



L-Università ta' Malta
Faculty of Engineering

Department of Systems
& Control Engineering



Annual Report

2021 - 2022

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DEPARTMENT OF SYSTEMS AND CONTROL ENGINEERING
Faculty of Engineering
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Key Descriptors

Members of Staff

Academics	8
Visiting Academics (a total of T4 appointments)	3
Systems Engineers	2
Assistant Laboratory Manager	1
Administrative Staff	1

Externally Funded Members of Staff

Research Support Officer IV	1
Research Support Officer I	1

Research Projects

25

Research Funds Disbursed During 2020/21

International Funds	€71,340
National Funds	€121,932
Internal Funds	€20,000

Students

Supervision/Co-supervision of B.Eng. Final Year Students	10
Supervision/Co-supervision of M.Sc. by Research Students	6
Supervision/Co-supervision of M.Phil./Ph.D. Students	8

Peer-reviewed Publications

Book chapters	1
Editorials	1
Journal papers	6
Conference papers	9

Teaching Activities

Postgraduate study units	14 (70 ECTS)
Undergraduate study units	21 (106 ECTS)
Pre-tertiary study units	3 (20 ECTS)



1. Foreword

If you think in terms of a year, plant a seed; if in terms of ten years, plant trees; if in terms of 100 years, teach the people.

Confucius

This annual report marks the end of a second year as head of the Department of Systems and Control. This year has been marked by the gradual return to some form of normalcy after the Covid pandemic, seeing lectures, lab sessions, supervisions, examinations, the faculty exhibition and even outreach activities shifting back to in-person events. We saw visiting students, internships and classroom visits taking hold again and, while online events are still taking place for the sake of efficiency and comfort, it is finally good to be able to meet and engage in person again.

While easing back to normality brought about new stresses and anxieties, the Department strove to continue offering the best possible service to students. This is evident in informal feedback obtained from the students twice, mid-semester throughout the year as well as through formal feedback obtained through the University feedback scheme. Our lecturers have been described as being the "gold-standard" in showing care and attention in their lecturing - qualities that cannot be quantified numerically.

This year has also brought about changes within the department. We welcomed Ing. Jean Gauci as our new Systems Engineer, while wishing Ing. Nathaniel Barbara good luck as he progresses in his career. We also saw the award of new research projects, which welcomed new researchers working with the department either on a full-time or a part-time basis. The latter, goes hand in hand with the dissemination of research and results in both scientific and non-scientific domains, continuing the Department's legacy in high-quality research and its dissemination to the community.

I am grateful for the effort and commitment of each member of the Department. Thank you! and let's have another successful year ahead.

Dr Alexandra BONNICI
Head of Department
30th October 2022

A close-up photograph of a LEGO Technic robot, likely a Mindstorms NXT or similar, with various sensors and cables attached. The robot is white and blue, with black wheels. A red banner with white text is overlaid on the image.

2. Staff Members

2.1 Staff Members List

Head of Department

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

Full Professors

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

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

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

Lecturers

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

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

Visiting Academics

Dr Brian Azzopardi, *B.Eng. (Hons.) (Melit.), Ph.D. (Manchester), PGCHE (Oxford Brookes)*

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

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

Research Support Officer IV

Dr Peter Ashley Clifford Varley, *M.A.,M.Sc.,Ph.D.,C.Eng.*

Research Support Officer I

Mr Matthew Mifsud, *B.Eng. (Hons.) (Melit.) (until July 2022)*

Mr Gilbert Vassallo *B.Eng. (Hons.) (Melit.), (part-time)*

Systems Engineers

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

Ing. Nathaniel Barbara, *B.Eng. (Hons.) (Melit.), M.Sc.(Eng.), (until August 2022)*

Ing. Jean Gauci, *B.Eng. (Hons.) (Melit.), M.Sc.(Eng.), (since August 2022)*

Assistant Laboratory Manager

Mr Noel Agius

Administrators

Ms Sanchia Cilia Lentini



3. Administrative Contributions

3.1 Administrative Contributions of Department Members

Department members contribute to the administration of the Department, Faculty and the University through memberships in various committees. The list below, indicates the administrative contribution of various department members throughout this academic year.

Prof. Ing. Kenneth P. Camilleri

- Member of the University Promotions Board
- Director of the Centre for Biomedical Cybernetics (CBC)
- Chair of the CBC's Doctoral Committee
- Chair of the CBC's Board of Studies for the M.Sc. by Research programme
- Member of the Board of Studies of the M.Sc. in Signals, Systems and Control
- CBC representative on the Board of the Malta Neuroscience Network (University of Malta)
- Assists the European Union's Research Executive Agency in its evaluations of proposals submitted to various Horizon 2020 and Horizon Europe calls
- Assists various international research agencies in their research proposal evaluations

Prof. Ing. Simon G. Fabri

- A member of the:
 - Academic Resources Funds Committee
 - Board of the Centre for Biomedical Cybernetics (Chair)
 - Board of the Institute for Climate Change and Sustainable Development
 - Doctoral Academic Committee
 - SEA-EU Quality and Ethics sub-committee
 - Board of Studies of the M.Sc. in Signals, Systems and Control,
 - Board of Studies of the M.Sc. by Research of the Centre for Biomedical Cybernetics
 - Doctoral Committee of the Centre for Biomedical Cybernetics
 - University Assessment Appellate Board
 - Doctoral School Board
 - PhD and Research Master Degrees Scholarship Board (co-Chair)
 - Board of the Institute of Physical Education and Sport (Chair)
 - IT Services Committee (Chair)
 - Malta University Publishing Board
 - Professional Development Committee (Chair)
 - Professional Doctorate Sub-committee
 - Research Engagement Committee (Chair)
 - Research Funds Committee (Chair)
 - Staff Affairs Committee
 - Staff Scholarships and Bursaries Committee
 - Board of Directors of MUIP
- Member of the Executive Board of the Mediterranean Control Association
- University Pro-Rector for Research and Knowledge Transfer

Dr Kenneth Scerri

- Chair of the Faculty of Engineering International Affairs Committee

- Running of the Intelligent Transportation Research Lab at the Faculty of Engineering
- Works to maintain the Data Science Research Platform at the University of Malta and establish research collaborations with local IT companies and start-ups

Dr Ing. Marvin K. Bugeja

- A member of the:
 - University of Malta PhD and Master Degrees (Research) Scholarship Selection Board
 - Board of Studies of the M.Sc. in Language and Computation offered by the Institute of Linguistics and Language Technology
 - Board of Studies of the M.Sc. in Signals, Systems and Control
 - Board of Studies of the B.Eng. Electrical and Electronics course
 - EEE Course Accreditation Committee
- Representative on the general assembly of the European Control Association (EUCA)
- Technical Advisor and Team Mentor for the IEEE R8 Robot Championships 2022

Dr Tracey Camilleri

- Department's representative on Faculty board
- Member of the Faculty's M.Sc. by Research Board of Studies
- Member of the Board of Studies of the M.Sc. in Signals, Systems and Control
- Board Member of the Centre for Biomedical Cybernetics
- Member on the Committee for the Implementation of the Students' Charter
- Faculty's representative in the Malta Neuroscience Network
- Academic advisor for first year electrical engineering students
- Counsellor of the IEEE Malta student branch
- Secretary of the IEEE Women in Engineering
- Member of the IEEE Malta Section committee

Dr Alexandra Bonnici

- A member of the:
 - Faculty Board of the Faculty of Engineering
 - Faculty's Board of Studies (B.Eng. Electrical and Electronics area of study)
 - Board of Studies of the MSc by Research in Engineering
 - Board of Studies of the MSc in Signals Systems and Control
 - Board of Studies of the Certificate in Engineering Sciences
 - TRAKE steering committee
 - Doctoral Board of Studies for the Centre of Biomedical Cybernetics
 - National STEM Engagement Working Group
 - Matsec Board
 - SEAC Engineering Technology syllabus panel
- Coordinator of the Faculty of Engineering Technology Clubs
- Coordinator of the Faculty of Engineering Job Shadowing Week
- Coordinator of the Faculty of Engineering Carousel Week
- Program Coordinator of the Certificate in Engineering Sciences

Dr Ing. Stefania Cristina

- Member of the Faculty's PR Committee
- Member of the University's Visiting Lecturers and External Examiners Committee
- Coordinator of the Department's Learning Thursdays
- Part of the Executive Team of the IET Vision & Imaging Technical Network
- Chair of the Malta Group of Professional Engineering Institutions (MGPEI)
- Representative of the MGPEI on the steering committee of the MEDPOWER conference
- Assists in the evaluations of project proposals submitted to various Horizon 2020 calls

Dr Ing. Luana Chetcuti Zammit

- A member of the SEC and SEAC Engineering Technology syllabus panel
- Assists in the promotion of the Department MSc course
- Assists in the running of the Intelligent Transportation Research Laboratory at the Faculty of Engineering

- A member of the FREC
- A member of the Faculty Sustainable Committee
- Coordinator of the MSc in Signals Systems and Control

Ms Sanchia Cilia Lentini

- Assists with the scheduling of the Technology Clubs

3.2 Other Support - Loan of Thermal Cameras

The Department has continued its support to the University and the Department of National Public Health by loaning four thermal cameras, one of which belongs to the Department of Systems and Control Engineering, and three of which are owned by the Centre for Biomedical Cybernetics, to the Office of the Superintendent of Public Health to assist with body temperature detection. As it is now commonly known, one of the symptoms of COVID-19 is fever, and although they cannot diagnose the virus per se, these thermal cameras provide a fast way of detecting elevated body temperatures without requiring physical contact as in other conventional close-range thermometers. The cameras were on loan until the 12th August 2022 after which, temperature checks were no longer considered necessary.



4. Academic Activities

Department members are active members of the research community, providing scholarly service to the community in addition to supervising students at various undergraduate and postgraduate levels and seeking funds to support the research community within the Faculty and the University. This section gives an overview of these activities, detailing scholarly activities, supervised projects, publications and other academic activities undertaken by the department members.

