the caption.

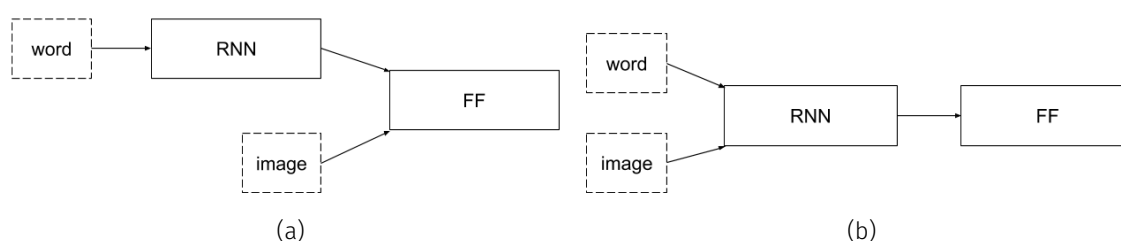


Figure 3.1: Two deep neural network architectures. (a) shows a ‘merge’ architecture and (b) shows an ‘inject’ architecture.

### Brain Controlled Applications (BrainApp)

MAIN INVESTIGATORS: Dr Tracey Camilleri, Prof. Ing. Kenneth P. Camilleri and Dr Owen Falzon

RESEARCH SUPPORT OFFICER: Ing. Rosanne Zerafa

FUNDING BODY: FUSION R&I Technology Development Programme

FUNDING AMOUNT: €136,335 (out of the total project funding €181,793 for the consortium)

AWARDEE: Dr Tracey Camilleri

A Brain Computer Interface (BCI) gives a person the ability to communicate with and control machines using brain signals instead of peripheral muscles. BCIs allow people with severely restricted mobility to control devices around them, increasing level of independence and im-

<sup>2</sup>Institute of Linguistics and Language Technology

<sup>3</sup>Institute of Linguistics and Language Technology

proving quality of life. BCIs may also be used by healthy individuals, e.g. in gaming, and are expected to become a ubiquitous alternative means of communication and control.

This year the project suffered some delays as the industrial partner had to withdraw from the project and an alternative partner had to be found. In this regard, 88.eu offered to take up the project instead of 6PM. Stage 2 of the three-stage project was extended by 4 months and is now planned to be concluded by end of November 2019.

As part of this project Ing Rosanne Zerafa is pursuing a doctoral degree entitled 'Switching Multiple Models for SSVEP-based Brain-Computer Interfaces'. The principal contributions of this work, which are in line with the BrainApp project, are listed below. Ing Zerafa has just submitted her MSc to PhD transfer report and is sitting for her interview in mid December.

List of contributions:

1. A comprehensive review of the different feature extraction methods employed in SSVEP-based BCIs found in the literature including (i) a brief mathematical description of each feature extraction algorithm; (ii) a categorisation of the training requirements of SSVEP-based methods into three categories, defined as training-free methods, subject-specific and subject-independent training methods; (iii) a comparative review of the training requirements of SSVEP feature extraction methods, providing a reference for future work on SSVEP-based BCIs.
2. Selected state-of-the-art SSVEP detection techniques have been implemented and applied to SSVEP data. These shall act as a benchmark with respect to which the proposed AR-SMM framework will be compared.
3. An investigation was conducted to evaluate whether AR models provide a good fit for SSVEP data. Different AR expert models were developed for each SSVEP class in a multiple model framework and then used for the prediction of new EEG data. This classification based on the model's predictive accuracy is different from the standard approach of using AR models in EEG analysis in which AR parameters are used directly to form features for classification.
4. The AR models are incorporated within a probabilistic multiple modelling (AR-MM) framework and applied to a 12-class SSVEP dataset from 10 subjects. The results revealed the potential of using the AR-MM probabilistic approach to distinguish between different classes using single-channel SSVEP data. Through this work it is shown that the univariate AR-MM probabilistic approach can yield a significant improvement in performance over power spectral density analysis (PSDA), a standard single-channel SSVEP detection method. The method's performance is comparable to that of canonical correlation analysis (CCA) and filter bank CCA (FBCCA), two standard multichannel SSVEP detection methods.
5. The continuous identification and segmentation of SSVEP data was further exploited in a switching multiple modelling (AR-SMM) approach. As EEG data switches from one SSVEP class to another, the AR-SMM approach is able to identify these transitions by switching between different models each representing the different SSVEP classes. As opposed to the typical window-based or batch mode classification, this framework provides a

sample-by-sample classification for SSVEP detection that may lead to faster detection of the user's intent and an improved ITR for the BCI application.

6. A study has been conducted to compare the EEG signal quality of different commercially available EEG signal acquisition systems and evaluate their ergonomics for use in an SSVEP-based BCI.
7. The effect of external distractors on SSVEPs has been analysed, highlighting the need of techniques that are able to effectively detect SSVEPs in real uncontrolled environments.
8. An SSVEP-based BCI, specifically a motorised bed BCI application, that is practical and can be used in a real-life setting is being developed. A prototype with the standard SSVEP detection techniques has already been implemented. The goal is to implement the proposed SSVEP detection technique, capture new data and test its performance and practicality in real-time.

The publications that have emerged so far in this project are:

1. R. Zerafa, T. Camilleri, O. Falzon, and K. P. Camilleri, To train or not to train? A survey on training of feature extraction methods for SSVEP-based BCIs, *J. Neural Eng.*, vol. 15, no. 051001, 2018. [Online]. Available: <https://doi.org/10.1088/1741-2552/aaca6e>
2. R. Zerafa, T. Camilleri, O. Falzon, and K. P. Camilleri, A comparison of a broad range of EEG acquisition devices - is there any difference for SSVEP BCIs? *Brain-Computer Interfaces*, vol.5, no. 4, pp. 121131, 2018. [Online]. Available: <https://doi.org/10.1080/2326263X.2018.1550710>
3. R. Zerafa, T. Camilleri, K. P. Camilleri, and O. Falzon, The effect of distractors on SSVEP-based brain-computer interfaces, *Biomed. Phys. Eng. Express*, vol. 5, no. 035031, 2019. [Online]. Available: <https://doi.org/10.1088/2057-1976/ab155d>
4. R. Zerafa, T. Camilleri, O. Falzon, and K. P. Camilleri, "An autoregressive multiple model probabilistic framework for the detection of SSVEPs in brain-computer interfaces," submitted to BIOSIGNALS 2020 conference - currently under review.

### **Eye based Control (EyeCon)**

MAIN INVESTIGATORS: Dr Tracey Camilleri, Prof. Ing. Kenneth Camilleri, Mr Nathaniel Barbara

FUNDING BODY: FUSION R&I Technology Development Programme

FUNDING AMOUNT: €122,772 (out of the total project funding €194,910 for the consortium)

AWARDEE: Dr Tracey Camilleri

EyeCon aims to use a particular eye movement recording technique known as electrooculography (EOG), whereby the electrical activity of the human eyes is captured using electrodes attached to the face in close proximity of the eyes, to develop a practical human-computer interface (HCI) system. This project aims to address practical issues related to the usage of EOG-based systems, particularly to fuse head pose information and develop head movement compensation algorithms, to allow the user to interact with an eye movement-based assistive application naturally and without restrictions.

This project was expected to start in September but due to some delays from the end of MCST, the project is now expected to start in February 2020.

## **Gaze Angle Estimation using a Dense Multi-Channel EOG Electrode Configuration with Varying Head Pose Compensation**

MAIN INVESTIGATORS: Dr Tracey Camilleri, Prof. Ing. Kenneth Camilleri

RESEARCH STUDENT: Mr Nathaniel Barbara

FUNDING BODY: University of Malta Research Grant

FUNDING AMOUNT: €2,200

AWARDEE: Dr Tracey Camilleri

Electrooculography (EOG) is an eye movement recording technique which is typically used in eye-gaze tracking applications, particularly to develop human-computer interface (HCI) systems, targeted mainly at the mobile impaired. Specifically, EOG captures the electrical activity that is generated by the human eye, which could be regarded to behave like an electric dipole, having the positive and negative poles at the cornea and retina respectively. In fact, the eye creates an electrical field and the electrical signal generated by this field is recorded through EOG via a number of electrodes which are attached to the subject's face, in peri-orbital positions around the eyes.

This doctoral research program has started in June 2018 and the student sat for his MSc to PhD transfer at the beginning of November 2019. The contributions of this work that were presented in this transfer are:

1. A systematic analysis on the best choice of parameters of the different EOG baseline drift mitigation techniques considered in the literature. Furthermore, their performance in mitigating the effect of the baseline drift on the same EOG data is also compared qualitatively and quantitatively for the first time, to assess which technique would be most suitable;
2. The adaptation of the battery model proposed by Shinomiya et al. <sup>4</sup> to cater for the influence of both ocular globes, thereby providing a more generalised and realistic model of the EOG potential recorded at any position on the face;
3. An investigation on the feasibility of using this adapted battery model for gaze angle estimation;
4. Tied with III above, an investigation on the feasibility of using the same adapted battery model to estimate the ocular angles of both ocular globes separately and hence, the subject's POG in 3D space;
5. The proposal of a novel real-time-implementable framework to estimate the ocular pose while taking into consideration the effect of baseline drift on the EOG signals. The framework must not disrupt the overall morphology of the EOG signals and must be able to work with non-zero centred data;
6. The modelling of fixations, saccades and blinks within the proposed framework in V above, using the adapted battery model of the eye;
7. A systematic analysis on the correlation between the number of EOG channels consid-

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<sup>4</sup>K. Shinomiya, H. Shiota, Y. Ohgi, N. Itsuki, R. Tabesh, M. Yamada, and M. Kubo, "Analysis of the characteristics of electrooculogram applied a battery model to the eyeball," in International Conference on Biomedical and Pharmaceutical Engineering, pp. 428–431, IEEE, Dec. 2006.



