L-Università ta' Malta
Faculty of Engineering

Department of Systems
& Control Engineering

Annual Report
2020 - 2021

Image on title page shows the Vicon Motion Capture System installed in the Biomedical Engineering Laboratory

Contents

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	2
Research Support Officer II	2
Research Support Officer I	3

Research Projects   23

Research Funds Disbursed During 2020/21

International Funds	€103,289
National Funds	€145,987
Internal Funds	€16,000

Students

Supervision/Co-supervision of B.Eng. Final Year Students	8
Supervision/Co-supervision of M.Sc. by Research Students	10
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)
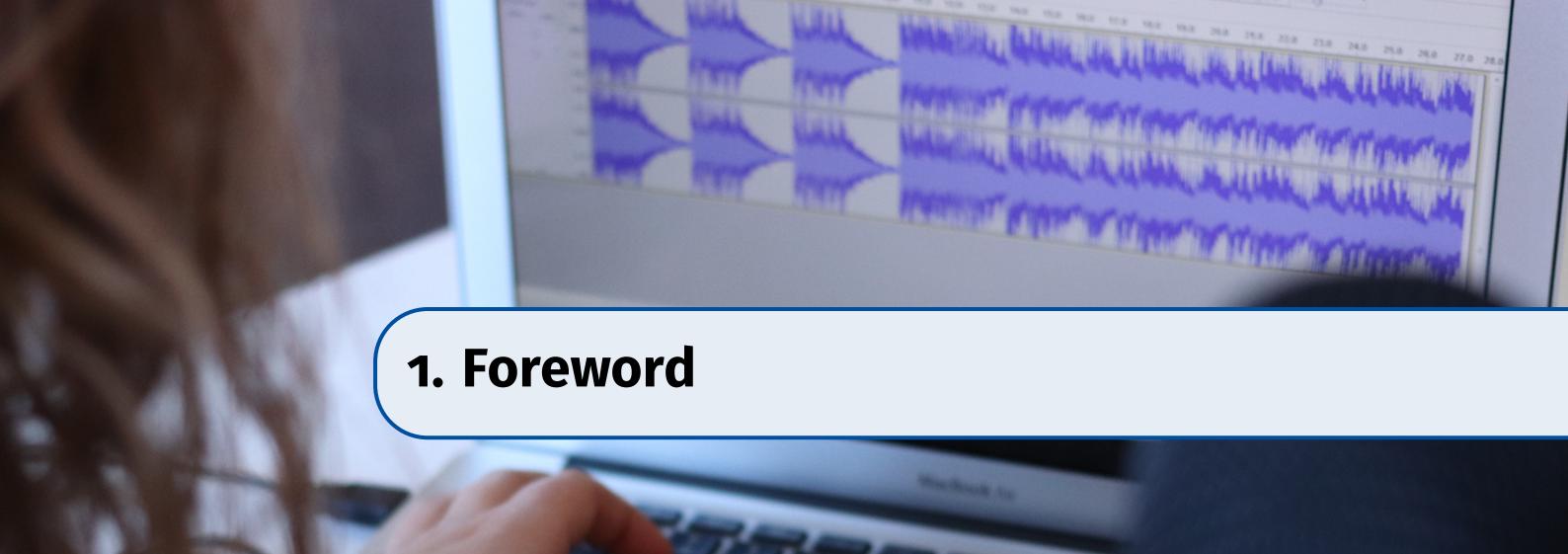
1. Foreword

It is with great honour that I am writing this forward, my first since taking over the headship of the department. I am thankful that I found a team of people patient enough to bear with my mistakes as I get to grips of this new role. I am equally thankful for the encouragement and mentorship I received, particularly from Kenneth Camilleri without whose guidance, many more mistakes would have been made.

Despite the Covid-fatigue that we all felt at some point or other during the last two years, the Department has continued to strive and through the collective efforts of all its individuals had a successful year. This can be seen in the students' reception to the study units and projects offered by the department, the recruitment of new postgraduate students, the research projects and publications achieved by the Department members. Our staff members have been recognised for their contributions to engineering on a national level as well as an international level by societies such as the Association of Computing Machinery and the Institute of Electrical and Electronics Engineers. Moreover, Prof. Simon Fabri has been selected to serve as pro-Rector for Research and Knowledge Transfer.