4.1 Overview of Scholarly Activities of Academic Staff Members

Prof. Ing. Kenneth P. Camilleri

Prof. Camilleri's academic work is concerned with signal and image processing, computer vision and machine learning, with a particular focus on the application of these areas to health and medicine. Specific scholarly contributions carried out during this academic year include:

- Project leader (Biomedical Engineering Sub-project) of the ERDF Project "Strengthening of the Analytical Chemistry, Biomedical Engineering and Electromagnetics RTDI Facilities" which facilitated the setting-up of the Biomedical Engineering Laboratory within the Department
- Principal investigator for the
 - MCST National R&I FUSION-TDP funded project R&I-2016-010-T "WildEye"
 - RIDT Malta Neuroscience Network Brain Fund Award "DeepMotionBMI"
 - TRAKE project "BrainCon"
- Co-investigator for the MCST National R&I FUSION-TDP funded projects
 - R&I-2015-032-T "BrainApp"
 - R&I-2017-002-T "Deep-FIR"
 - R&I-2017-028-T "MAProHand"
 - R&I-2018-012-T "EyeCon"
 - R&I-2018-004-T "NIVS"
- Co-investigator for the MCST Research Excellence Programme funded project REP-2022-002 "LuminEye"
- Co-investigator for the TRAKE projects
 - "CAMVISM"
 - "EyeDesign"
 - "CONAI"
- Co-investigator for the RIDT Cancer Research Grant 2018 project entitled "Combined Thermal and Visual Imaging for Early Detection of Skin Cancer"
- Participant and Management Committee member of the COST Action CA19121 "GoodBrother"
- Member of the Editorial Board of the Journal of Neuroscience Methods (Elsevier)

- Regular reviewer for several journals, including:
 - IEEE Transactions on Image Processing
 - IEEE Access
 - SPIE Journal of Electronic Imaging
 - Elsevier Expert Systems with Applications
 - Taylor & Francis Brain Computing Interfacing Journal
- Reviewer and/or member of various International Programme Committees of several international conferences, including:
 - International Conference on Intelligent Environments (IE 2022)
 - ACM Symposium on Document Engineering (DocEng2022)
 - Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC 2022)
 - International Conference on Informatics in Control, Automation and Robotics (ICINCO 2022)
 - International Conference on Pattern Recognition (ICPR2022)

Prof. Ing. Simon G. Fabri

Prof. Fabri's academic work is concerned with Automatic Control Engineering, particularly adaptive and intelligent control; computational intelligence methodologies for control, modelling and signal processing; nonlinear and stochastic control; systems theory; robotics and robot control systems; and biomedical applications of control and signal processing. Specific scholarly contributions include:

- Project leader of the ERDF Project "Modernizing the University of Malta's Control Systems Engineering Laboratory" which upgraded the equipment and facilities of the Control Systems Engineering Laboratory within the Department
- Main investigator on the TRAKE project "CONAI"
- Co-investigator in project "BRAINCON", funded by TRAKE
- Co-investigator in the MCST National R&I FUSION-TDP funded projects
 - R&I-2019-003-T "SMARTCLAP"
 - R&I-2017-003T "Ride+Safe"
- Reviewer for several academic journals
- Review committee member or associate editor for several international conferences
- Associate Editor of the International Journal of Systems Science published by Taylor and Francis

Dr Kenneth Scerri

Dr Scerri's academic work is concerned with system modelling and data engineering with applications in transportation, air quality and biomedical signal processing. Specific scholarly contributions include:

- Co-investigator on the H2020 project "A vision for human-centred future cities" (VARCITIES).
- Successful co-applicant on the H2020 project "Activation of NATURE-based solutions for a JUST low carbon transition" (JustNature).
- Co-investigator on a two year research collaboration with ST Microelectronics (Malta).
- Participated in the EU COST action "CA18232 - Mathematical models for interacting dynamics on networks"
- Reviewer for the International Journal of Systems Science and various international scientific conferences.

Dr Ing. Marvin K. Bugeja

Dr Bugeja's academic work is concerned with robotics and automatic control systems. Specific research areas of interest in robotics include: autonomous mobile robots, mobile manipulators, multi-robot systems and robot control; while focus areas in general control systems include: nonlinear, adaptive, intelligent, stochastic and neuro control, as well as mechatronic and process control systems, among others. Specific scholarly contributions include:

- Co-investigator in project "CONAI", funded by TRAKE
- Co-investigator in project "BRAINCON", funded by TRAKE
- Co-investigator in the MCST National R&I FUSION-TDP funded project R&I-2019-005-T "Smart In-sole Technology for the Salvage of the Diabetic Foot (Sit-Diab)"
- Reviewer or programme committee member for several conferences and journal submissions, including, among others, the
 - IEEE Transactions on Cybernetics
 - IEEE Transactions on Automatic Control
 - International Journal of Systems Science
 - Neurocomputing International Journal by Elsevier
 - International Conference on Informatics in Control, Automation and Robotics
- Member of the Astrionics research group (Astrea), University of Malta
- Member of the Particle Detector and Accelerator research group, University of Malta
- Research committee member of the Centre Innovation Drones de Normandie (CIDN)
- Regular invited lecturer at the ISMMB, Department of Mechatronics, Faculty of Mechanical Engineering, Brno University of Technology, Brno, Czech Republic

Dr Tracey Camilleri

Dr Camilleri's academic work is concerned with the signal processing of biomedical data and development of human machine interface systems. Specific scholarly contributions include:

- Reviewer for journal submissions including, among others:
 - Journal of Selected Topics in Signal Processing
 - Journal of Biomedical Engineering and Control
 - IEEE Transactions on Biomedical Engineering
- Principal investigator for the MCST National R&I FUSION-TDP funded projects:
 - R&I-2015-132-T "BrainApp"
 - R&I-2018-012-T "EyeCon"
- Co-investigator of the RIDT Malta Neuroscience Network Brain Fund Award "DeepMotionBCI".
- Co-investigator in project "BRAINCON", funded by TRAKE

Dr Alexandra Bonnici

Dr Bonnici's academic work is concerned with image processing and computer vision, applying these disciplines to document engineering, specifically focusing on sketched documents and musical documents. Specific scholarly contributions include:

- Reviewer or committee member for international conferences and journals, including:
 - The Eurographics Workshop on Sketch Based Interfaces and Modelling
 - Computer and Graphics Journal
 - International Symposium on Document Engineering
 - Eurographics Conference on Visualization.
- Member of the Steering Committee of the ACM International Symposium on Document Engineering

- Associate editor on Xjenja, the journal of the Malta Chamber of Scientists.
- Co-investigator on the TRAKE “EyeDesign” project
- Currently editing a book “Interactive Sketch-Based Interfaces and Modelling for Design” for the River Series in Document Engineering
- Topic editor for the research topic “Music and AI” for the journal Frontiers in Artificial Intelligence

Dr Ing. Stefania Cristina

Dr Cristina’s academic work is concerned with image processing and computer vision, with particular focus on their application to assisted living technologies. Specific scholarly contributions include:

- Reviewer for several conferences and journal submissions, including:
 - International Workshop on Assistive Computer Vision and Robotics (ACVR)
 - ACM Symposium on Eye Tracking Research and Applications (ETRA)
 - ACM Symposium on Document Engineering (DocEng)
 - ACM Transactions on Multimedia Computing, Communications, and Applications (TOMM).
- Principal investigator for the
 - TRAKE “EyeDesign” project
 - MCST Research Excellence Programme funded project REP-2022-002 “LuminEye”
- Co-investigator of the MCST Research Excellence Programme funded project REP-2022-006 “Doc2Speech”
- Part of the project management team of the National R&I Fund Award R&I-2016-010T “WildEye”
- Participant and Management Committee Member of the COST Action CA19121 “GoodBrother”
- Contributes, as a senior writer, to one of the largest websites covering machine learning topics, machinelearningmastery.com

Dr Ing. Luana Chetcuti Zammit

Dr Chetcuti Zammit’s academic work is concerned with machine learning and control with applications in transportation. Specific scholarly contributions include:

- Reviewer for several international conferences such as the
 - Australian Control Conference
 - IEEE Intelligent Transportation Systems Conference
- Member of the EU COST Action PROCLIAS (CA19139)

4.2 Student Projects and Supervision

4.2.1 B.Eng. (Hons) Students

PROJECT TITLE: Detection of Traffic Events from Social Media Data

STUDENT: Aiden Bezzina

SUPERVISOR: Dr Ing. Luana Chetcuti Zammit

PROJECT TITLE: Draw to Model: a 3D interpretation tool for paper-based drawings

STUDENT: Gaetano Matteo Bugelli

SUPERVISOR: Dr Alexandra Bonnici

PROJECT TITLE: A document segmentation tool

STUDENT: Erika Spiteri Bailey

SUPERVISOR: Dr Alexandra Bonnici

PROJECT TITLE: IoT-based Air Quality Monitoring
STUDENT: Neil Buttigieg
SUPERVISOR: Dr Kenneth Scerri

PROJECT TITLE: Modelling and Simulation of a Robotic Hot-Wire Cutter
STUDENT: Jacob Jordan Catania
SUPERVISOR: Dr Ing. Marvin Bugeja
CO-SUPERVISOR: Prof Ing Simon Fabri

PROJECT TITLE: Design and Development of a Remote-Control System for Electric Wheelchairs
STUDENT: Luca Fenech
SUPERVISOR: Dr Ing. Marvin Bugeja

PROJECT TITLE: Controlling external devices using an SSVEP based BCI
STUDENT: Cheryl Gilford
SUPERVISOR: Dr Tracey Camilleri
CO-SUPERVISOR: Prof Kenneth Camilleri

PROJECT TITLE: A Pacesetting Mobile Robot for Track Runners
STUDENT: Andrew Pirotta
SUPERVISOR: Dr Ing. Marvin Bugeja

PROJECT TITLE: Identifying Optimal Investment Strategies with Deep Learning
STUDENT: Samwel Portelli
SUPERVISOR: Dr Kenneth Scerri

PROJECT TITLE: Design and Implementation of a Miniature Stewart Platform and Control System
STUDENT: Andrew George Vella
SUPERVISOR: Prof. Ing. Simon Fabri

PROJECT TITLE: Sensorless Angular Velocity Measurement of Brushed DC Motors for CubeSat Applications
STUDENT: Davide Cusmano
SUPERVISOR: Prof. Ing. Simon Fabri

4.2.2 M.Sc. by Research Students

PROJECT TITLE: Dwell-free typing using an EOG based virtual keyboard
STUDENT: Mr Matthew Mifsud
SUPERVISOR: Dr Tracey Camilleri
CO-SUPERVISOR: Prof. Ing. Kenneth P. Camilleri

PROJECT TITLE: Controlling a smart wheelchair using steady-state visually evoked potentials
STUDENT: Mr Shawn Darmanin
SUPERVISOR: Prof. Ing. Kenneth P. Camilleri
CO-SUPERVISOR: Dr Tracey Camilleri

PROJECT TITLE: Automatic error detection for an SSVEP-based music player application
STUDENT: Mr Fabian Camilleri
SUPERVISOR: Dr Tracey Camilleri

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

PROJECT TITLE: Anomaly Detection on Smart Meter Data

STUDENT: Mr Michael Farrugia

SUPERVISOR: Dr Kenneth Scerri

CO-SUPERVISOR: Dr Andrew Sammut ¹

PROJECT TITLE: Design and Implementation of the Control System for a Physical Motorcycle Simulator

STUDENT: Mr. Daniel Cassar

SUPERVISOR: Prof. Ing. Simon Fabri

PROJECT TITLE: A Real Time Hand-movement Motion Capture System for Rehabilitation of Children with Cerebral Palsy

STUDENT: Dr. Mario Farrugia

SUPERVISOR: Prof. Ing. Simon Fabri

CO-SUPERVISOR: Dr. Ing. Owen Casha ²

PROJECT TITLE: Pedestrian Detection and Pose Estimation for Intention Recognition in Autonomous Vehicles