- ered and the ocular pose estimation accuracy;
8. An investigation on the effect of a varying head pose on the EOG signal characteristics, and the development of corresponding compensation algorithms which also take into consideration the dynamic aspects of the eye-head coordination during gaze shifts.

Two publications have been generated through this work so far. Specifically:

- The comparative analysis of the different baseline drift mitigation techniques was submitted and accepted for publication at the Elsevier Biomedical Signal Processing and Control journal. This is expected to be published soon.
- Furthermore, the adapted battery model of the eye and the methods used for electrode position estimation and gaze angle estimation using offline, baseline de-drifted EOG data has been published in the Proceedings of the International Conference of the IEEE Engineering in Medicine and Biology Society, 2019.

### **Developing a practical human machine interface**

MAIN INVESTIGATORS: Dr Tracey Camilleri, Prof. Ing. Kenneth Camilleri, Dr. Owen Falzon

FUNDING BODY: University of Malta Research Grant

FUNDING AMOUNT: €2,100

AWARDEE: Dr Tracey Camilleri

This project aims to develop a practical human machine interface that allows a person to control computer applications using biosignals rather than the standard keyboard, mouse or touch screen interface. Particularly, brain signals and eye movements can be used to allow a person with limited mobility to communicate and control applications that will provide him/her with a better quality of life.

This research grant is being used to support two PhD students, Ing. Rosanne Zerafa and Mr. Nathaniel Barbara, as well as MSc student Mr. Jeanluc Mangion. In different ways, all three students are working on improving the practicality of the difference human machine interface systems they are working on. Specifically, Ing. Zerafa is working on the use of switching autoregressive models for SSVEP based brain computer interface systems, Mr Barbara is focussing on modelling of eye movements captured through EOG (electrooculography), for improved point of gaze estimation, while Mr. Mangion is considering an SSVEP based system which also exploits eye movement information captured in real time from EEG electrodes.

### CT Radiation Doses in Nigeria: Establishment of Diagnostic Reference Levels and Radiation Dose Optimisation

MAIN INVESTIGATORS: Prof. Ing. Simon G. Fabri, Dr Francis Zarb<sup>5</sup>, Prof. Mark McEntee<sup>6</sup>

RESEARCH STUDENT: Mr Idris Garba<sup>7</sup>

Computed Tomography (CT) procedures are considered as high radiation dose examinations. In view of this, every country is encouraged by international regulatory agencies such as the IAEA and ICRP, to develop Diagnostic Reference Levels (DRLs) that aim to establish radiation levels that should not be exceeded where good practice is applied, without compromising the quality of the scans for clinical purposes in the interest of patient protection. The aim of this project is to establish national DRLs for CT examinations in Nigeria for the purpose of radiation dose optimisation.

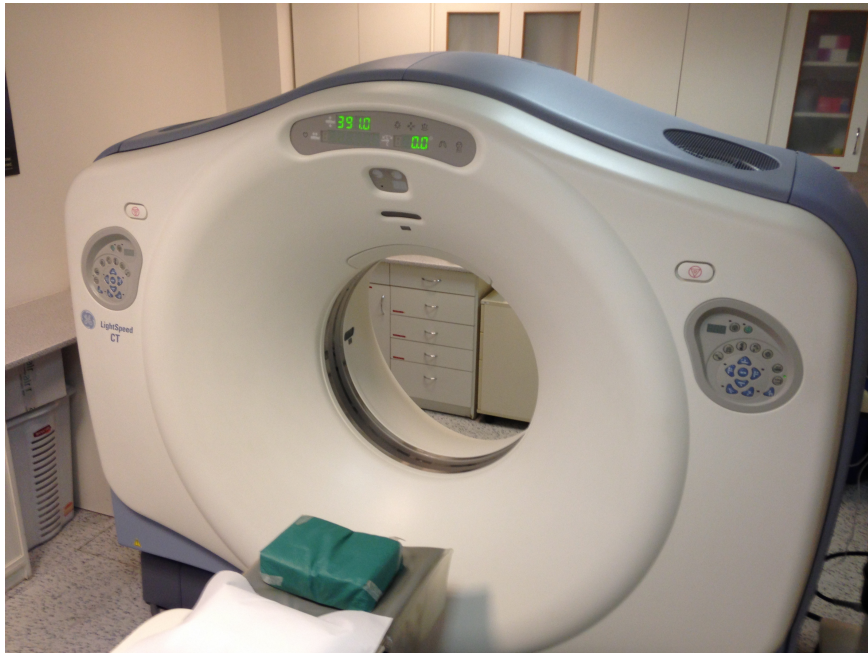


Figure 3.2: Typical CT scanning equipment

The study has applied quantitative methodologies with a cross sectional research design to identify radiation dose in terms of Computed Tomography Dose Index (CTDI) and Dose Length Product (DLP) for CT examinations. Both retrospective and prospective approaches were adopted. Retrospective dose data for the initial radiation dose assessment was collected for adults and paediatrics. This data was used to identify those centres where high or possibly unnecessary radiation exposure is used. A novel optimisation procedure was developed and executed whereby, through systematic adjustment of the CT scan parameters (kV, mAs, slice thickness, pitch), radiation dose is minimised while maintaining acceptable image quality for diagnostic purposes. Data was once again collected for the re-evaluation of the radiation dose after optimisation in centres where there is unnecessary high radiation dose value with respect to other CT centres or countries.

<sup>5</sup>Department of Radiography, Faculty of Health Sciences

<sup>6</sup>Brain and Mind Research Institute, The University of Sydney, Australia

<sup>7</sup>Department of Radiography, Faculty of Health Sciences

### Towards Autonomic Control of Urban Traffic Junctions

MAIN INVESTIGATORS: Ing. Luana Chetcuti Zammit

FUNDING BODY: University of Malta Research Grant

FUNDING AMOUNT: €2,200

AWARDEE: Ing. Luana Chetcuti Zammit

As increasing traffic demands are reaching critical levels worldwide, advanced traffic signal management is becoming a fundamental requirement. Despite recent advances in ITS, current systems can become suboptimal when networks are subject to major unanticipated irregularities, such as roadworks, accidents and extreme weather conditions, or to drastically changing and unpredictable traffic demand, say during rush hour. Autonomous-based systems are required to self-handle these complexities by modelling the network behaviour and adapting to the changes as required, in order to control traffic signals so as to optimize the flow of vehicles. This research work is directed towards the design of autonomous-based systems for signalized traffic junctions.

### Transport Modelling and Control Applied to the Maltese Traffic Network

MAIN INVESTIGATORS: Prof. Ing. Simon G. Fabri, Dr Kenneth Scerri, Prof. Maria Attard<sup>8</sup>

RESEARCH STUDENT: Ing. Luana Chetcuti Zammit

As increasing traffic demands are reaching critical levels worldwide, advanced traffic signal management is becoming a fundamental requirement. Intelligent Transportation Systems (ITS) have been implemented through the evolution and generation of traffic signal control concepts that integrate advances in control, communications and computational technologies to provide, amongst others, intelligent control of traffic lights that adapt themselves according to time-varying traffic density or to changing road conditions.

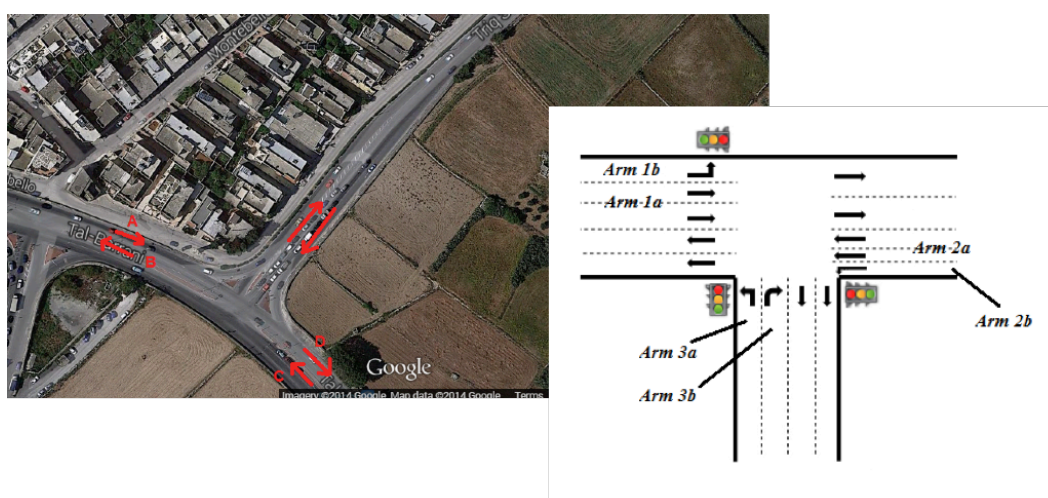


Figure 3.3: A junction map extracted from Google Maps.