The Department research funding exceeds a quarter of a million. Such funding allows for the purchasing of equipment to support innovative research and research collaborations in all areas of interest of the Department: control and automation, robotics, transport, biomedical signal processing and computer vision. This funding also supports the employment of researchers in these fields, further increasing the opportunities for young researchers.

The Department has also honoured its societal obligations participating in educational and outreach activities even within the social limitations of the current pandemic, reverting to online activities when in-person activities were not possible.

All of this would not have been possible without the hard work and competence of all academic, administrative and technical staff. For this, I am grateful that we have a good team which, notwithstanding our individuality, supports each other in our endeavours, recognising that it is through working together that we each may excel.

Thank you and let's have another successful year ahead.

Dr Alexandra Bonnici
Head of Department
30th October 2021
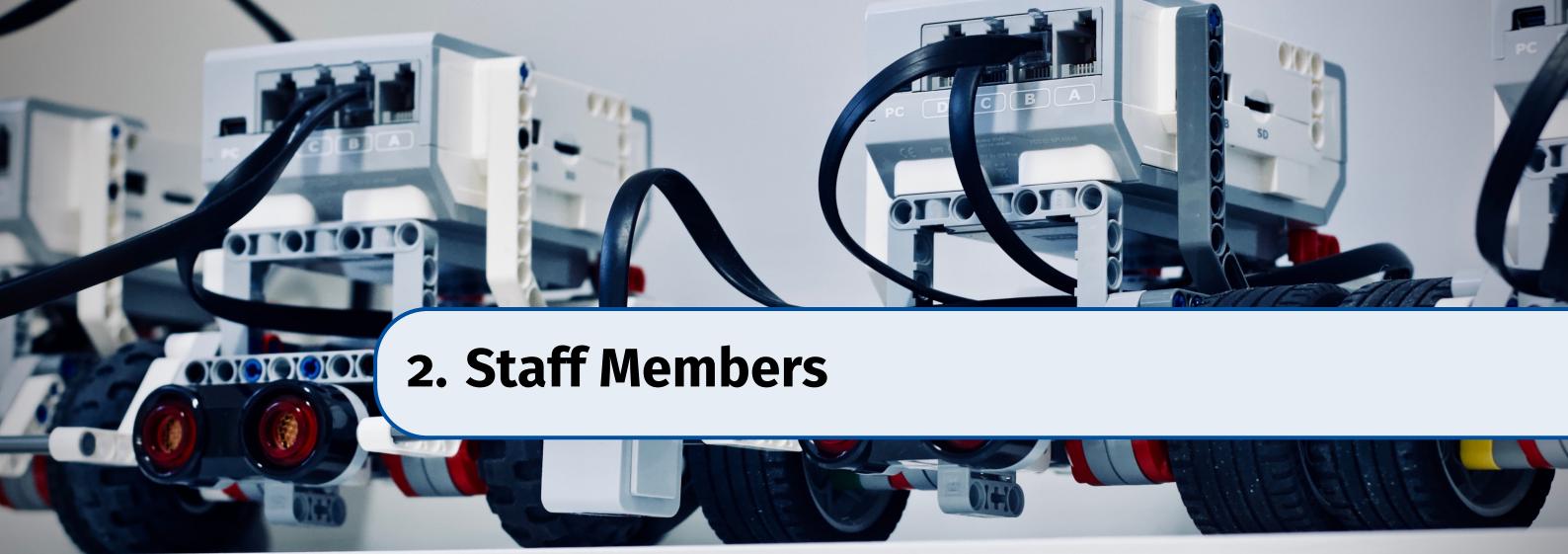
2. Staff Members

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.*
Dr Mark Borg, *B.Sc.(Melit.), M.Sc.(Reading), Ph.D.(Melit.), (until June 2021)*

Research Support Officer II

Ing. Rosanne Zerafa, *B.Eng. (Hons.) (Melit.), M.Sc.(Eng.), (until November 2020)*
Mr Daniel Bonanno, *B.Sc in ICT (Hons.) (Melit.), M.Sc. ICT (Melit.)*