STUDENT: Mr Gilbert Vassallo

SUPERVISOR: Dr Ing. Stefania Cristina

PROJECT TITLE: Hand Pose Estimation using Deep Learning

STUDENT: Ms Michaela Spiteri

SUPERVISOR: Dr Ing. Stefania Cristina

PROJECT TITLE: Integrating Contextual Cues in Pedestrian Behaviour Prediction for Autonomous Driving

STUDENT: Mr Luke Scicluna

SUPERVISOR: Dr Ing. Stefania Cristina

4.2.3 M.Phil. / Ph.D. Students

PROJECT TITLE: Electrode Modelling for Applications of Functional Electrical Stimulation

STUDENT: Ms Mary Grace Cassar ³

SUPERVISOR: Prof. Cristiana Sebu ³

CO-SUPERVISOR: Prof. Ing. Kenneth Camilleri

PROJECT TITLE: Towards SSVEP-Based BCI Applications for Real-World Environments Interfaces

STUDENT: Ing. Rosanne Zerafa

SUPERVISOR: Dr Tracey Camilleri

CO-SUPERVISORS: Prof. Ing. Kenneth Camilleri

PROJECT TITLE: EOG-Based Gaze Angle Estimation With Varying Head Pose

STUDENT: Ing. Nathaniel Barbara

SUPERVISOR: Dr Tracey Camilleri

CO-SUPERVISOR: Prof. Ing. Kenneth Camilleri

¹Department of Electronic Systems Engineering

²Department of Microelectronics and Nanoelectronics

³Department of Mathematics

PROJECT TITLE: Coordination and Control of Multi-Robot Systems
STUDENT: Ing. Rachael Duca
SUPERVISOR: Dr Ing. Marvin Bugeja

PROJECT TITLE: Analysis of temperature transient patterns using dynamic infrared thermography
STUDENT: Ing. Jean Gauci ⁴
SUPERVISOR: Dr Owen Falzon ⁵
CO-SUPERVISOR: Prof. Ing. Kenneth Camilleri

PROJECT TITLE: An Enhanced Wearable System for Kinematic and Kinetic Gait Analysis
STUDENT: Mr Nikiforos Okkalidis ⁵
SUPERVISOR: Dr Owen Falzon ⁵
CO-SUPERVISORS: Dr Ing. Marvin Bugeja, Dr Alfred Gatt ⁶

PROJECT TITLE: Towards More Compact Chip to Chip Communication Methods
STUDENT: Mr Andre Micallef ⁷
SUPERVISOR: Dr. Ing. Marc Anthony Azzopardi ⁷
CO-SUPERVISOR: Prof. Ing. Simon G. Fabri

PROJECT TITLE: An Active Fault Tolerant Attitude Determination and Control System for a Pico-satellite
STUDENT: Mr Darren DeBattista ⁷
SUPERVISOR: Dr Ing. Marc A. Azzopardi ⁷
CO-SUPERVISOR: Dr Ing. Marvin Bugeja
CO-SUPERVISOR: Prof. Ing. Simon G. Fabri

PROJECT TITLE: Development of a Framework for the Conversion of a Home to a Robot Inclusive Space, and for the Design of a Compatible Autonomous Domestic Robot
STUDENT: Mr Prabhu Rayudu Narahariseti ⁸
SUPERVISOR: Dr Ing. Michael A. Saliba ⁸
CO-SUPERVISOR: Prof. Ing. Simon G. Fabri

4.2.4 Internships

Development of an energy consumption and emissions calculation online application

STUDENT: Mr Yann Kerdoncuff and Mr Sylvain Madre, ⁹
SUPERVISOR: Dr Ing. Luana Romano, Dr Kenneth Scerri

Yann Kerdoncuff and Sylvain Madre from the Graduate School of Engineering Polytech Nantes in La Roche sur Yon carried out a 9-week internship with the Department. During this internship, Yann and Sylvain designed and launched an online application that allows the user to choose the departure point, and destination point of a car journey to calculate the energy consumed during the trip as well as the amount and type of emissions incurred.

⁴Centre for Biomedical Cybernetics

⁵Centre for Biomedical Cybernetics

⁶Department of Podiatry, Faculty of Health Sciences, University of Malta

⁷Department of Electronic Systems Engineering

⁸Department of Industrial and Manufacturing Engineering

⁹Polytech Nantes in La Roche sur Yon, France

Improvements and new developments on the department's smart wheelchair

STUDENT: Mr Roman Adámek,¹⁰

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

Roman Adámek, a PhD candidate and researcher at Brno University of Technology in Brno, Czech Republic, carried out a five month internship with the Department. During this internship Roman performed substantial hardware and software upgrades to the department's smart wheelchair. In particular: he designed, implemented, and tested a novel local path planner that greatly improves the wheelchair's navigation function, installed and integrated a RealSense D455 depth camera to enhance the sensing and obstacle avoidance capabilities of the wheelchair, designed a new graphical user interface (GUI) that greatly facilitates wheelchair operation and code-debugging, created a realistic wheelchair simulator in ROS that is particularly useful to test new algorithms prior to physical experiments, and performed an experimental analysis that compares the performance of various SLAM algorithms in ROS on the smart wheelchair. As a result of this work, Roman, with the help of his supervisors, has recently submitted a paper for review to the 20th Mechatronika conference, to be held in December 2022 in Pilsen. Figure 6.4 illustrates the smart wheelchair and the resulting map obtained during semi-autonomous navigation.

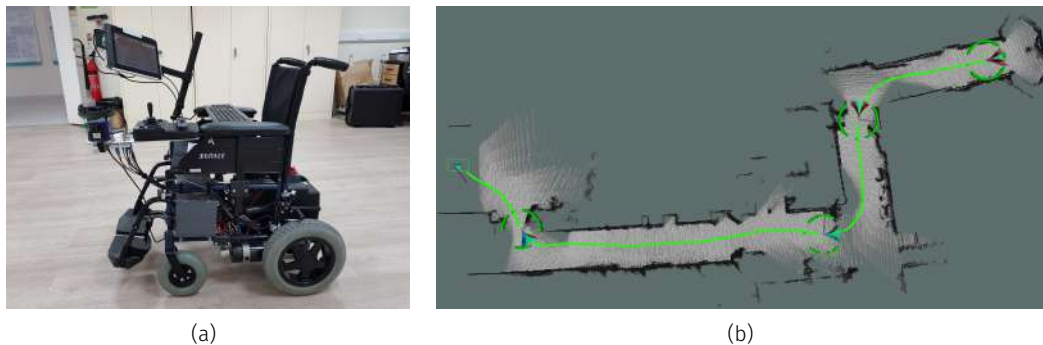


Figure 4.1: (a) The upgraded UM Smart Wheelchair. (b) Semi-autonomous navigation in an indoor environment (physical experiments)

Endurance characterisation of motors used in micro-satellites for attitude control

STUDENT: Mr Andy Bruot,¹¹

SUPERVISOR: Prof. Ing. Simon G. Fabri, Dr Marc-Anthony Azzopardi, Mr Darren Debattista

During this internship, Mr Bruot worked on the endurance characterisation of motors used in micro-satellites for attitude control. This involved setting up electronic rigs for motor performance testing, MATLAB coding for collection of test data, analysis of results, including parameters trends of failed motors, and performance of motors under vacuum conditions. A scientific poster on the work performed was also compiled by the intern.

4.3 Teaching Activities

The Department is responsible for teaching several study-units at both undergraduate and postgraduate levels, offering its teaching services with the following degree courses:

- B.Eng.(Hons) in Electrical and Electronic Engineering (Faculty of Engineering)
- B.Eng.(Hons) in Mechanical Engineering (Faculty of Engineering)

¹⁰Faculty of Mechanical Engineering, Brno University of Technology, Brno, Czech Republic

¹¹Universite de Lorraine, Polytech Nancy, France

- Certificate in Engineering Sciences (Faculty of Engineering)
- B.Sc.(Hons) in Communications and Computer Engineering (Faculty of ICT)
- B.Sc.(Hons) in Physics, Medical Physics and Radiation Protection (Faculty of Health Sciences)
- M.Sc. in Language and Computation (Institute of Linguistics)
- M.Sc. in Medical Physics (Faculty of Health Sciences)
- M.Sc. in Environmental Management and Sustainability (Institute of Earth Systems)
- M.Sc. in Artificial Intelligence (Faculty of ICT)
- M.Sc. in Applied Oceanography (Faculty of Science)

In addition, the Department also coordinates and delivers a taught M.Sc. in Signals, Systems and Control, offering this course on both a full-time and part-time basis. The study units offered by the Department at undergraduate and postgraduate levels are listed in Tables 4.1 and 4.2 respectively.

Besides these teaching duties, the department also offers additional 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 \LaTeX to write their dissertations and two seminars during which students deliver a 10-minute presentation on their work.

Table 4.1: Undergraduate study units offered by the Department in 2020/2021

Code	Name	ECTS
SCE Undergraduate Study Units		
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
SCE3115	Introduction to Robotics	5
SCE3216	Automatic Control Systems 4	5
SCE4101	Computational Intelligence 1	5
SCE4102	Systems Theory	5
SCE4103	An Introduction to Biomedical Signal Analysis	5
SCE4104	Practical Applications in Computer Vision	5
Other Undergraduate Study Units supported by SCE		
ENR3008	Team Project (unit co-ordination and project supervision)	5
ENR4200	Engineering Project (project supervision & assessment)	20
Pre-tertiary Study Units Supported by SCE		
ENR0012	Trigonometry and Vectors (part of)	6
ENR0013	Matrices, Numerical Methods and Probability (part of)	6
ENR0010	Experimental Setup and Procedures	3
ENR0011	Engineering Technology	5
Study units offered to other undergraduate degrees		
SCE2112	Control Systems 1 (ICT)	5
SCE3114	Introduction to Control Engineering (Mechanical Engineering)	5
SCE3116	Introduction to Control Engineering (Education & Learning)	5
SCE3021	Biomedical Signal & Image Processing for Medical Physics (Health Sciences)	6

Table 4.2: Postgraduate study units offered by the Department in 2020/2021

Code	Name	ECTS
SCE Postgraduate Study Units		
SCE5101	Linear Dynamic Systems and Signals	6
SCE5102	Estimation and System Identification	5
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	5
SCE5204	Adaptive and Intelligent Control	5
SCE5205	Computer Vision	5
SCE5301	Research Project in Systems and Control Engineering	30
Other Postgraduate Study Units supported by SCE		
ENR5006	Research Methods for Engineers (part of)	5
ENR5026	Science Communication in Engineering (part of)	5
SCE5107	Principles of Biomedical Signal Processing for Medical Physics	5
SCE5108	Principles of Biomedical Image Processing for Medical Physics	5
OMS5004	Data Resources in Operational Oceanography (part of)	10
MEC5014	Condition Monitoring and Systems (part of)	5
ARI5321	Automation and Applied Robotics (part of)	5

4.4 Other Academic Activities

In addition to teaching study units to service degree programs, department members engage in other academic activities examples of which described hereunder.