Despite recent advances in ITS, current systems can become suboptimal when networks are subject to major unanticipated irregularities, such as roadworks, accidents and extreme

<sup>8</sup>Institute for Sustainable Development and Climate Change

weather conditions, or to drastically changing and unpredictable traffic demand, say during rush hour. Autonomous-based systems are required to self-handle these complexities by modelling the network behaviour and adapting to the changes as required, in order to control traffic signals so as to optimize the flow of vehicles. The aims of this research are to obtain a computationally efficient numerical model to reflect the changing traffic behaviour with little prior knowledge of the underlying traffic parameters through novel real-time joint state and parameter estimation algorithms and to design novel control strategies for adjusting the signals in real time according to changing traffic conditions captured by the model.

### **Design and Implementation of the Control System for a Physical Motorcycle Simulator**

MAIN INVESTIGATOR: Prof. Ing. Simon G. Fabri

FUNDING BODY: MCST FUSION R&I TDP

RESEARCH STUDENT AND INVESTIGATOR: Daniel Cassar, Denise Baldacchino

This project forms part of a larger MCST-funded research programme called *Ride+Safe*, led by the Department of Industrial and Manufacturing Engineering. This project involves the design and implementation of a control system for a Stewart Platform (hexapod) that will carry a mock-up motorcycle along with a user. A virtual reality headset worn by the user will display the motorcycle ride from a commercial software simulator, and the platform will manoeuvre the user in such a way as to emulate the physical dynamics of this simulation. The rider's physical movements, control of the motorcycle and vestibular effects are used to manipulate the platform with the effect of realistically emulating the feel of a motorcycle ride, including acceleration, banking and so on, through motion cueing algorithms.

### **Attitude Control of a Pico Satellite**

MAIN INVESTIGATORS: Prof. Ing. Simon G. Fabri, Dr Ing. Marvin K. Bugeja, Dr Ing. Marc Anthony Azzopardi<sup>9</sup>

RESEARCH STUDENT: Mr Darren Debattista<sup>10</sup>

This project is part of the Faculty-wide Astrea project aimed at launching a pico-satellite designed and developed at the University of Malta. During the past year, this subproject focused on data fusion techniques for reliable simulation of the satellite attitude and position through various sensors, and the design of 3-axis attitude control systems using reaction wheels and magnetorquers.

The design of a complete model of the kinematics and dynamics of the satellite in orbit of the Earth was developed and simulated. This was followed by a physical mock-up of the satellite to test the attitude determination and control systems as a proof of concept.

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<sup>9</sup>Department of Electronic Systems Engineering

<sup>10</sup>Department of Electronic Systems Engineering

## Musical Score Analysis

MAIN INVESTIGATORS: Dr Alexandra Bonnici, Dr Ing. Stefania Cristina, Prof. Ing. Kenneth Camilleri

Printed musical scores have, for centuries, given musicians the necessary instructions to reproduce musical pieces according to the composer's intent. The musical score presents information related to the melodic and rhythmic nature of the notes as well as other information related to the expressive nature of the note, such as its articulation, loudness and any ornamental embellishments that may be added to the notes. In addition, the musical score, presents the music player with the sequence with which the music is to be played since, unlike the reading of text, the reading and playing of music is not bound by reading in a forward direction only.

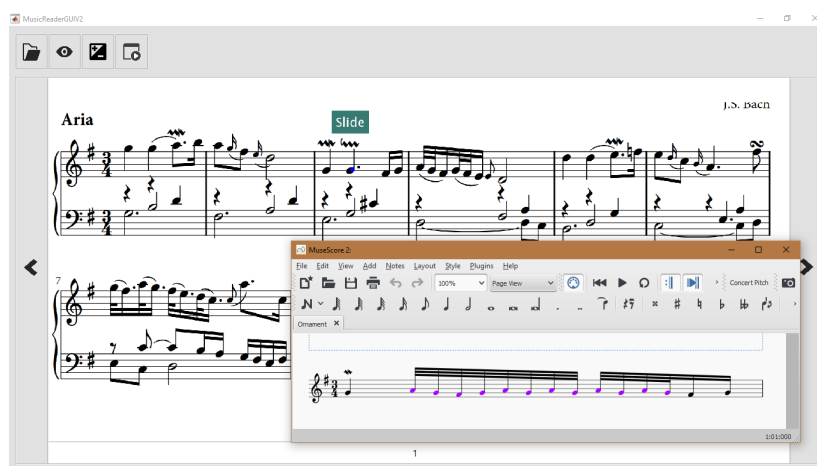


Figure 3.4: A user-interface which allows the pianist to select an ornamented noted and display this as a fully expressed ornament.

While musical notation has developed to suite the needs of printed publications, advances and widespread availability of technology no longer restricts music to the printed score. By performing optical musical recognition (OMR) we can identify the contents of the musical score and re-write this into digital formats, notably in MusicXML format which can be displayed on music readers such as MuseScore among others, and in the MIDI format which can be played by digital instruments. In the former case, we use musical knowledge on the interpretation of ornaments to fully express ornamented notes, creating a user interface which allows the piano student to switch between the notated ornament and the fully expressed ornament as illustrated in Figure 3.4. The MIDI file format allows us to interpret the musical notation and introduce expressiveness to the notes. Here, machine learning techniques such as Kalman filters are used to introduce expressions which are implied by the music but not necessarily notated in the score.

## Cloud-Based Intelligent Traffic Light Control

MAIN INVESTIGATORS: Dr Kenneth Scerri

RESEARCH STUDENTS: Various

FUNDING BODY: University of Malta Research Grants

FUNDING AMOUNT: €2,100

AWARDEE: Dr Kenneth Scerri

This research projects aims to develop the infrastructure and software for a cloud connected intelligent solution for traffic light control in urban environments. Developed over multiple years with the efforts of both undergraduate and postgraduate students, this project has developed and validated the hardware required to measure vehicle queues at the urban intersections. The cloud architecture required for the implementation of the machine learning algorithms have also been extensively investigated and a working solution is being tested. This project is now entering its final phase of testing the complete solution on a local traffic light junction.

### **Intracranial stereo-EEG analysis during grasping movement and intent: a neuroscientific and brain-machine interface study (DeepMotionBMI)**

MAIN INVESTIGATORS: Prof. Kenneth P. Camilleri, Dr Tracey Camilleri, Prof. Giuseppe De Giovanni<sup>11</sup>, Dr Fausto Caruana<sup>12</sup>

FUNDING BODY: RIDT Brain Research Fund of the Malta Neuroscience Network

Funding Amount: €5,000

AWARDEES: Prof. Kenneth P. Camilleri, Dr Tracey Camilleri, Prof. Giuseppe De Giovanni, Dr Fausto Caruana

This proposal in collaboration with the University of Parma concerns the signal analysis of intracranial stereo-EEG collected from 14 patients during voluntary opening and closing of a set of normal and reverse-action pliers while the position of the pliers was also being measured. This work seeks to build on earlier single neuron recordings, obtained from macaque monkey by the Parma group, to throw light on the human neural basis of the opening and closing motor actions and on the higher level intentional grasping action which can be differentiated from the data obtained when subjects used the normal versus the reverse-action pliers. It is planned that through spectral analysis and bandlimited ERP analysis of the motor system activity insight into the neural basis of grasping action in humans may be obtained and related to the earlier single neuron recording work. Furthermore, this work intends to investigate singletrial classification of the open-close event and of the actual plier opening in the context of the further development of brain-machine interfaces, building on the University of Malta's track record of work on scalp EEG brain-computer interfacing, which in turn may be used to control external devices without muscle control or drive neural prostheses.

During the second semester, Prof. Fabri facilitated the Erasmus+ visit of Ms Giovanna Stella from the University of Catania, who worked on this project for her M.Sc. thesis under the supervision of the project team, Prof. Fabri, and Prof. Maide Bucolo from the University of Catania. Ms Stella carried out pre-processing and a preliminary analysis of the stereo EEG signals that were provided for this project by our collaborators at the CNR Institute of Neuroscience, Parma, Italy. Through this work, the electrodes that exhibited signals that were mostly related to the different plier action tasks were identified.

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<sup>11</sup>University of Parma, Italy

<sup>12</sup>University of Parma, Italy

### **A prospective longitudinal study investigating underlying mechanisms of upper limb somatosensory impairments of people with stroke**

MAIN INVESTIGATORS: Dr Lisa Tabone, Prof. Kenneth P. Camilleri, Prof. Dr Geert Verheyden <sup>13</sup>

FUNDING BODY: Reach High Scholars Programme

FUNDING AMOUNT: €198,000 <sup>14</sup> (in collaboration with the University of Malta, Centre for Biomedical Cybernetics, and Katholieke Universiteit Leuven)

AWARDEES: Dr Lisa Tabone, Professor Kenneth P. Camilleri, Prof. Dr Geert Verheyden

Somatosensation includes exteroception (e.g. touch and pain), proprioception (e.g. position sense) and higher cognitive somatosensation (e.g. stereognosis). In a prospective longitudinal study involving 70 people with stroke which were assessed on admission to an acute ward and at two, four and six months' post-stroke, Upper Limb (UL) stereognosis (which was associated with UL motor performance) and proprioception were more frequently impaired than tactile sensations. In the aforementioned and other, but smaller longitudinal studies on somatosensory dysfunction, only clinical measures were used. Clinical measures do not allow the investigation of underlying mechanisms of brain dysfunction. One safe, non-invasive and portable method that can be used to monitor brain activation is electroencephalography (EEG) which records the electrical activity of the brain at the scalp. It has been suggested that oscillatory EEG rhythms between sensorimotor cortices might have an important function post stroke. Furthermore, a relationship was found between severity of UL motor impairment and event-related desynchronization in the unaffected hemisphere. Thus, further longitudinal studies exploring changes in brain activation in relation to the clinical manifestation of somatosensory impairments from the early to the chronic stage are warranted. Such studies can provide a more thorough understanding of whether over-activity in the unaffected cortex is a contributor to sensorimotor impairments and subsequently, when being an independent predictor for motor outcome, provide a rationale for novel treatment options.