4.4.1 Final Year Project Exhibition

The Faculty's Final Year Project Exhibition was held on campus between the 24th and the 26th of June 2022 following a two-year absence due to Covid-19. The Department's final-year students participated in this exhibition, showcasing their project work ranging from research in transport systems, to biomedical engineering applications, robotics and control systems, to the general public.

4.4.2 Engineering Students Summer Training Course

Between the 4th of July and the 19th August 2022, Ing. Nathaniel Barbara and Mr Noel Agius delivered a four-day summer training course as part of Faculty's summer training program for the Electrical and Mechanical Engineering degree students. This training program was followed by students in their second-year of studies, with the training being repeated over a seven-week period to accommodate all students.

Training in Robotics

Ing. Nathaniel Barbara started the training by providing some background information to robotics, specifically by discussing the general concepts of robotics, the different types of robots that exist and the main components of a robot, including different sensors that may be used as well as other attachments. Following this discussion, the students engaged in five hands-on programming tasks which were based on the VEX V5 Robot.

The first task focused on the implementation of a pick-and-place application which required the students to program the four motors on board the VEX Robot to drive the robot; to adjust the arm position; and to open/close the claw in sequence. The students also made use of the screen on the onboard microcontroller to display text indicating which motor function is being carried out while the robot is in operation.

During the second day, the students familiarised themselves with the vision sensor that the VEX Robot was also equipped with. The students implemented a colour recognition application and used the robot's display to output the colour detected by the robot in real-time. Furthermore, the students used the same vision sensor to implement a selective pick-and-place robot such that the robot only picks up blocks of a predetermined colour. Finally, the students paired a joystick controller with the robot to be able to drive the robot and control the arm and claw motors wirelessly.

Training in wiring of a direct-on-line starter and forward & reverse starter

Mr Noel Agius started the training by giving the students a demonstration of a direct-on-line and forward and reverse starter by controlling a single-phase capacitor start induction motor and a 3-phase star-connected induction motor.

During the demonstration, measuring instruments were used to measure direct current (24V DC) and alternating current (230/400v AC); to detect a 3-phase rotation sequence; and to measure the motor shaft speed. Devices such as the contractor, auxiliary contacts, thermal overload relay, 4-pole RCBO (3P+N), 2-pole MCB, single phase RCD, power supply (230V AC to 24V DC), single-phase overvoltage/undervoltage relay, under voltage/overvoltage protector phase sequence/phase loss protector and power display, were shown and explained to the students. Moreover, students were shown how to interpret the information listed on each motor name plate; how to connect the terminals of a 3-phase motor in both star and delta configurations; and how to use bootlace terminals.

Students were then assigned two practical tasks:

Task 1: The students used an electric circuit diagram to wire a direct-on-line starter, controlling a 12V DC motor. The contactor hold-on coil operates by a 24V DC supply.

Task 2: The students used an electric circuit diagram to wire a forward and reverse starter, controlling a 24V DC motor. The contactor hold-on coil operates by a 24V DC supply.

In both tasks the students used wax lacing to keep the wires neatly and tightly bundled together. For both tasks, before switching on the students carried out a visual inspection and continuity test. After switching the students measured DC voltages across the terminals of the electrical circuit.

4.4.3 Certificate in Engineering Sciences

Dr Alexandra Bonnici once again coordinated the Certificate of Engineering Sciences on behalf of the Faculty of Engineering. This Certificate course provides students with an alternative entry route to the Bachelor degree courses offered by the Faculty. The Certificate course helps individuals who need to top-up their Maths and Physics Advanced Levels, who want to redirect their studies to the Engineering field, or who are entering back into academic education after working in the industry. Six students successfully completed this Certificate programme during the 2021/22 academic year and these are now enrolled in the undergraduate courses offered by the Faculty of Engineering, the Faculty of ICT, and the Faculty of Science.

4.5 SEA-EU Service Learning Study Visit

Between the 11th and 13th October 2021, Dr Alexandra Bonnici participated in SEA-EU study group on Service Learning. In this study visit, participants were provided with various examples from the University of Split where service learning is applied to courses taken by undergraduate students in the areas

of chemistry, biology and marketing. The study visit included discussions on the application of service learning in the various fields across the SEA-EU alliance.

4.6 Participation in the SEA-EU Alliance Joint Course in Research Excellence

Dr Alexandra Bonnici was one of the lecturers participating in the joint course on Research Excellence offered to undergraduate and postgraduate students from across the SEA-EU alliance. A total of 116 students participated in the course which was offered as an online course between March and July 2022. The course was divided into six different modules and Dr Bonnici was responsible for the module on Data Collection, Analysis and Presentation.

4.7 SEA-EU Joint workshop

Linking training to research in international and cross-sectoral dimension

Between the 7th and 8th July 2022, Dr Alexandra Bonnici participated in SEA-EU Joint workshop on linking training to research in international and cross-sectoral dimension. In the first day of the meetings, experiences of all stake holders involved in the SEA-EU research and training programmes, that is, students, tutors, industrial mentors and academic mentors, as well as the outcomes of various focus groups were presented to the audience. The difficulties and challenges as well as the good working practices were highlighted. The challenges were discussed in further depth on the second day, outlining potential solutions and ways forward to better the SEA-EU alliance goals.

4.8 Staff Erasmus visits

The Department members participated in Erasmus exchanges to encourage collaborations with different institutions. Two such visits took place during this academic year.

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

Between the 13th and 22nd April 2022, Dr Ing. Marvin Bugeja visited (through Erasmus+) the Department of Mechatronics at Brno University of Technology, hosted by the head of department Prof. Robert Grepl. During his visit, Dr Bugeja delivered several lectures and practical sessions on “Linear & Nonlinear Systems”, and “Technical Report Writing & Presentations”, to groups of undergraduate and postgraduate students. Moreover, he discussed a number of possibilities for future internships, joint research projects and extended lecturing visits between the two departments.

4.8.2 Erasmus Learning Exchange in Gdansk, Poland

Between the 24th and the 28th May 2022, Dr Alexandra Bonnici participated in an Erasmus Learning exchange at the University of Gdansk in Poland. While there, Alexandra participated in two lectures with students following a course in early learning education, during which different methods for early childhood exposure to STEM education were explored. The visit also served as a learning experience through which different approaches towards outreach programmes were identified. This visit follows on from the visit held earlier in March by Prof. Adam Jagiełło-Rusiłowski and strengthens the ties between the department and the University of Gdansk.

4.9 Participation in the EUCA General Assembly meeting - Imperial College London

As the Maltese representative on the European Control Association (EUCA), Dr. Ing. Marvin Bugeja attended the EUCA General Assembly meeting, held on the 12th July 2022 at Imperial College London. As is customary, the EUCA General Assembly met just before the opening ceremony of the European

Control Conference (ECC). Among several items, the agenda of this meeting included the election of new members of the assembly, and the consideration and selection of proposals for the organisation of the European Control Conferences (ECC) of 2026. Interestingly, ECC 2022 (12-15 July) was the first ECC held in hybrid format. The physical sessions of ECC 2022 took place in the South Kensington Campus of Imperial College London.

4.10 Seminar - Inter-disciplinary PhDs: perspectives from staff and students

On the 28th April, Prof. K. P. Camilleri was invited to contribute as a Panelist in the seminar 'Inter-disciplinary PhDs: perspectives from staff and students' which was jointly organised by the Department of Information Policy & Governance within the Faculty of Media & Knowledge Science together with the Doctoral School.

4.11 Management Committee and Working Group Meeting

CA19121 GoodBrother Cost Action

On the 8th and 9th of September 2022, Dr Stefania Cristina attended and participated in a Management Committee and Working Group meeting for the CA19121 GoodBrother Cost Action, which was held in Naples, Italy. During this meeting, items related to the status and progress of the Action itself have been discussed. Meetings between members of the different Working Groups were also held in order to plan the ongoing and forthcoming activities, and presentations were delivered by members of the Action in order to disseminate their ongoing research work and foster potential collaborations.

4.12 Publications

Journal Publications

1. M. Borg, A. Tabone, A. Bonnici, S. Cristina, R. A. Farrugia, K. P. Camilleri, 'Detecting and ranking pornographic content in videos', *Forensic Science International: Digital Investigation*, vol. 42, September 2022.
2. N. Padfield, K. P. Camilleri, T. Camilleri, S. Fabri, M. Bugeja, 'A Comprehensive Review of Endogenous EEG-Based BCIs for Dynamic Device Control', *Sensors* 2022, vol. 22, 5802, August 2022.
3. L. T. Triccas, K. P. Camilleri, T. Camilleri, F. H. Mansoureh, B. Wittevrongel, F. Muscat, L. Boccuni, D. Mantini, G. Verheyden, 'Reliability of Upper Limb Pin-Prick Stimulation With Electroencephalography: Evoked Potentials, Spectra and Source Localization', *Frontiers in Human Neuroscience*, 16, July 2022.
4. M. Aquilina, C. Galea, J. Abela, K. P. Camilleri, R. Farrugia, 'Improving Super-Resolution Performance using Meta-Attention Layers', *IEEE Signal Processing Letters*, October 2021.

Conferences Publications (Peer Reviewed)

1. E. Spiteri-Bailey, A. Bonnici, S. Cristina, 'A cascaded approach for page-object detection in scientific papers. In *ACM Symposium on Document Engineering 2022 (DocEng '22)*, September 20-23, 2022, San Jose, CA, USA. ACM, New York, NY, USA
2. M. Mifsud, T. A. Camilleri, K. P. Camilleri, "Dwell-free typing using an EOG-based virtual keyboard, 24th International Conference on Human-Computer Interaction, June 2022.
3. P. R. Naraharisetti, M.A. Saliba, S.G. Fabri, "Towards the Quantification of Robot-inclusiveness of a Space and the Implications on Robot Complexity", in *Proceedings of the 8th International Conference on Automation, Robotics and Applications ICARA*, February 2022.

4. T. Sindel, P. R. Naraharisetti, M.A. Saliba, S.G. Fabri, "Bounding Box Matching: A sparse object-centric correspondence method for stereo vision", in Proceedings of the 8th International Conference on Automation, Robotics and Applications ICARA, February 2022.
5. T. Camilleri, J. Mangion, K. Camilleri, 'Exploiting EEG-extracted Eye Movements for a Hybrid SSVEP Home Automation System', 15th International conference on Bio-Inspired Systems and Signal Processing, BIOSIGNALS 2022, February 2022.
6. R. Zerafa, T. A. Camilleri, and K. P. Camilleri, "SAT: A Switch-And-Train Framework for Real-Time Training of SSVEP-based BCIs," (accepted for publication) in 43rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), IEEE, November 2021.
7. N. Barbara, T. A. Camilleri, K. P. Camilleri, "TEMoD: Target-Enabled Model-Based De-Drifting of the EOG Signal Baseline using a Battery Model of the Eye", 43rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society, November 2021.

4.12.1 Non-peer reviewed articles

1. The Malta Independent about The Smart Insole Technology for the management of the Diabetic Foot, "University developing technology to reduce the incidence of diabetic foot complications", 26th September 2022. Dr Ing. Marvin Bugeja is a collaborator on this project.
2. R. Laviera, interviewing Dr Alexandra Bonnici, "Women in Science: taking girls into STEM," Malta Today, February 6th 2022.



5. Professional Development

Department members engage in learning activities in order to keep abreast with technologies, thereby improving their own research and providing a better service to students. This section describes such activities undertaken by department members during this academic year.

5.1 Designing, Delivering & Evaluating Online Study-Units

Between February and March, Dr Alexandra Bonnici participated in the professional development course on the design, delivery and evaluation of online study units. The 9-week course is designed to provide academic staff with the support to transfer study-units from a face-to-face to a blended or online format. The course provides participants with the basic knowledge and skills required to design, deliver and evaluate one online session in a study-unit while experiencing what it is like to be an online learner.

5.2 Evaluator's training on EPPS

In June, the academics of the Department have attended a training course on how to evaluate tender offers on EPPS.

5.3 Learning Thursdays

In addition to following courses and training offered by the University or external parties, the Department maintains its commitment to offer its members the opportunity to share knowledge and experiences. To this extent, this year, the Department rebranded its Internal Research Workshop Series into Learning Thursdays which take place every first Thursday of the month. The Learning Thursdays provide a platform for academic and technical staff members, research support staff and post-graduate students of the Department, the Centre for Biomedical Cybernetics, as well as close research collaborators from other departments or institutes to discuss academic matters of common interest as well as providing final year and postgraduate students the opportunity to communicate their research work. The following summarises the sessions held during this year.

5.3.1 28th October 2021 and 4th November 2021: Lectures on Data Clustering with Julia, delivered by Professor Ivan Slapničar, from the University of Split in Croatia

The lectures consisted of two parts. In the first section, a short introduction to Julia and its ecosystem was given, followed by the lecture on k-means algorithm for data clustering and package `Clustering.jl`. The second section consisted of lectures on spectral graph bi-partitioning, spectral graph k-partitioning, and spectral partitioning of bipartite graphs, followed by an application to clustering of textual data using terms-document matrix and packages `TextAnalysis.jl` and `Languages.jl`. Prof. Slapničar is a

Professor associated with the Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture at the University of Split, Croatia, where is his currently serving as the Chair of Mathematics. He received his PhD in Mathematics from the Fernuniversität Hagen, Germany. The talk was delivered as part of SEA-EU Virtual Courses initiative.

5.3.2 2nd December 2021: Presentation delivered by Daniel Camilleri from CyberSelves

Robots are the third generation of personal devices. However, the mass adoption of robots as social companions or as workers within the service industry has failed to pick up even during the particularly challenging times of peak COVID infection rates, where these applications would have been most useful. We believe this to be a function of three principal issues faced by the robotics community today. During this presentation, Daniel Camilleri discussed how these issues have been solved in the past for Personal Computers and Smartphones, and how those lessons can teach us how to do the same with robotics.

Daniel Camilleri is the founder and CEO of Cyberselves, a startup with the mission to "Realise the True Potential of Robotics". An electronic engineer by background, he holds a Masters degree in Robotics, and has 5 years experience as a researcher on EU-funded collaborative projects in robotics, working on control and communications for robot humanoids.

5.3.3 3rd February 2022: Documentary by Deutsche Welle

Artificial intelligence (AI) is changing our lives. It touches on all aspects of society - private life, business, security – including in the spread of fake news and the challenges posed by the advent of autonomous weapons.

This documentary looked at the rapid change digitalization is causing as it unfolds. In particular, breakthroughs in artificial intelligence are opening completely new horizons. In their film about AI, Tilman Wolff and Ranga Yogeshwar examine the role AI plays in the spread of fake news. They also consider a future with robots and the risks and ethical questions posed by the development of autonomous weapons. To address these issues, they travel the globe to speak with leading experts. AI can generate perfectly forged sound and videos, making it effective for purveying fake news. Discerning the truth from fiction will become increasingly difficult. Technology will streamline work, making some jobs surplus to requirements. Software will pilot self-driving cars and aerial drones. AI is rapidly opening up new vistas, but turning blind corners at speed can be risky. How sensible is this type of progress, and at which point should society step in and set limits to its development?

5.3.4 3rd March 2022: Presentation delivered by Natasha Padfield, University of Malta

If brain-computer interfaces (BCIs) are to be widely adopted by potential end- users, they need to have better classification performance, faster processing times and use the lowest possible number of channels. In the first part of this talk, Natasha Padfield discussed a lightweight majority-voting decision fusion approach which improved the classification accuracies of four conventional classifiers for EEG data. The second part illustrated how genetic algorithm channel selection was used to improve the computational times of a sparse learning classifier, whilst maintaining its high classification performance. This system, however, used subject-specific channel selection, which significantly increases latency for the end user since they need to wait for the system to select the optimal channels. During the third part of this talk, Natasha discussed a custom CNN layer that was designed to carry out subject-independent channel selection, thus completely removing this channel selection latency. This layer was versatile, performing well on two different CNN networks on two different datasets.

Natasha graduated with a B.Eng.(Hons) from the University of Malta in 2017, after which she followed our MSc in Signals, Systems and Control, which she completed successfully in 2018. For the past years, she has been reading for her PhD with the University for Strathclyde in Biomedical Signal Processing. Her work is focused on effective EEG analysis for AI-driven brain-computer interface systems. During

this talk, she presented the research work she has done during her Ph.D studies.

5.3.5 7th April 2022: ACM TechTalk by Anima Anandkumar, How to Create Generalizable AI

Anima Anandkumar Director of ML Research, NVIDIA; Bren Professor, California Institute of Technology
Anima Anandkumar is a Bren Professor at Caltech and Director of ML Research at NVIDIA. She was previously a Principal Scientist at Amazon Web Services. She has received several honors such as the Alfred. P. Sloan Fellowship, NSF Career Award, Young Investigator Awards from DoD, and Faculty Fellowships from Microsoft, Google, Facebook, and Adobe. She is part of the World Economic Forum's Expert Network. She is passionate about designing principled AI algorithms and applying them in interdisciplinary applications. Her research focus is on unsupervised AI, optimization, and tensor methods.

This ACM TechTalk gives a high-level overview of challenges in deep-learning benchmarks. Current deep-learning benchmarks focus on generalization on the same distribution as the training data. However, real-world applications require generalization to new, unseen scenarios, domains, and tasks. The speaker presented key ingredients that she believe are critical towards achieving this, including (1) compositional systems that have modular and interpretable components; (2) unsupervised learning to discover new concepts; (3) feedback mechanisms for robust inference; and (4) causal discovery and inference that capture underlying relationships and invariances. Domain knowledge and structure can help enable learning in these challenging settings.

5.3.6 5th May 2022: An Introduction to the Malta Cooperative, Mr Victor Fiorini and Mr John Mallia

An invited speaker, Mr Victor Fiorini, was invited to talk about the Malta Cooperative Federation and the opportunities that this entity offers for the development of small business and enterprises.

5.3.7 10th June 2022: Final Year Projects mock presentations

This session provided an opportunity for the students to practice their presentation and communication skills prior to the final project presentations. During these mock presentations, the students are prepared for their dissertation defence.

5.3.8 7th July 2022: ACM TechTalk: A Chat with Andrew Ng on MLOps - From Model-centric to Data-centric AI

This talk, delivered by Dr Andrew Ng, speaks about data-centric vs model-centric AI, where the former focuses more on improving the AI performance by engineering the data so that it clearly conveys what the model needs to learn, vs the latter where the AI performance is sought to be improved by improving the performance of the model itself.



6. Research Activities and Collaborations

The Department has an active research track-record with its members actively involved in seeking research funds to support postgraduate and post-doctoral students. This section describes the work carried out through these projects.

6.1 Externally Funded Projects

BrainCon - User-intuitive Continuous Brain Control of a Smart Wheelchair

MAIN INVESTIGATORS: Prof. Ing. Kenneth P. Camilleri, Dr Tracey Camilleri, Prof. Ing. Simon G. Fabri and Dr Marvin Bugeja

RESEARCH SUPPORT OFFICER: Ms Natasha Padfield ¹

FUNDING BODY: TRAKE 2020 (Second Call)

This project is financed by the University of Malta through the Transdisciplinary Research and Knowledge Exchange Complex (TRAKE). Prof. Ing. Kenneth Camilleri is the project leader and this project was awarded to the Center for Biomedical Cybernetics. Dr Tracey Camilleri, Prof. Ing. Simon Fabri and Dr Marvin Bugeja are collaborators on this project together with the Rehabilitation Specialist-in-Training, Dr Andrei Agius Anastasi.

The project seeks to: (a) integrate a BCI signal to the dynamic model of a smart wheelchair; (b) develop new methods permitting multi-dimensional control signal integration to include, e.g., speed control and direction control; (c) estimate signal integration parameters by reinforcement learning to be tuned by practice; and (d) explore more intuitive mental states, such as thought speech. Combining an intuitive mental state command with a paradigm of continuous BCI control would lead to a more natural brain-machine interaction resembling embodied control, making this technology more viable for people with motor impairment. The BCI experts involved in this project, two of whom are members of the Department, will contribute to the development of a BCI platform and to the investigation of alternative BCI mental states; the robot and control experts, members of the Department, will contribute to the development of the physical wheelchair model and the integration models; and a medical doctor specialising in rehabilitation medicine will contribute end-user advice and recruitment.

¹ Centre for Biomedical Cybernetics

EyeDesign

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

RESEARCH SUPPORT OFFICER: Dr Peter Ashley Clifford Varley

FUNDING BODY: TRAKE 2019 (First Call)

FUNDING AMOUNT: 119,000

AWARDEE: Dr Ing. Stefania Cristina

In the collaborative design process, where multiple users interact with a single object, gaze visualisations are designed to help collaborators understand where others are looking at in a shared visual space. Such visualisations are key to effective communication and collaboration between entities, particularly when the collaborators are not co-located and first-hand observation of the attentiveness of the collaborators is not possible. However, eye-gaze trackers require lengthy user calibration which is not conducive to quick and easy collaborative design. As a result, eye-gaze tracking techniques have not been adopted in the field, despite the advantages that they bring into the field.

During the past year, the research work has applied deep learning techniques in order to estimate the eye-gaze angles from images that combine the two eye regions, so called *eye strips*. A ResNet-18 model has been trained to predict the eye-gaze angles on various datasets, such as MPIIGaze and Gaze360. A demo application to demonstrate a multi-user journey-planning system is also being developed, where the predicted eye-gaze is visualised on a map displayed on the screen. This demo has been showcased during Science in the City 2021, and a refined version of it is planned to be displayed during Science in the City 2022.

6.1.1 National Funding

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 Technology Development Programme

FUNDING AMOUNT: €6,000 research scholarship

RESEARCH STUDENT AND INVESTIGATOR: Daniel Cassar

This project forms part of a larger MCST-funded research programme called *Ride+Safe*, led by Prof. Philip Farrugia from 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 as illustrated in Figure 6.1.