This project aims to investigate the changes in brain activation of UL somatosensory impairments post stroke, and specifically to:

1. Pilot EEG measurements of brain activation for UL somatosensory impairments in people with stroke and present a standardised protocol;
2. Identify the longitudinal recovery pattern of clinical somatosensory measurements and corresponding changes in cortical EEG activity for UL somatosensory impairments in the early, sub-acute and chronic stage of stroke;
3. Investigate the longitudinal relationship of changes in cortical EEG activity for UL somatosensory impairments and clinical somatosensory measurements with UL motor impairment and function, spasticity and stroke impact in the early, sub-acute and chronic stage of stroke.

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<sup>13</sup>Katholieke Universiteit Leuven

<sup>14</sup>€99,000 of these funds is accounted for in the Department's external funding.

#### **4NSEEK - Forensic Analysis for Child Sexual Abuse**

MAIN INVESTIGATORS: Prof. Ing. Kenneth P. Camilleri, Dr Alexandra Bonnici, Dr Ing. Stefania Cristina, and Dr Ing. Reuben Farrugia

RESEARCH SUPPORT OFFICER: Mr. Andre Tabone

FUNDING BODY: EU

FUNDING AMOUNT: €76,674

FUNDING BODY: University of Malta Research Grant

FUNDING AMOUNT: €4,400

AWARDEES: Prof. Ing. Kenneth Camilleri, Dr Alexandra Bonnici

Thousands of images and video data pertaining to child pornography is made available on the Internet every month. Tracking such data to curtail the sharing of pornography, protect the children involved and prosecute the perpetrators is, therefore, a critical aspect of cyber-crime activities. Software capable of fast detection of pornographic content is essential to law enforcement agencies (LEAs). Such needs have driven researchers to propose algorithms which aid LEAs in their fight against cybercrime. Thus, tools that detect pornographic content, perform age estimation, and search for specific keywords in file names, amongst others, exist to aid LEAs. The aim of the 4NSEEK project is to investigate new, faster and more accurate deep-learning algorithms to create a single tool which allows LEAs to investigate new cases of potential child abuse more efficiently.

The role of the Maltese research team in this project is the detection and labelling of private body parts within pornographic images. Algorithms which analyse images specifically to determine whether these contain private body parts would provide LEAs with essential descriptors of the image content, providing for a better understanding of why images were considered pornographic without the need for manual inspection of the images. To this extent, we have created a two-step approach, in which the first step is a pornographic image detector, and the second step uses a windowing approach to detect private body parts within the image.

We are in the process of creating a labelled dataset in which pornographic images are being manually labelled with the location and label of the exposed private body part. This labelled data-set is being used to train the deep-learning architectures being investigated.

We are investigating the use of different deep learning classifiers, using transfer learning and fine-tuning techniques based on pre trained (on Imagenet data set) models of VGG-19, Inception-V3 and MobileNet architectures, using the TensorFlow GPU module. Through our investigations we have been able to implement a VGG classifier that reached a validation accuracy of 80.15% on the labelled data currently available, and a MobileNet classifier which achieved an accuracy of 80.72%, but at a fraction of the computational time used by the VGG.

#### **POINTact - Natural Interaction for Smart Environments**

MAIN INVESTIGATORS: Dr Ing. Stefania Cristina and Prof. Ing. Kenneth P. Camilleri

FUNDING BODY: FUSION R&I Commercialisation Voucher Programme 2019

FUNDING AMOUNT: €17,000

AWARDEE: Dr Ing. Stefania Cristina



The ability to interact in a natural manner with objects in one's environment is especially beneficial to enhance the personal autonomy of persons with impaired mobility or speech. The POINTact project proposes to address the challenge of interacting with objects within a smart environment unobtrusively, based on image information captured by suitably placed cameras within the environment. The image-based detection of different interaction modalities by means of finger, head and possibly eye pointing, will be investigated for more natural interaction that does not rely on obtrusive wearable devices. The project has successfully completed Stage 1 of the FUSION CVC, namely the IP Check Stage, and has now progressed to Stage 2, namely the Market Research and Product Development Costings Stage.

### **Leggiero: A piano students' companion**

MAIN INVESTIGATORS: Dr Alexandra Bonnici and Prof. Ing. Kenneth P. Camilleri

FUNDING BODY: FUSION R&I Commercialisation Voucher Programme 2019

FUNDING AMOUNT: €17,000

AWARDEE: Dr Alexandra Bonnici

Music students who follow music lessons as private, after-school activity spend longer periods of unsupervised practice than students who attend specialised music schools. This, in turn, leads to a greater chance that the teacher's instruction and hence facilitate the learning of an instrument.

The Leggiero application requires four main algorithms, namely

- Interpreting the score using optical music recognition and re-writing it in MusicXML format
- Creating computational expressive models to play back the score expressively
- Transcribing the notes played by the user to compare with the written score for feedback
- Creating suitable ornament interpretations

The first algorithm will be based on machine learning approaches whereby different note instances are used to train machine learning algorithms such that these may be detected each time they occur in the musical score. A second algorithm will use samples of expressive playing from recorded music and use these samples to build models for expressions. The music will then be analysed to determine the rise and fall patterns of the melody line and the models of expressive playing will be applied to these patterns. Computational intelligence algorithms will be used to create the expressive models, to locate the rise and fall patterns of the music and to apply the models to these patterns. A third algorithm will be used to transcribe the music played by the user. This will involve obtaining the Fourier transform of the musical signal and applying unmixing techniques such as non-negative matrix factorisation to determine the notes being played from the frequency signal. Finally, the last algorithm will consider various factors including speed, duration of the note as well as the musical context of the piece to suggest suitable ornament interpretations based on musical theory. The suggestions will be ordered according to their suitability for the piece being studied. The project is currently undergoing Stage 3 of the FUSION CVC, namely the Economic Impact and Risk Profile Assessment Stage.

### **VRSurge - Virtual Reality Surgical Training Simulator**

MAIN INVESTIGATORS: Prof. Ing. Simon G. Fabri

FUNDING BODY: FUSION R&I Commercialisation Voucher Programme 2019

FUNDING AMOUNT: €17,000

AWARDEE: Prof. Ing. Simon G. Fabri

VRSurge proposes the use of 3D Virtual Reality and immersive technologies to develop a simulator for training of medical surgeons and assistants. Trainees are able to visualize realistic 3D images of human organs and surgical instruments while manipulating physical mock-up instruments to perform actions such as dissection, suturing and knotting on a virtual patient. The mock-up instruments transmit back tactile feedback of the forces and sense of touch as felt by surgeons during real interventions. The use of such techniques makes the simulator very realistic and enhances skills acquisition for the trainees.

### **An Internet of Things Solution for Urban Traffic Control (IoT4UTC)**

MAIN INVESTIGATORS: Dr. Kenneth Scerri

FUNDING BODY: FUSION R&I Commercialisation Voucher Programme 2019

FUNDING AMOUNT: €17,000

AWARDEE: Dr. Kenneth Scerri

Modern urban life is significantly shaped and often scarred by our need for transportation. Traffic on our urban network can be managed by various means. In this project, we propose to optimize traffic flow in urban regions through the use of Artificial Intelligence (AI), while leveraging on the connectivity and processing power of Internet of Things (IoT) solutions. The big players in the field of transport control have been slow in adopting these novel technologies; creating the vacuum to be exploited by this project.