Smartclap: A Real Time Hand-movement Motion Capture System for Rehabilitation of Children with Cerebral Palsy

MAIN INVESTIGATORS: Prof. Ing. Simon G. Fabri, Dr. Ing. Owen Casha ²

FUNDING BODY: MCST FUSION R&I Technology Development Programme

FUNDING AMOUNT: €6,000 research scholarship

RESEARCHER AND INVESTIGATOR: Dr. Mario Farrugia

² Department of Microelectronics and Nanoelectronics



Figure 6.1: Motion cueing to physically emulate the motorcycle ride

This project forms part of a larger MCST-funded research programme called *SmartClap*, led by Prof. Philip Farrugia from the Department of Industrial and Manufacturing Engineering. This project is concerned with the design, implementation and testing of a Motion Capture System to track finger, wrist and arm movements of children with Cerebral Palsy (CP) while playing a Virtual Reality (VR) game purposely designed to help with their rehabilitation therapy. In addition to designing and implementing a Motion Capture Algorithm (MCA), the design, fabrication and testing of the back-end hardware and electronics is also included.

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, Mr Gilbert Vassallo

FUNDING BODY: MCST FUSION R&I Technology Development Programme

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 was awarded funding under the FUSION R&I Technology Development Programme 2017, and 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 are 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 permits commands to be issued by the selection of icons on a suitably designed user interface. This project addressed 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.

A Graphical User Interface (GUI) was designed and implemented by the commercial partner, Seasus Ltd, to which the algorithmic engine connects. A set of trials were also carried out on the finalised GUI, following the design of a protocol, which enabled us to verify the results that we had obtained from an

initial set of trials, where we had identified a good compromise between the number of buttons to use and the attainable accuracy. The finalised GUI enables the user to choose between 15 different buttons.

On the 25th of January, a half-day event was held at Esplora, Bighi to showcase the project work and to mark the project closure.

EyeCon - Eye-based Control

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

RESEARCH SUPPORT OFFICER: Mr Matthew Mifsud

FUNDING BODY: MCST 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 as shown in Figure 6.2. 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 started in mid February 2020 and is planned to be completed by mid December 2022. The University of Malta took care of developing the necessary algorithms for point of gaze estimation with varying head pose. EOG was used for the measurement of eye movements while an electromagnetic 6 degrees of freedom system was used for the tracking of the user's head pose and position. The external partner has started re-writing these algorithms onto the EyeCon platform and will soon start to incorporate the recording of the eye and head pose measurements. Once this is completed, the platform will be tested on a number of subjects, replicating the tests that the team at UM have already carried out in the lab.

A sub-contractor has also been employed through the project to develop a customised EOG glasses including measurements from various electrodes as well as an orientation sensor to be able to measure the yaw, pitch and roll of the user's head while using the developed EOG-based human computer interface system.



Figure 6.2: Typing using an EOG-based interface.

MAProHand - Development of the mechanical and control framework for a minimal anthropomorphic prosthetic hand

MAIN INVESTIGATORS: Prof. Ing. Michael A. Saliba ³, Prof. Ing. Kenneth Camilleri, Dr Jesmond Attard ⁴

RESEARCH SUPPORT OFFICERS: Ms Yesenia Aquilina, Ms Rachel Cauchi

FUNDING BODY: MCST FUSION R&I Technology Development Programme

The project MAProHand is run by the Department of Mechanical Engineering. Building on previous work carried out at the University of Malta, the primary research objective of this work is to carry out a systematic exercise to seek a practical solution that optimizes the trade-off between simplicity, dexterity and usability of a prosthetic hand within a single device by extracting an acceptable and optimum dexterity out of the simplest possible architecture while maintaining high usability of the device. The Department's contribution to this project is mainly related to the extraction of surface electromyography (sEMG) signals from the forearm and to relate these to finger movement.

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

MAIN INVESTIGATORS: Prof. Kenneth P. Camilleri, Dr Tracey Camilleri, Prof. Giuseppe De Giovanni, Dr Fausto Caruana ⁵

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.

This work seeks to investigate the neural basis of grasping action in humans using spectral analysis and bandlimited ERP analysis of the motor system activity. Furthermore, this work intends to investigate single trial 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.

After the work carried out in 2018-2019 by Ms Giovanna Stella, an Erasmus+ M.Sc. student from the University of Catania, who had carried out signal preprocessing and a preliminary analysis of the stereo EEG signals provided for this project by our collaborators at the CNR Institute of Neuroscience, Parma, Italy, during this academic year, Ms Ella Miceli-Farrugia, a B.Eng. final year project student, investigated single trial classification of the open-close event. In this work, Ms Miceli-Farrugia investigated various signal feature extraction and selection methods which permitted the extraction of suitable features for plier movement classification and perform single-trial grasp classification.

Over the past year, Ms Miceli-Farrugia has been working as a casual Research Support Officer investigating the temporal correlation between the spectral band features and the plier motion.

³ Department of Mechanical Engineering

⁴ Department of Podiatry

⁵ University of Parma, Italy

Doc2Speech - Document binarization for text-to-speech applications

MAIN INVESTIGATORS: Dr Alexandra Bonnici, Dr Stefania Cristina

FUNDING BODY: MCST Research Excellence Program

Funding Amount: €50,000

RESEARCH SUPPORT OFFICERS: Mr Andre Tabone, Mr Luke Abela, Ms Erika Spiteri-Bailey

While text-to-speech tools exist, these often support the more common languages, used by millions of people rather than a few hundred. Moreover, many of these text-to-speech tools assume that the text is easily distinguishable from the page background. This is not necessarily the case, particularly in children's books where pictures and illustrations are often part of the background. In these cases, simple binarisation algorithms will fail to distinguish the text from the illustration and the text-to-speech algorithm fails to read such text correctly. This project aims to investigate techniques to eliminate this problem by increasing robust text extraction algorithm able to distinguish text from the illustrations. We also aim to continue developing our earlier work in the development of a text-to-speech algorithm for the Maltese language.

LuminEye - Robust Eye-Gaze Tracking Under Variable Illumination Conditions and Iris Occlusions

MAIN INVESTIGATORS: Dr Stefania Cristina, Prof. Kenneth P. Camilleri

FUNDING BODY: MCST Research Excellence Program

Funding Amount: €50,000

RESEARCH SUPPORT OFFICERS: Mr Nipun Sandamal

For many years, the process of estimating the eye-gaze exploited the use of the ocular shape or features around the eye region. With the emergence of deep neural networks and their application to eye-gaze tracking, most recent research work started focusing on using the image information in its entirety rather than relying on specific features alone, achieving promising results. Furthermore, technological advancements have spurred an interest in pervasive eye-gaze tracking, where the eye movements are tracked and analysed in daily life conditions.

Fuelled by an interest in pervasive eye-gaze tracking for assisting persons with limited mobility, years of research work have led us to develop a passive eye-gaze tracking platform that can estimate the eye-gaze by integrating information regarding the centre of the iris region and the head pose, into a model that compensates for appearance changes due to head rotation in estimating the eye pose. While we have achieved angular gaze errors comparable to the state-of-the-art when the iris was sufficiently visible, the Achilles' heel of the platform has remained the robust localisation of the iris centre coordinates under varying illumination conditions and iris occlusions.

In light of our challenges, this project aims to develop deep learning methods for robust iris centre localisation under varying illumination conditions and occlusions. Our primary application is human-computer interaction, whereby we aim to provide persons with physical impairments with an alternative modality to control a computer.

6.2 Internally Funded Projects

Less Constrained Eye-Gaze Tracking for More Natural User Interaction

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

FUNDING BODY: University of Malta Research Grant

FUNDING AMOUNT: €2,500

AWARDEE: Dr Ing. Stefania Cristina

Our long-standing work on eye-gaze tracking has focused mainly on human-computer interaction, where the user sits at a distance of 60-70cm from the camera (mounted on a monitor screen) and their point-of-regard is mapped onto the monitor screen following the estimation of gaze. More recent work has been exploring ideas to permit eye-gaze tracking in less constrained conditions, such as by extending the user-camera distance to a few metres, and to reduce the need for calibration before the user can interact. If successful, this can potentially extend the user's interaction space to one's 3D environment. This project aims to continue this ongoing work, by developing deep learning-based methods for less constrained eye-gaze tracking.

Control, Robotics and Automated Systems

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

RESEARCH STUDENTS: Various

FUNDING BODY: University of Malta Research Grants

FUNDING AMOUNT: €5,000

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

Projects in this area study various aspects of control systems engineering, robot control on different platforms, including mobile robots, and other automation systems. This year saw two projects focused on mobile robotics.

The first is a continuation final year project dealing with the design and development of a robotic training partner for track runners. The aim is to have the robot move along the running track (by following the lane lines) at user-specified speeds for given distances. This year's work primarily focused on the redesign of the line-following system, for which computer vision is now being used, modifications and upgrades to the speed control algorithms, and the integration and experimental evaluation of the final design on a running track (refer to Figure 6.3(a)).

The second project aimed to develop, implement, and test a realistic simulator of a robotic hot-wire cutter based on the IRB120 manipulator (refer to Figure 6.3(b)). The project studied a number of interesting and not-trivial challenges, including: forward and inverse kinematic modelling of the IRB120 robot, virtual modelling of the wire-cutter tool (end-effector), and realistic trajectory tracking experiments in ROS/Gazebo. This project is the result of a collaboration with I+A Ltd., a local design studio.

The third project focused on the design and development of a wireless remote-control system for a commercially available motorised wheelchair. The main challenge of this project was to come up with a design that can be integrated on the user's wheelchair with minimal hardware changes, minimal installation time (downtime for the user), and without comprising the wheelchairs safety. The final design uses an Arduino micro-controller that communicates with a remote-control via Bluetooth and routes the signals to the wheelchairs built-in motors' driver. This project was inspired by Mr Ronald Balzan.

Another project centred on the design and implementation of a miniature Stewart Platform together with its control system (Figure 6.3(c)). The Stewart Platform is a classical example of a parallel robotic manipulator. Its interesting kinematics yield all six degrees of freedom in 3D space (linear displacement along the three Cartesian axes plus roll, yaw and pitch rotations). It is used in applications ranging from

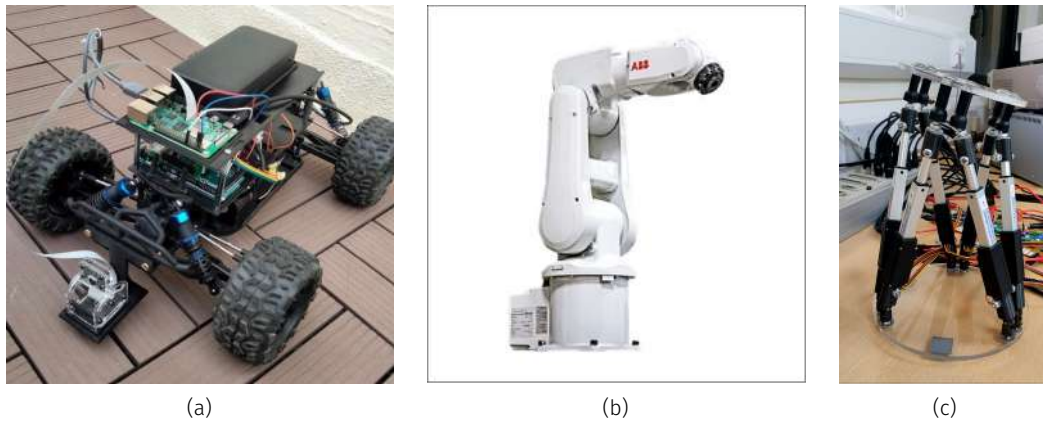


Figure 6.3: (a) The robotic pacer, (b) The IRB120 robot, (c) The miniature Stewart Platform

physical flight simulators for training or entertainment, CNC tools and telescope positioning systems. This project involved the complete design and implementation of a miniature Stewart Platform, starting from mechanical construction, all the way to developing the electronics and digital control systems to position the robot.

Intelligent Transportation Systems

MAIN INVESTIGATORS: Ing. Luana Chetcuti Zammit
 FUNDING BODY: University of Malta Research Grant
 FUNDING AMOUNT: €2,500
 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 optimise the flow of vehicles. This research work is directed towards the design of autonomous-based systems for signalised traffic junctions.

Intelligent Traffic Junctions

MAIN INVESTIGATORS: Dr Kenneth Scerri
 RESEARCH STUDENTS: Various
 FUNDING BODY: University of Malta Research Grants
 FUNDING AMOUNT: €2,500
 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.

Application of Computer Vision Algorithms for Music Analysis

MAIN INVESTIGATORS: Dr Alexandra Bonnici

FUNDING BODY: University of Malta Research Grant

FUNDING AMOUNT: €2,500

AWARDEE: Dr Alexandra Bonnici

Optical music recognition (OMR) is the musical equivalent to optical character recognition and deals with the extraction of musical information, in the form of pitch, rhythm, lyrics and other data from the musical document. Traditionally, OMR is carried out through hand-crafted features, designed specifically to extract some artefact from the musical document. This could include techniques such as run-lengths, wavelets, the Hough transform for identification and removal of staff-lines, template matching or morphological operations for the identification of musical symbols and more. One common aspect with these methods is that they often rely on some heuristics which, while tuned to achieve good results with one specific style of document, are not easily re-tuned to provide good results on other styles. In more recent years, researchers have turned to artificial intelligence, using neural networks and their many variants to perform the various tasks of the OMR. These may range from using classification techniques to separate the musical score into various layers hence performing the image pre-processing step of the OMR pipeline; to borrowing of the object detection methods to perform symbol recognition, bypassing the document pre-processing step. The advantage of artificial neural networks, and their variants is that, to change from one style of musical document to another does not require manually changing some heuristic rules, but rather, can be achieved by retraining the network. Such retraining can often be carried out with smaller datasets given some pre-trained networks. Artificial neural-network methods are not without their problems. Specific to optical musical recognition is the fact that musical symbols are typically small in comparison to the musical document. Moreover, the document page is often densely packed with many symbols which are also highly connected and overlapping providing a challenge to existing object detection methods.

This research work investigates the state of the art in artificial intelligence approaches applied for optical music recognition, performing a comparative study of some of these algorithms to determine the research problems that remain. Since neural network-based approaches rely on the existence of adequately labelled datasets, the paper will also provide an overview of existing datasets discussing their merits, scope and utility.

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: €2,500

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. Matthew Mifsud. In different ways, all three students are working on improving the practicality of the different 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 EOG (electrooculography) based point of gaze estimation with varying headpose, while Mr. Mifsud is exploring the use of hidden Markov models for

eye-swipe typing . Nathaniel has submitted his dissertation in May 2022, Rosanne has submitted her dissertation in September 2022 and Matthew has submitted his dissertation in May 2022.

Vision-based eye-gaze tracking: System development and deep net gaze estimation (EGT-SD)

MAIN INVESTIGATORS: Prof. Kenneth P. Camilleri, Dr Stefania Cristina

FUNDING BODY: University of Malta Research Grants

Funding Amount: €2,500

AWARDEES: Prof. Kenneth P. Camilleri

Our ongoing work on vision-based eye-gaze tracking is based on classical computer vision with hand-crafted feature extraction, geometric modelling and point-of-gaze mapping. Through FUSION projects and industrial collaboration, we have developed a server-based software for eye-gaze tracking. Deep neural networks have recently been applied to eye-gaze tracking tasks, namely, iris segmentation, pupil centre localisation, head pose and gaze estimation, and point-of-regard estimation. Through this project we continue to develop the server-based system, investigate state of the art of deep network eye-gaze tracking, and integrate our existing algorithmic architecture with state of the art deep network eye-gaze tracking architectures.

6.3 Non-funded PhD 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 maximises 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. At the moment, this research is focusing on coverage control performed by a multi-robot system when constraints are present in the system itself and in the environment. Such constraints include having a time-varying environment, where certain important regions in the environment are varying with time, battery level limitations, since the energy of the robots is not unlimited, and also constraints posed by the sensory capabilities of the robots. All these together make up an optimization problem solved through gradient-descent techniques, among others.

EOG-Based Gaze Angle Estimation With Varying Head Pose

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

RESEARCH STUDENT: Mr Nathaniel Barbara

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 research focuses on the development of a robust EOG-based point of gaze estimation platform which also takes into consideration varying head pose and position conditions, providing a practical human-computer interface that allows one to freely perform natural head movements. This doctoral research program started in June 2018 and the student sat for his viva examination in May 2022.

Towards SSVEP-Based BCI Applications for Real-World Environments

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

RESEARCH STUDENT: Ing Rosanne Zerafa

Brain-computer interfaces (BCIs) provide direct communication and control of applications through brain signals. This work focuses on non-invasive BCIs that use electroencephalography (EEG) to record brain signals and are based on the neural response known as steady-state visually evoked potentials (SSVEPs). SSVEPs are electrical potentials evoked in response to a repetitive visual stimulus flickering at a specific frequency.

In the past few decades SSVEP-based BCIs have improved significantly but there are still several challenges that limit their use in real-world environments. This work investigates and proposes innovative solutions to address these challenges including: i) the proposal of a benchmark to evaluate the signal quality of EEG acquisition devices for SSVEP-based BCIs, ii) the proposal of a double blink mechanism as a solution to address the annoyance of the flickering stimuli and to reduce the execution of unwanted BCI actions, iii) an investigation on the performance of SSVEP-based BCIs in an uncontrolled environment, iv) an investigation of the demanding training requirements to use such systems, v) and the proposal of a switch-and-train (SAT) framework as a novel SSVEP detection method to reduce this training time. This work also investigates the use of a novel probabilistic autoregressive modelling framework and its extension to an autoregressive switching multiple model (AR-SMM) framework for the detection of SSVEPs in BCI applications. The benefit of the proposed approaches for this type of application, as opposed to the standard feature extraction and classification techniques used in SSVEP-based BCIs, is that minimal training data is required, a minimum of two electrodes are necessary, a probabilistic decision for classification is provided which can be used as a measure of certainty in the decision making process, and the ability to discriminate between rest and control states. Furthermore, the AR-SMM framework provides classification on a sample-by-sample basis that is shown to lead to a faster detection of SSVEPs, shorter flickering time and improved BCI information transfer rate.

6.4 Projects with Department Members as Collaborators

JUSTNature - Activation of NATURE-based solutions for a JUST low carbon transition

MAIN LOCAL INVESTIGATORS: Dr. Edward Duca⁶, Dr Kenneth Scerri and Dr Daniel Micallef⁷

FUNDING BODY: EU H2020 LC-CLA-11-2020

AWARDEE: Dr. Kenneth Scerri

⁶ Centre for Entrepreneurship and Business Incubation

⁷ Faculty for the Built Environment

Cities are major energy consumers and significantly contribute to greenhouse gas (GHG) emissions. They have a high density of socio-economic activities and a built environment design that enhance these issues. In this regard, especially developed cities can be exemplars in leading the way towards a low-carbon society, and turning it into an opportunity as recently iterated by the European Green Deal. Such advances can address several other challenges arising from urbanisation and structural socio-economic changes. Cities represent a complex setting, where low income populations are more exposed to environmental ills, environmental and climate impacts are not distributed evenly, environmental qualities are becoming increasingly exclusive to high-income households, and wealthier neighbourhoods are more biologically diverse than others. In this regard, the overall objective of JUST-Nature is the activation of nature-based solutions (NbS) by ensuring a just transition to low-carbon cities, based on the principle of the right to ecological space. This in particular refers to the right to clean air and indoor/outdoor thermal comfort for human health and well-being, as well as thriving biodiversity and ecosystems. It also refers to the duty of not constraining the ecological space of others, in particular in relation to the mitigation of climate change and measures required for reducing GHG emissions. JUSTNature will contribute to this vision of shaping low-carbon cities by developing a set of typical Low carbon | High air quality NbS in seven European city practice labs. By activating their just implementation, it will drive the co-design, co-creation and co-decision of supporting interventions with regard to four innovation dimensions: 1) enabling effective governance, 2) enabling NbS system maintenance and operation, 3) enabling innovative business models and market design, and 4) enabling efficient technologies and applications.

Varcities - A vision for human-centred future cities

MAIN LOCAL INVESTIGATORS: Dr Daniel Micallef⁸, Dr. Edward Duca⁹ and Dr Kenneth Scerri

FUNDING BODY: EU H2020 SC5-14-2019

AWARDEE: Dr. Kenneth Scerri

In an increasingly urbanised world, governments are focusing on boosting cities' productivity and improving citizens' living conditions and quality of life. Despite efforts to transform the challenges facing cities into opportunities, problems such as overburdened social services and health facilities, air pollution and exacerbated heat create a bleak outlook. With these challenges in mind, the EU-funded VARCITIES project aims to create a vision for future cities with the citizen and the so-called human community at the centre. It will therefore implement innovative ideas and add value by creating sustainable models for improving the health and well-being of citizens facing diverse climatic conditions and challenges around Europe. This will be achieved through shared public spaces that make cities liveable and welcoming.

Fault Tolerant Attitude Control of a Pico Satellite

MAIN INVESTIGATORS: Prof. Ing. Simon G. Fabri, Dr Ing. Marvin K. Bugeja, Dr Ing. Marc Anthony Azzopardi¹⁰

RESEARCH STUDENT: Mr Darren Debattista¹⁰

This project is part of the Faculty-wide Astrea collaborative project led by the Department of Electronic Systems Engineering, aimed at launching a pico-satellite designed and developed at the University of Malta (refer to Figure fig:sat). Previous works have developed 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. In the past months, this subproject has shifted focus on the design and implementation of active fault tolerant attitude control. Initial

⁸ Faculty for the Built Environment

⁹ Centre for Entrepreneurship and Business

¹⁰ Department of Electronic Systems Engineering

works include: a literature review in a number of relevant areas including Fault Detection and Isolation (FDI) and Fault Tolerant Control (FTC); evaluation of sensors, actuators and power drive solutions; Initial Failure Mode and Effect Analysis (FMEA) of actuators; and a rigorous simulation study of real-time parameter estimation algorithms for FTC. During the past year this work started to shift focus on the use of dual-adaptive control to develop fault-tolerant schemes. The first results indicate that this idea can yield an interesting and novel contribution to satellite control.