## **3.2 Student Projects and Supervision**

### **3.2.1 B.Eng. STUDENTS**

PROJECT TITLE: Vision-based Pupil and Iris Detection

STUDENT: Diana Antic

SUPERVISOR: Prof. Ing. Kenneth Camilleri

CO-SUPERVISOR: Dr Ing. Stefania Cristina

PROJECT TITLE: Natural Language Processing (NLP) for Sentiment Analysis

STUDENT: Luke Camilleri

SUPERVISOR: Dr Kenneth Scerri

PROJECT TITLE: Automation Enforcement on Priority Lanes

STUDENT: Caroline Debattista

SUPERVISOR: Dr Kenneth Scerri

CO-SUPERVISOR: Dr Alexandra Bonnici

PROJECT TITLE: Vibration Control in Flexible Systems with Multiple Modes  
STUDENT: Rebecca Spiteri  
SUPERVISOR: Dr Ing. Marvin Bugeja

PROJECT TITLE: Automated Page Turner for Musicians  
STUDENT: Andre Tabone  
SUPERVISOR: Dr Alexandra Bonnici  
CO-SUPERVISOR: Dr Ing. Stefania Cristina

PROJECT TITLE: IoT-Based Traffic Light Control  
STUDENT: Matthew Zammit  
SUPERVISOR: Dr Kenneth Scerri

### 3.2.2 M.Sc. by Research Students

PROJECT TITLE: EEG based control of a home automation system  
STUDENT: Mr Jeanluc Mangion  
SUPERVISOR: Prof. Ing. Kenneth P. Camilleri  
CO-SUPERVISOR: Dr Tracey Camilleri

PROJECT TITLE: Towards Robot-Assisted Living through Universal Design of the Environment  
STUDENT: Ms Yesenia Aquilina<sup>15</sup>  
SUPERVISOR: Prof. Ing. Michael A. Saliba<sup>16</sup>  
CO-SUPERVISOR: Prof. Ing. Simon Fabri

PROJECT TITLE: Stability and Optimisation of a High Dynamic Motor Starter Prototype's Current Control Algorithm  
STUDENT: Mr Daniel Lendi<sup>17</sup>  
SUPERVISOR: Dr. Daniel Reiko<sup>18</sup>  
CO-SUPERVISOR: Prof. Ing. Simon Fabri

PROJECT TITLE: Principal Component Analysis for Vision-Based Non-Contact Heart Rate Monitoring  
STUDENT: Ing. Lucianne Gauci  
SUPERVISOR: Dr Owen Falzon<sup>19</sup>  
CO-SUPERVISOR: Prof. Ing. Kenneth Camilleri

PROJECT TITLE: An EEG-Based Biometric System  
STUDENT: Ms Elysia Calleja<sup>20</sup>  
SUPERVISOR: Dr Owen Falzon  
CO-SUPERVISOR: Prof. Ing. Kenneth P. Camilleri

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<sup>15</sup>Dept. of Industrial and Manufacturing Engineering

<sup>16</sup>Dept. of Industrial and Manufacturing Engineering

<sup>17</sup>Dept. of Industrial and Electrical Power Conversion

<sup>18</sup>Dept. of Industrial and Electrical Power Conversion

<sup>19</sup>Centre for Biomedical Cybernetics

<sup>20</sup>Centre of Biomedical Cybernetics

PROJECT TITLE: Enhancing the Common Spatial Patterns Method for BCI Classification by Integrating Temporal Information

STUDENT: Mr Edward Zammit<sup>21</sup>

SUPERVISOR: Dr Owen Falzon

Co-SUPERVISOR: Prof. Ing. Kenneth P. Camilleri

PROJECT TITLE: Design of an Attitude Control and Determination System for the UoMBSat1 Pico-Satellite

STUDENT: Mr Darren DeBattista<sup>22</sup>

SUPERVISOR: Dr Ing. Marc A. Azzopardi<sup>23</sup>

Co-SUPERVISOR: Dr Ing. Marvin Bugeja

ADVISOR: Prof. Ing. Simon Fabri

### 3.2.3 Taught M.Sc. in Signals, Systems and Control Students

PROJECT TITLE: A study on the nonlinear control of the pendubot with simulation and experimental results

STUDENT: Mr Aaron Bonavia

SUPERVISOR: Dr Ing. Marvin Bugeja

PROJECT TITLE: A heuristic solution for the selective dial-a-ride problem

STUDENT: Mr Mark Cauchi

SUPERVISOR: Dr Kenneth Scerri

### 3.2.4 M.Phil. / Ph.D. Students

PROJECT TITLE: Electrode Modelling for Applications of Functional Electrical Stimulation

STUDENT: Ms Mary Grace Cassar<sup>24</sup>

SUPERVISOR: Prof. Cristiana Sebu,<sup>25</sup>

Co-SUPERVISOR: Prof. Ing. Kenneth Camilleri

PROJECT TITLE: Switching Multiple Models for SSVEP-Based Brain-Computer Interfaces

STUDENT: Ing. Rosanne Zerafa

SUPERVISOR: Dr Tracey Camilleri

Co-SUPERVISORS: Dr Owen Falzon, Prof. Ing. Kenneth Camilleri

PROJECT TITLE: Gaze Angle Estimation using a Dense Multi-Channel EOG Electrode Configuration with Varying Head Pose Compensation

STUDENT: Mr Nathaniel Barbara

SUPERVISOR: Dr Tracey Camilleri

Co-SUPERVISOR: Prof. Ing. Kenneth Camilleri

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<sup>21</sup>Centre of Biomedical Cybernetics

<sup>22</sup>Electronic Systems Engineering

<sup>23</sup>Electronic Systems Engineering

<sup>24</sup>Department of Mathematics

<sup>25</sup>Department of Mathematics

PROJECT TITLE: Analysis of temperature transient patterns using dynamic infrared thermography

STUDENT: Mr Jean Gauci

SUPERVISOR: Dr Owen Falzon

CO-SUPERVISOR: Prof. Ing. Kenneth Camilleri

PROJECT TITLE: Coordination and Control of Multi-Robot Systems

STUDENT: Ing. Rachael Duca

SUPERVISOR: Dr Ing. Marvin Bugeja

PROJECT TITLE: Towards Autonomic Control of Urban Traffic Junctions

STUDENT: Ing. Luana Romano

SUPERVISOR: Prof. Ing. Simon G. Fabri

CO-SUPERVISOR: Prof. Maria Attard<sup>26</sup>

ADVISOR: Dr. Kenneth Scerri

PROJECT TITLE: CT Radiation Doses in Nigeria: Establishment of Diagnostic Reference Levels and Radiation Dose Optimisation

STUDENT: Mr Idris Garba<sup>27</sup>

SUPERVISOR: Prof. Ing. Simon G. Fabri

CO-SUPERVISOR: Dr Francis Zarb<sup>28</sup>

ADVISOR: Prof. Mark McEntee<sup>29</sup>

PROJECT TITLE: Visual Object Recognition based on Textual Descriptions

STUDENT: Mr Marc Tanti<sup>30</sup>

SUPERVISOR: Dr Albert Gatt<sup>31</sup>

CO-SUPERVISOR: Prof. Ing. Kenneth P. Camilleri

PROJECT TITLE: An Enhanced Wearable System for Kinematic and Kinetic Gait Analysis

STUDENT: Mr Nikiforos Okkalidis<sup>32</sup>

SUPERVISOR: Dr Owen Falzon

CO-SUPERVISORS: Dr Ing. Marvin Bugeja, Dr Alfred Gatt

ADVISOR: Prof. Ing. Kenneth P. Camilleri

PROJECT TITLE: Quantifying Atherosclerosis using Freehand 3D Ultrasound Imaging

STUDENT: Mr Carl Azzopardi<sup>33</sup>

SUPERVISOR: Dr Yulia Hicks<sup>34</sup>

ADVISOR: Prof. Kevin Cassar<sup>35</sup>, Prof. Ing. Kenneth P. Camilleri

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<sup>26</sup>Institute for Climate Change and Sustainable Development

<sup>27</sup>Faculty of Health Sciences, University of Malta

<sup>28</sup>Faculty of Health Sciences, Univ of Malta

<sup>29</sup>The University of Sydney, Australia

<sup>30</sup>Institute of Linguistics and Language Technology

<sup>31</sup>Institute of Linguistics and Language Technology

<sup>32</sup>Centre for Biomedical Cybernetics

<sup>33</sup>Cardiff University, Wales, UK

<sup>34</sup>Cardiff University, Wales, UK

<sup>35</sup>Dept. of Surgery

### 3.2.5 Postdoctoral Scholars

POSTDOCTORAL SCHOLAR: Dr Lisa Tabone

PROJECT TITLE: Neural Correlates of Upper Limb Somatosensory Impairments and Recovery after Stroke: An EEG Investigation

MENTOR: Prof. Ing. Kenneth P. Camilleri

MENTOR: Prof. Geert Verheyden<sup>36</sup>

### 3.2.6 Internships

#### Development of a Ball and Beam Control System

STUDENT: Mr Maxime Lardeux,<sup>37</sup>

SUPERVISOR: Prof. Ing. Simon G. Fabri, Dr. Ing. Marvin K. Bugeja

During this internship, Maxime designed and commenced the implementation of a ball and beam balancing control system. He implemented the mechanical setup, designed and simulated the control algorithm, and designed/implemented the electronics for the sensors, the motor drive and the interfacing with the data acquisition and control hardware.

#### Development of image processing & computer vision demos

STUDENT: Mr Arthur Kaplan,<sup>38</sup>

SUPERVISOR: Dr Alexandra Bonnici, Dr Ing. Stefania Cristina

During this internship, Arthur was tasked with the implementation of computer vision and image processing algorithms on a Raspberry Pi microcomputer for public demonstration purposes. These tasks include the use of a visual camera to capture a live video stream and to apply photorealistic filters to the live stream, detect faces from the video stream and apply “stickers” at the relevant places on the detected faces. A simple user-interface using a touch-pad was also requested.

#### Implementation of feature descriptors and classifiers for forensic analysis

STUDENT: Mr Vincent Pellerano<sup>39</sup>

SUPERVISOR: Dr Alexandra Bonnici, Dr Ing. Stefania Cristina

During this internship, Vincent was tasked with implementing feature descriptors that could be used for the detection of nudity in images. This task was set to aid our team in an ongoing research project with the intention to detect and prevent child sexual abuse. During this internship, Vincent was required to implement features which include colour moments, gray-level cooccurrence matrices and histogram of gradients. Vincent was also required to implement classifiers such as MLP and SVM to distinguish between features obtain from regions that display nudity and others that contain no nudity.

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<sup>36</sup>Katholieke Universiteit Leuven, Belgium

<sup>37</sup>ENSMM, Besancon, France

<sup>38</sup>Grenoble Phelma INP

<sup>39</sup>Grenoble Phelma INP

### Engineering Appreciation and Job Shadowing

STUDENT: Ms Mia Gauci

SUPERVISOR: Dr Alexandra Bonnici

During this internship, Mia was tasked with implementing a Sonic Pi workshop which could be used as a demonstration workshop for visiting school-children. The workshop prepared by Mia includes interactive code to play single notes, tunes, synthesize different sounds, play beats and interact with the digital piano available in our laboratory.

### Tourist Itinerary Planning

STUDENT: Ms Kouakov Milacet Aimee Laurette <sup>40</sup> and Ms Amy Spiteri

SUPERVISOR: Dr Kenneth Scerri

During these summer internships, Milacet and Amy collaborated, under the supervision of Dr Kenneth Scerri, on the development of itinerary planning algorithms for tourists visiting cities such as Valletta. These algorithms are being developed to leverage on the computing power of the cloud and make use of data available from providers such as Google and Trip Advisor.

## 3.3 Staff Publications

### Journal Publications

1. A. Bezrouka, T. Hosszú, O. Falzon, P. Vodaa, M. Vachek, J. Záhora, V. Mašín, K. P. Camilleri, J. Kremláček, Digital orbitoplethysmograph: a new device to study the regional cerebral circulation using extraorbital plethysmography, *Journal of Neuroscience Methods*, October 2019 (Accepted for publication).
2. A. Bonnici, A. Akman, G. Calleja, K. P. Camilleri, P. Canturk, P. Fehling, A. Ferreira, F. Hermuth, J. Habakuk Israel, T. Landwehr, J. Liu, N. M. J. Padfield, T. Metin Sezgin, P. L. Rosin, "Sketch-based Interaction and Modelling: Where do we stand?" in *Artificial Intelligence for Engineering Design, Analysis and Manufacturing*, October 2019.
3. N. Okkalidis, G. Marinakis, A. Gatt, M.K. Bugeja, K.P. Camilleri, O. Falzon, A multi-segment modelling approach for foot trajectory estimation using inertial sensors, *Gait & Posture*, September 2019.
4. R. Zerafa, T. Camilleri, K. P. Camilleri and O. Falzon, "The effect of distractors on SSVEP-based brain-computer interfaces," in *Biomedical Physics and Engineering Express*, vol. 5, issue 3, April 2019.
5. L. Chetcuti Zammit, S. G. Fabri, K. Scerri, "Real-Time Parametric Modeling and Estimation of Urban Traffic Junctions," in *IEEE Transactions on Intelligent Transportation Systems*, January 2019.
6. N. Barbara, T. A. Camilleri and K. P. Camilleri, "EOG-Based Eye Movement Detection and Gaze Estimation for an Asynchronous Virtual Keyboard," in *Biomedical Signal Processing and Control*, vol. 47, pp. 159-167, January 2019.
7. R. Zerafa, T. Camilleri, O. Falzon and K. P. Camilleri, "A comparison of a broad range of

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<sup>40</sup>Polytech Nancy

EEG acquisition devices – is there any difference for SSVEP BCIs?” in *Brain-Computer Interfaces*, vol. 5, issue 4, pp. 121-131, December 2018.

### Conferences Publications

1. M. Miller, A. Bonnici, M. El-Assady, "Augmenting Music Sheets with Harmonic Fingerprints," in *Proceedings of the ACM conference on document engineering, DocEng 2019*, Berlin, Germany, September 2019.
2. S. Cristina, K. P. Camilleri, "Gaze Tracking by Joint Head and Eye Pose Estimation Under Free Head Movement," in *27th European Signal Processing Conference (EUSIPCO)*, September 2019.
3. M. Aquilina, M.K. Bugeja and S.G. Fabri, "Smart Wheelchairs: Using Robotics to Bridge the Gap between Prototypes and Cost-effective Set-ups," in *Proceedings of the 16th International Conference on Informatics in Control, Automation and Robotics (ICINCO 2019)*, Volume 2, pp.181-189, July 2019.
4. L. Gauci, O. Falzon, K. P. Camilleri, "PCA-Driven Detection and Enhancement of Microchanges in Video Data Associated with Heart Rate," in *Engineering in Medicine and Biology Society (EMBC), Annual International Conference of the IEEE*, July 2019.
5. N. Barbara, T. A. Camilleri and K. P. Camilleri, "EOG-based Gaze Angle Estimation Using a Battery Model of the Eye," in *Engineering in Medicine and Biology Society (EMBC), Annual International Conference of the IEEE*, July 2019.
6. M. Borg and K. P. Camilleri, "Sign Language Detection "in the Wild" with Recurrent Neural Networks," in *IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*, pp. 1637-1641, May 2019.

### Non-peer reviewed publications

1. M. Miller, H. Schäfer, A. Bonnici and M. El-Assady, "Visual Pattern Analysis using Digital Sheet Music" Late Breaking/Demos of the *International Conference on Music Information Retrieval (ISMIR)*, 2019

## 3.4 Internal Research Workshop Series

This year marks the third year during which the internal research workshop series was held. Such workshops were open for the staff and postgraduate students of the Department and of the Centre for Biomedical Cybernetics, as well as close research collaborators from other departments or institutes. Table 3.1 summarizes the workshops carried out during this academic year.



Table 3.1: Summary of the Internal Research Workshops for 2018 - 2019

**IRWS 2018 - 2019**

|                          |                                           |                    |
|--------------------------|-------------------------------------------|--------------------|
| Dr Kenneth Scerri        | Teaching with Python and Jupyter Notebook | 22nd February 2019 |
| Dr Ing Stefania Cristina | Computer Vision Using OpenCV              | 8th May 2019       |
| Dr. Marvin Bugeja        | Sequential Control with PLCs              | 29th May 2019      |
| Prof Kenneth Camilleri   | Weak AI, Strong AI and Consciousness      | 19th June 2019     |

**3.5 Participation in Courses, Meetings and Overseas Visits****Presentation to MSc in AI students, University of Malta**

Dr Tracey Camilleri gave a presentation to students following the MSc in AI with the Faculty of ICT on Human Machine Interface systems. This presentation was held on 6th November 2019.

**EU Cost Action - CA18232**

In September 2019, Dr Kenneth Scerri participated in a kick off meeting of an EU Cost Action. This treated the topic "Mathematical models for interacting dynamics on networks." This Action seeks to bring together groups of people from around Europe, who are working on modelling and analysis of mathematical models for dynamical systems on networks.

**THINK Soapbox**

In September 2019, Prof. Ing. Kenneth Camilleri and Mr Daniel Bonanno participated in the first event of THINK Soapbox. During this event, they have presented the WildEYE project.

**Participation in the INCIBE CyberSecurity Bootcamp**

On July 25th and 26th, Dr Alexandra Bonnici participated in the CyberSecurity Bootcamp organised by Instituto Nacional de Ciberseguridad (INCIBE) in Leon, Spain. During this bootcamp, Dr Bonnici delivered a talk entitled "Detection of sexual organs in pornographic images" which represented an overview of the research work carried out by Prof Kenneth Camilleri, Dr Stefania Cristina and Dr Reuben Farrugia on the 4NSEEK project.

**Lecturing and Research visit at Brno University of Technology, Czech Republic**

In April 2019 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 "Nonlinear Systems" and "Linear Control Systems Analysis and Design" to a number of postgraduate and undergraduate students respectively. Moreover, he discussed a number of possibilities for joint research projects and extended lecturing visits between the two departments.

**Inaugural lectures of the Department of Computer Science, Leuven, Belgium**

On the 20th and the 21st March 2019, Dr Kenneth Scerri delivered a lecture on "Cloud-Based Artificial Intelligence in Consumer and Industrial Products".

**Presentation at MNN Seminar, University of Malta**

On the 13th March 2019, Prof. Ing. Kenneth Camilleri and Dr Tracey Camilleri delivered a lecture on "Brain Signal Analysis" during an MNN Seminar. This coincided with Brain Awareness Week 2019.

**Presentation at Health 2.0 Malta Meetup Number 3, Umana Medical Technologies, Malta.**

On the 31st January 2019, Dr Tracey Camilleri and Dr Owen Falzon delivered a presentation at the Health 2.0 meetup.

**3.6 External Lectures and Visitors****From the University of Leon, Spain**

Between the 17th June and the 22nd July, the Department hosted Dr Enrique Alegre from the University of Leon, Spain. Dr Alegre conducted research work related to the 4NSEEK project.

**From the University of Catania, Italy**

On the 4th and the 5th June 2019, the Department hosted Prof. Maide Bucolo from the University of Catania. Prof. Bucolo delivered a set of lectures on the topic: "Analysis of Biosignals - methods and case studies". These lectures were attended by staff, researchers and postgraduate students from the Faculty of Engineering, the Centre for Biomedical Cybernetics and the Faculty of Media and Knowledge Sciences.

**From Cardiff University, Wales**

Between the 29th and 30th April, the Department hosted Prof Paul Rosin from Cardiff University. Prof. Rosin delivered two lectures in the study unit SCE3204 Image Analysis and Computer Vision in which he introduced the students to the concept of learning in vision applications. Prof. Rosin also delivered a public lecture entitled Virtually Unrolling Historical Scrolls.