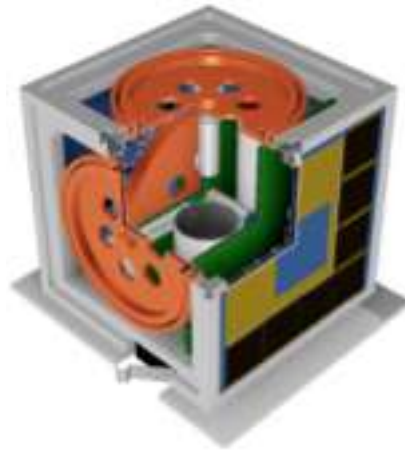


Figure 6.4: Cutaway drawing of the UoMSat-1 pico-satellite

DeepFIR - Restore Very Low-Resolution Facial Images

MAIN INVESTIGATORS: Dr Reuben A. Farrugia ¹¹, Prof. Ing. Kenneth Camilleri, Prof. John M. Abela ¹²

RESEARCH SUPPORT OFFICERS: Dr Christian P. Galea ¹¹, Mr Matthew Aquilina ¹¹

FUNDING BODY: MCST FUSION R&I Technology Development Programme

The Deep-FIR project is run by the Department of Communications and Computer Engineering of the Faculty of ICT. The project aims to design and implement a face image restoration algorithm that is able to restore very low-resolution facial images captured by CCTV systems with unconstrained pose and orientation. The user will be able to restore the whole head, including the hair region, which is important for person identification, while minimising the manual work of the operator. Apart from improving the quality of the restored facial images, this project intends to reduce the complexity and therefore the time needed to enhance an image or video frame. The developed algorithm will be tested on real-world CCTV videos and compared against existing video forensic tools used by forensic experts in their labs.

Sit_Diab - Smart Insole Technology for the Salvage of the Diabetic Foot

MAIN INVESTIGATORS: Prof. Alfred Gatt ¹³, Prof. Cynthia Formosa ¹³ and Dr. Ing. Marvin Bugeja

FUNDING BODY: MCST FUSION R&I Technology Development Programme

This project aims to develop and validate a device in an attempt to reduce the incidence of diabetic foot complications. The technology being developed assesses the patient's risk of getting a diabetic ulcer by monitoring foot plantar pressure and temperature during walking. The technology uses Artificial Intelligence to process the pressure and temperature signals to determine areas which have a high risk of ulceration during daily activities. The proposed solution is envisaged to eventually replace traditional offloading techniques, which have been shown to be ineffective in reducing amputation rates in practice.

¹¹ Department of Communications and Computer Engineering

¹² Department of Computer Information Systems

¹³ Department of Podiatry



7. New Facilities

The Department makes efforts to acquire new equipment to support its research activities. This equipment was funded through University's Capital Funds, Department funds, as well as individual Research funds. A list of new equipment obtained during this academic year is listed hereunder.

NAO6 Humanoid Robot The NAO6 Humanoid Robot is the latest addition to the growing collection of robotic systems in the Systems and Control Laboratory. This humanoid robot is able to interact with humans through speech and vision, and may be programmed to perform specific tasks. This was purchased as part of the TRAKE project.

Quanser 6 DOF Robotic Arm The Quanser 6 DOF robotic arm is a versatile and light-weight robotic manipulator with a two-fingered gripper. Through its RS-485 interface, its joints may be controlled and programmed to perform a number of tasks through its open architecture framework. This was purchased as part of the TRAKE project.

3D LiDAR The RS-LiDAR-16 has 16 laser/detector pairs which makes it ideal to rapidly spin and send out high-frequency laser pulses in order to scan the environment and collect 3D point clouds. Such a sensor is able to provide reliable data for localization, navigation and obstacle avoidance, among other applications. This was purchased as part of the TRAKE project.

Augmented Reality Headset A Microsoft HoloLens2 was acquired through the TRAKE ERDF funding. This headset provides the ability for the user to visualise 2D and 3D virtual objects superimposed on the real-world, thus enabling interactions with virtual objects within an augmented reality space. This was purchased as part of the TRAKE project.

Refurbishment of laboratory computers A number of high performance computers were purchased to replace the existing laboratory computers. Upgrades to a number of existing software were also purchased in order to be compatible with Windows 10.



8. Public Outreach

8.1 Launch of the Systems and Control Blog Webpage

On the 8th of February 2022, the Blog Webpage systemsandcontrol.com was launched. The aim of this blog is to reach an audience of various levels of expertise not just with our research, but also with areas of interest in the academic and technological field. The first blog was posted on the International Day of Women and Girls in Science, on the 8th of February 2022.

8.2 STEM outreach in schools

Dr Bonnici was invited to deliver a number of talks, as part of a STEM outreach programme, to various students in different primary and secondary schools. These include a talk to St Monica School (Gzira) delivered on the 11th of November 2021, and to St Monica School (Birkirkara) delivered on the 6th of May 2022.

8.2.1 St Ignatius Middle School, Qormi

On Thursday 4th February 2022, Dr Alexandra Bonnici together with Dr Brian Zammit and students from UESA delivered a workshop on mobile phones and their operation to students attending the St Ignatius Middle School in Qormi. The workshop that was prepared by Dr Bonnici, demonstrates the inner workings of the mobile phones as well as provides a brief history of the evolution of telephone communication using interactive games.

8.2.2 St Nicholas Middle School Rabat

On Wednesday 23rd March 2022 was again delivered to students attending the St Nicholas Middle School in Rabat. This time, Dr Alexandra Bonnici was accompanied by Prof. Adam Jagiello Rusilowski who presented the students with a game which tested out the students' focus, teamwork and communication skills.

Prof. Adam Jagiello Rusilowski is a member of the University of Gdansk in Poland where he specializes in educational changes and use of creativity in education. He participated in this workshop as part of the Erasmus+ Training Mobility. After the workshop, Alexandra and Adam exchanged ideas on how to enable and empower young students to learn and to discover knowledge through practical experiences.

8.2.3 STEM Stories for primary schools

As part of the Department's commitment to outreach activities, Dr Alexandra Bonnici participated in the Explora Storytelling activity for school children. During this activity, Alexandra read the book "How Machines Work - Zoo Break!" by David Macaulay. This book tells the story of two zoo animals, Sloth and Sengi, as they make attempts to break out of their enclosure by building different simple machines.



Figure 8.1: Visit to St Nicholas School Rabat

It explains the use of gears, levers, screws, pulleys and touches on the principle of moments. The book was read to a group of 35 students from the Mellieha primary school and the San Lawrenz (Gozo) primary school, on the 19th January 2022, and to 33 students from the Lija, San Gwann and Balzan primary schools on the 28th January 2022.

8.3 Julian's Pathfinder Foundation Programme

The Department participated in the Julian's Tech Start-up Challenge 2022 - Bionic Inventions organised by the Julian's Pathfinder Foundation. On Tuesday 13th September Dr Alexandra Bonnici delivered a talk to the students, explaining the use of computer vision in biomedical applications, on Wednesday 14th September Prof Simon Fabri, Dr Marvin Bugeja and Dr Natasha Padfield with the assistance of Ing. Jean Gauci and Mr Noel Agius demonstrated different uses of robots, an intelligent wheelchair, the VICON system and the g.Tec EEG system to the students. Prof Simon Fabri was also acting as a member on the panel of experts that provided feedback to the students during the presentations of their ideas and inventions.

8.4 Funded Projects Engagement Events

8.4.1 RIDE + SAFE Public Engagement Event

On the 7th April 2022, the project RiDE+SAFE was presented during a Public Engagement Event held at Esplora. Hon. Clifton Grima, Minister for Education, Sport, Youth, Research and Innovation, Hon. Keith Azzopardi Tanti, Parliamentary Secretary for Youth, Research and Innovation and Dr Jeffrey Pullicino Orlando, Executive Chairman for the Malta Council for Science and Technology delivered speeches during this event. A presentation was delivered by Prof. Ing. Simon Fabri.

8.4.2 WildEYE Public Engagement Event

On the 25th January 2022, the project WildEYE was presented during a Public Engagement Event held at Esplora. Presentations were given by Dr Ing. Stefania Cristina and Prof. Ing. Kenneth Camilleri.

8.4.3 BrainApp Public Engagement Event

On the 7th October 2021, the project BrainApp was presented during a Public Engagement Event held at Esplora. Presentations were given by Dr Tracey Camilleri and Prof Kenneth Camilleri. This also led to

Dr Camilleri being invited on TVAM to discuss the outcomes of the project as well as press releases on Newspoint, and various other social media such as TVM and ONE news portals.

8.5 Participation in National Events

Department members also participated in national events and science-related festivals that took place during the academic year as described hereunder.

8.5.1 Science in the City 2022

On Friday 30th September 2022, Dr Alexandra Bonnici exhibited an AR application, Dr Ing. Marvin Bugeja exhibited the smart wheelchair, Dr Tracey Camilleri, Mr Nathaniel Barbara and Mr Matthew Mifsud exhibited the EyeCon project, showing the public how to type using their eyes, and Dr Stefania Cristina and Dr Peter Varley exhibited an eye-based public display project, during Science in the City 2022.

8.5.2 Participation in the Esperimenta Tikka Xjenza Event

Yann Kerdoncuff and Sylvain Madre, under the supervision of Dr Luana Chetcuti Zammit, participated in the Esperimenta Tikka Xjenza, held on Saturday 23rd July. During this event the transportation demo was presented to the general public. The transport demo, which is available online, is an interactive GUI. This allows the user to select the start and end points of the journey on the map. The user can also input the time of the journey together with the type of vehicle. The system calculates the average time to complete the journey and the pollution emissions generated by the vehicle.



9. Prizes, Awards and Appointments

9.1 Funding awards

- In June 2022, Dr Alexandra Bonnici and Dr Stefania Cristina were awarded the MCST REP award for the project Doc2Speech: Document binarisation for text-to-speech applications.
- In June 2022, Dr Stefania Cristina and Prof. Kenneth P. Camilleri were awarded the MCST REP award for the project LuminEye: Robust Eye-Gaze Tracking Under Variable Illumination Conditions and Iris Occlusions.
- In August 2022, Dr Tracey Camilleri and Prof. Kenneth P. Camilleri were awarded the MCST FUSION Smart Cities award for the project SmartGaze: Control of devices using EOG-based eye gaze tracking for a smart home environment.

9.2 Staff appointments

- In August 2022, Ing. Jean Gauci was appointed as Systems Engineer with the Department of Systems and Control Engineering.



10. Contact Us

For further information, we invite you to visit:

- our **Facebook** page: www.facebook.com/um.scedepartment/
- our **University webpage**: www.um.edu.mt/eng/sce
- our **Blog page**: www.systemsandcontrol.com/

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

- on our **e-mail** address: sce.eng@um.edu.mt
- on **Messenger**: m.me/um.scedepartment
- Secretarial Office - Ms. Sanchia Cilia Lentini: 2340 3385.