**From Brno University of Technology, Czech Republic**

Between the 25th and the 29th of March, the Department hosted Prof. Robert Grepl, the head of Department of Mechatronics at Brno University of Technology. Prof Grepl delivered a brief workshop to the undergraduate electrical second year students on the use of MATLAB and SIMULINK for the simulation and design of dynamic and control systems.

**From the Technical University of Crete**

On the 3rd December 2018, the department hosted Professor Markos Papageorgiou. He delivered a lecture to fourth year engineering students during SCE 4102 and a public talk entitled 'Traffic Management in the Era of Vehicle & Communication Systems'.

### 3.7 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. Additionally, the Department also delivers a taught M.Sc. in Signals, Systems and Control programme on full-time and part-time basis. It also participates in the M.Sc. course in Language and Computation organised by the Institute of Linguistics and the M.Sc. in Environmental Management and Sustainability organised by the Institute of Earth Systems. These study units are listed and summarized in Table 3.2.

The department also offers training to its final year students to assist them in the presentation of the dissertation work. This training consists of a tutorial on the use of  $\text{\LaTeX}$  to write their dissertations and two seminars during which students deliver a 10-minute presentation on their work.

Table 3.2: A selection of study units offered by the Department in 2017/2018

| <b>Unit code</b>                                        | <b>Unit Name</b>                                                                                   | <b>ECTS Credits</b> |
|---------------------------------------------------------|----------------------------------------------------------------------------------------------------|---------------------|
| <b>SCE Undergraduate Study Units</b>                    |                                                                                                    |                     |
| SCE1201                                                 | Dynamic Systems and Signals 1                                                                      | 5                   |
| SCE2111                                                 | Automatic Control Systems 1                                                                        | 5                   |
| SCE2112                                                 | Control Systems 1                                                                                  | 5                   |
| SCE2201                                                 | Numerical Methods for Engineers                                                                    | 5                   |
| SCE2213                                                 | Automatic Control Systems 2                                                                        | 5                   |
| SCE3101                                                 | Dynamic Systems and Signals 2                                                                      | 5                   |
| SCE3205                                                 | Dynamic Systems and Signals 3                                                                      | 5                   |
| SCE3204                                                 | Image Analysis and Computer Vision                                                                 | 5                   |
| SCE3112                                                 | Control Systems Technology and Automation                                                          | 5                   |
| SCE3113                                                 | Automatic Control Systems 3                                                                        | 5                   |
| SCE3114                                                 | Introduction to Control Engineering                                                                | 5                   |
| SCE3216                                                 | Automatic Control Systems 4                                                                        | 5                   |
| SCE4101                                                 | Computational Intelligence 1                                                                       | 5                   |
| SCE4102                                                 | Systems Theory                                                                                     | 5                   |
| <b>Other Undergraduate Study Units supported by SCE</b> |                                                                                                    |                     |
| ENR3008                                                 | Team Project (unit co-ordination and supervision of two team projects)                             | 5                   |
| ENR4200                                                 | Engineering Project (final year project supervision by several academic members of the department) | 20                  |
| <b>SCE Postgraduate Study Units</b>                     |                                                                                                    |                     |
| SCE5101                                                 | Linear Dynamic Systems and Signals                                                                 | 6                   |
| SCE5102                                                 | Estimation and System Identification                                                               | 6                   |
| SCE5103                                                 | Continuous-time Control Systems                                                                    | 5                   |
| SCE5104                                                 | Discrete-time Control Systems                                                                      | 5                   |
| SCE5105                                                 | Advanced Signal Processing                                                                         | 5                   |
| SCE5106                                                 | Research Methods for Systems and Control Engineering                                               | 4                   |
| SCE5201                                                 | Machine Learning and Pattern Recognition                                                           | 10                  |
| SCE5202                                                 | Nonlinear Systems and Control                                                                      | 5                   |
| SCE5203                                                 | System Optimisation and Control                                                                    | 4                   |
| SCE5204                                                 | Adaptive and Intelligent Control                                                                   | 5                   |
| SCE5205                                                 | Computer Vision                                                                                    | 5                   |
| SCE5301                                                 | Research Project in Systems and Control Engineering                                                | 30                  |
| <b>Other Postgraduate Study Units supported by SCE</b>  |                                                                                                    |                     |
| LIN5508                                                 | Language and Embodied Agents (part of)                                                             | 10                  |
| IES5009                                                 | Introduction to System Dynamics                                                                    | 6                   |
| OMS5004                                                 | Data Resources in Operational Oceanography (part of)                                               | 10                  |
| ENR5006                                                 | Research Methods (part of)                                                                         | 5                   |
| ENR5007                                                 | Engineering Seminar                                                                                | 5                   |
| MEC5014                                                 | Data Analysis Techniques in Condition Monitoring                                                   | 5                   |
| ENR5026                                                 | Science Communication in Engineering (part of)                                                     | 5                   |



## 4. Prizes, Awards and Appointments

### Awards

- In September 2019, Dr Ing. Marvin Bugeja, as part of a small team headed by the podiatrist Dr Alfred Gatt, was one of two team awardees of the TAKEOFF Seed Fund Award (TOSFA) in the Proof of Concept category, for the project named iFoot. The project is investigating several novel ideas to assess foot pressure and temperature, and provide active offloading of certain foot areas through the use of a smart insole.
- In September 2019, Dr Alexandra Bonnici was awarded DocEng Best Paper Award for the paper Augmenting Music Sheets with Harmonic Fingerprints, during the ACM Symposium on Document Engineering, in Berlin, Germany.
- In July 2019, Dr Ing. Stefania Cristina was awarded the MCST Commercialisation Voucher Programme (CVP), for the project entitled POINTact: Natural Interaction for Smart Environments.
- In July 2019, Prof. Simon G Fabri was awarded the MCST Commercialisation Voucher Programme (CVP) for the project entitled VRSurge: Virtual Reality Surgical Training Simulator.
- In June 2019, Dr Tracey Camilleri was awarded the MCST Technology Development Programme (TDP) for the project entitled Eye based Control (EyeCon).
- In March 2019, Dr Alexandra Bonnici was awarded the MCST Commercialisation Voucher Programme (CVP) for the project entitled Leggiero: A piano music companion.
- In March 2019, Dr Kenneth Scerri was awarded the MCST Commercialisation Voucher Programme (CVP), for the project entitled “An Internet of Things Solution for Urban Traffic Control” (IOT4UTC).



## 5. Collaboration with Third Parties

### Erasmus student from the University of Catania

#### Identification of Intracranial Activity by Stereo-EEG Analysis during Grasping Movement and Intent

STUDENT: Ms Giovanna Stella <sup>1</sup>

SUPERVISOR: Prof. Ing. Simon Fabri, Dr. Tracey Camilleri, Prof. Ing. Kenneth P. Camilleri

During this visit, funded through Erasmus+, Giovanna worked on her MSc project for the University of Catania. Her contributions to this project included a preliminary analysis and pre-processing of stereo EEG signals (provided by the CNR Institute of Neuroscience in Parma) obtained from a set of tool-action exercises where subjects had to grasp and release an object using two kinds of pliers – normal pliers and reverse pliers. Signals corresponding to the movements of the pliers were also recorded in the data set, in synchronisation with the EEG signals. Through the analysis performed, it was possible to identify which of the electrode signals are most significant, i.e. which ones present a significant interaction and a significant main effect related to the different action phases in the tool-action tasks.

### Collaboration with the University of Konstanz

#### Konstanz, Germany

Dr Alexandra Bonnici collaborated with Dr Mennatallah El-Assady and Mr Matthias Miller from Data Analysis and Visualisation Group at the University of Konstanz to develop a visualisation tool for musical pattern analysis. This collaboration led to the presentation of a paper at the DocEng 2019 conference and a demo at the ISMIR 2019 conference.

#### Carousel Week

Between the 25 and 29 March, the Faculty of Engineering participated, for the first time, in the Carousel Week alongside the Budapest University of Technology and Economics (Hungary), Häme University of Applied Sciences (Finland) and the University of Applied Sciences Nancy-Brabois (France). The Carousel Week is an international student exchange program aimed at providing first-year electrical engineering students with experience in teamwork, practical engineering work, industrial visits as well as social and cultural events.

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<sup>1</sup>University of Catania, Italy

Ten Maltese students used this opportunity to travel to France, Hungary and Finland and received sponsorships to offset their travel costs. The remaining students participated from Malta together with six international students. In Malta, students attended a talk on creative thinking and entrepreneurship delivered by Dr Leonie Baldacchino from the Edward Debono Institute for the Design and Development of Thinking; participated in industrial visits to Medavia, ST Microelectronics and Methode Electronics; carried out project work to create an Arduino-based 'Automatic Plant Irrigation System'. Students also participated in a walking tour of Valletta, a treasure hunt in Mdina and a visit to the Haġar Qim Temples.

The student project work was carried out under the guidance and supervision of Prof. Simon Fabri, Mr Andre Micallef, Dr Ing. Brian Zammit, Prof. Cyril Spiteri-Staines, Mr Donald Vella, Mr Steven Caruana and Mr Kevin Caruana-Montaldo. Social activities were organised by the University Engineering Students' Association (UESA) while Dr Alexandra Bonnici coordinated the week's events.

The Carousel Week was sponsored by Methode Electronics, ST Microelectronics, Medavia, Tektraco Ltd., TUA Engineering Ltd., and RS Electronics and the Conventions Malta. These sponsorships allowed the Faculty to offer travel grants to students and equip the laboratory with the materials necessary for the project work and arrange a varied social and cultural program for the students.



## 6. Public Outreach

### 6.1 Laboratory Visits by Schools

#### Participation in Bahrija Summer School

Ing. Lucianne Gauci organized a school visit on the 1st of August 2019, for children attending Bahrija Summer School. Children aged 5 to 16 were grouped into age groups, and they have participated in a number of workshops on SonicPi, Lego Mindstorms and Thermal Imaging. These workshops were delivered by Ing. Lucianne Gauci, Dr Alexandra Bonnici, Ing. Rachael Duca and Mr Noel Agius.

#### Participation in PWC Summer School

Twenty students from the PWC summer school were given a workshop on Sonic Pi programming in which the students learnt how to program their computers to play single notes and melodies. These workshops were delivered on the 8th and 16th of July 2019 by Dr Alexandra Bonnici.

#### Tours for International School for Foundation Studies students

On the 29th March 2019, Dr Ing. Stefania Cristina, together with the PR Committee of the Faculty of Engineering, organized laboratory tours of the Department's Control Systems Laboratory and Biomedical Engineering Laboratory. The aim of these tours was to familiarize prospective students with our laboratories as well as the projects and research carried out within our Department.

#### Participation in Job Shadowing

The Department participated in three job shadowing activities, namely between the 11th and 15th March, between the 25th and 29th March and between the 1st and 5th April. In these three weeks, the Department hosted a total of 12 students from St Nicholas College and Sir Thomas More college. All students were in year-10. During the week, the students participated in workshops and project work that demonstrated the Department's work and research. The students worked under the supervision of Mr Noel Agius, Mr Jean Gauci, Mr Jeanluc Mangion and Dr Alexandra Bonnici.

#### Brain Awareness Week 2019

Brain Awareness Week 2019 was held in March 2019. Between the 12th and 14th March 2019, Ing. Rosanne Zerafa, Mr Nathaniel Barbara and Mr Daniel Bonanno have opened our Biomedical Engineering Lab to several students from various schools. During these visits, our members of staff have demonstrated their research and working prototypes of their work.



### **Career Talk at St Monica School (B’Kara)**

On the 8th March 2019, Dr Alexandra Bonnici delivered a talk to Form 2 students at the St Monica School in Birkirkara. The talk was part of a career week activity organised by the school. During the talk, Dr Bonnici discussed different aspects of the Engineering profession, course requirements and job opportunities. At the end of the talk, Dr Bonnici held a short practical workshop during which students programmed a Lego Mindstorms robot.

### **Organisation and Participation in the Faculty of Engineering Technology Clubs**

For the third consecutive year, Dr Alexandra Bonnici organised the Faculty of Engineering Technology Clubs. Through these clubs, the Faculty hosted 847 secondary school students from different state, church and independent schools in Malta and Gozo. The department contributed to these clubs by providing workshops on signal processing, image processing and robotics.

After the workshops, Dr Bonnici delivered a talk in which she explained the different roles of engineers, job opportunities and the entry requirements for the engineering degree course.

The Engineering Technology Clubs 2018-19 were supported by the Malta Chamber of Engineers.

### **Participation in the Kids on Campus**

A workshop series of six sessions were organised by the Department for the Kids On Campus. A total of 30 school children were given three workshops using Sonic Pi programming in which the students learnt how to program their computers to play single notes, introduce live loops to play melodies and add different synthesisers and beats. These were followed a further three workshops in Lego Mindstorms in which the children learnt how to program their robots to move for a specific distance, use touch and ultrasonic sensors to detect obstacles as well as to shoot balls. These workshops were delivered by Dr Alexandra Bonnici, assisted by Ing Lucianne Gauci, Ing. Rachael Duca and Mr Noel Agius.

Furthermore, during this week, Prof. Ing. Kenneth Camilleri and Dr Tracey Camilleri have delivered a seminar on Brain Signal Analysis, which was open to the public.

## **6.2 International Public Outreach**

### **Visit by Russian Teachers**

On the 28th March, a delegation of 15 teachers accompanied by Mr Mario Cassar, Deputy Director of UM’s Communications Office and Mr Victor Tarasov from the Russian Boarding School based in Malta visited the Faculty. They were given a tour of the department’s teaching labs by Prof. Simon Fabri.

## **6.3 Participation in National Events**

### **Participation in Science in the City**

On the 27th of September 2019, members of staff Dr Tracey Camilleri, Prof. Ing. Kenneth Camilleri, Ing. Lucianne Gauci, Ing. Rosanne Zerafa, Mr Daniel Bonanno, Mr Nathaniel Barbara and Mr Jeanluc Mangion participated in the annual event of Science in the City. During this event,

our staff demonstrated the use of several pieces of equipment including thermal cameras, eye gaze equipment and EEG equipment.

During the same event, Ing. Rosanne Zerafa and Mr Daniel Bonanno participated in the session called Meet the Researcher, where they met and conversed with members of the public regarding their research on the BrainApp and WildEye projects, respectively.

### **Participation in the Malta Robotics Olympiad**

During the Malta Robotics Olympiad 2019, held between the 10th and the 12th May 2019, Dr Ing. Stefania Cristina and Dr Tracey Camilleri exhibited thermography and EEG research work performed by the Department. During the same exhibition, Mr Noel Agius also participated by demonstrating the work of one of our students which was the smart wheelchair.

### **Family Science Days at Esplora Interactive Centre**

On the 25th of April 2019, Ing Rosanne Zerafa and Mr Daniel Bonanno participated in the Family Science Days at Esplora, where they have demonstrated some of the Department's research in Brain Computer Interfacing and Eye Gaze Tracking, to the general public.

### **Health 2.0 Meetup**

On the 28th February 2019, Dr Tracey Camilleri, an academic from our department, and Dr Owen Falzon, an academic from the Centre for Biomedical Cybernetics, have delivered talks during Health 2.0 meetup of the Healthcare Information and Management Systems Society. Mr Nathaniel Barabara and Mr Daniel Bonanno also attended this meetup.

### **ICT Accessibility Presentations at FITA**

On the 28th of February 2019, Dr Ing. Stefania Cristina and Mr Daniel Bonanno have delivered a presentation about their current research carried out for the WildEye project. Speakers Dr Ing. Stefania Cristina and Mr Daniel Bonanno gave an overview of eye-gaze tracking technology and explained how eye movements have long been recognised to provide an alternative channel for communication with, or control of, a machine such as a computer, substituting traditional peripheral devices.

## **6.4 Media Exposure**

### **Non-peer reviewed articles**

1. "Eyes Front!", THINK magazine, issue 29, 25th September 2019. This article features the WildEye project.
2. S. Cristina and K. P. Camilleri, "University of Malta's WildEye project seeks to capture the eye-gaze tracking market," Lifestyle & Culture section, The Malta Independent, 9th September 2018.
3. C. Porter, T. Camilleri, "The web and brain signals," The Sunday Times of Malta, 5th August 2018.
4. T. Camilleri, "Brain technology for independence," 22nd July 2018.
5. "Photo of the Week", The Sunday Times of Malta, 22nd July 2018.
6. T. Camilleri, "Brain Control," THINK Magazine, 27th June 2018.

### **Television Appearances and Interviews**

1. Dr Tracey Camilleri, in October 2019, was interviewed about women in engineering on the radio programme "100 years of women on campus," on Campus FM. The presenter was Ms Patricia Camilleri and there was Dr Francois Mifsud from the Faculty of Education who participated in this same programme. The discussion was about the reduced number of women in Engineering and that of men in Education. Statistics show that in the Faculty of Engineering, this year only 24% of the undergraduate cohort were women and around 20% for the postgraduate cohort. It seems that the trend of a gender gap in STEM areas is an issue world wide and there are various initiatives to help children relate to these subjects (Science, Technology, Engineering and Mathematics) from a young age to take up courses at higher levels. Even though girls tend to do well in Maths and Science exams, often better than boys, they still think that certain subjects are for boys and they lack the necessary self-efficacy to help them take up these subjects later on. Being in a class where females are a minority does not help either in encouraging girls to take courses in STEM areas. Hence the role of teachers and career guidance teachers is vital to help break down the stereotypes that exist and help students understand how much these subjects compliment each other and how important they are in the real world. Girls in particular need to be given the self confidence needed so that they do not only look for careers that are an extension of their domestic life, such as teaching, secretarial work, nursing etc, but also other job opportunities that can also help society at large and are vital for driving economic growth.
2. Dr Tracey Camilleri and Ing. Rosanne Zerafa participated in one of the first podcasts recorded by the team of Think magazine, in October 2019. This set of podcasts is called "ReThink." During this podcast, Dr Camilleri and Ing. Zerafa discussed their research in Brain Computer Interfaces and brain control technology.



## 7. Contact Us

For further information, we invite you to visit:

- our **Facebook** page: [www.facebook.com/um.scedepartment/](http://www.facebook.com/um.scedepartment/)
- our **University webpage**: [www.um.edu.mt/eng/sce](http://www.um.edu.mt/eng/sce)

Furthermore, you may wish to contact us through one of the following means:

- on our **e-mail** address: [sce.eng@um.edu.mt](mailto:sce.eng@um.edu.mt)
- on **Messenger**: [m.me/um.scedepartment](https://m.me/um.scedepartment)
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