Research Support Officer I

Mr Andre Tabone, *B.Eng. (Hons.) (Melit.), (until June 2021)*
Mr Matthew Mifsud, *B.Eng. (Hons.) (Melit.)*
Mr Gilbert Vassallo *B.Eng. (Hons.) (Melit.), (part-time)*

Systems Engineers

Ing. Lucianne Gauci, *B.Eng. (Hons.) (Melit.), M.Sc.(Eng.), (until February 2021)*
Ing. Rachael Duca, *B.Eng. (Hons.) (Melit.), M.Sc.(Eng.), MIEEE*
Mr Nathaniel Barbara, *B.Eng. (Hons.) (Melit.), M.Sc.(Eng.), (since June 2021)*

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
    - Board of the Institute for Climate Change and Sustainable Development
    - Quality Assurance Committee
    - 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
- Coordinator of the M.Sc. course on Signals, Systems and Control
- Member of the Malta Government Engineering Profession Board
- Member of the Executive Board of the Mediterranean Control Association
- Appointed as the University's 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

- Representative on the general assembly of the European Control Association (EUCA)
- 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
- Faculty of Engineering IT affairs committee

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
- 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
- Chairs 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 establishment of the Intelligent Transportation Research Laboratory at the Faculty of Engineering

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.

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
- Project coordinator for the Horizon 2020 project "4NSEEK"
- 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 "DeepMotionBCI"
    - TRAKE project "BrainCon"
- Co-investigator for the MCST National R&I FUSION-TDP funded projects
    - R&I-2015-032-T "BrainApp"
    - R&I-2015-048-T "FIHI"
    - R&I-2017-002-T "Deep-FIR"
    - R&I-2017-028-T "MAProHand"
    - R&I-2018-012-T "EyeCon"
    - R&I-2018-004-T "NIVS"
- Co-investigator for the TRAKE projects
    - "CAMVISM"
    - "EyeDesign"
- 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 2021)
  - – ACM Symposium on Document Engineering (DocEng2021)
  - – Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC 2021)
  - – International Conference on Informatics in Control, Automation and Robotics (ICINCO 2021)
- Guest Editor in the Research Topic "Music and AI" in the journal Frontiers in Artificial Intelligence, Machine Learning and Artificial Intelligence section

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:

- Member on the Editorial Board of the International Journal on Advances in Intelligent Systems
- Associate Editor of the International Journal of Systems Science published by Taylor and Francis
- 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 journal submissions, including, among others, the
  - – International Journal on Advances in Intelligent Systems
  - – International Journal of Control
  - – IEEE Transactions on Neural Networks and Learning Systems
  - – IEEE Transactions on Aerospace & Electronic Systems
- Review committee member or associate editor for several international conferences

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 Insole 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 Xjenza, 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 Serires in Document Engineering
- Topic editor for the research topic "Music and AI" for the journal Frontiers in Artificial Intelligence
- Co-investigator on the "4NSEEK" project co-financed through the H2020 ISFP-2017-AG-CYBER call
- Program Chair of the 21st International Symposium on Document Engineering

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 of the TRAKE "EyeDesign" project
- Part of the project management team of the National R&I Fund Award R&I-2016-010T "WildEye"
- Co-investigator of the "4NSEEK" project co-financed through the H2020 ISFP-2017-AG-CYBER call
- 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

4.2 Student Projects and Supervision

4.2.1 B.Eng. (Hons) Students

PROJECT TITLE: Deep Sketching: Vectorization of Sketched Drawings using Deep Learning
STUDENT: Nicole Bonnici
SUPERVISOR: Dr Alexandra Bonnici

PROJECT TITLE: Hand Gesture Recognition for an Augmented Reality Sandbox
STUDENT: Karl Miggiani
SUPERVISOR: Dr Alexandra Bonnici

PROJECT TITLE: Head Pose Estimation Using Deep Learning
STUDENT: Jason Schembri
SUPERVISOR: Dr Ing. Stefania Cristina

PROJECT TITLE: Maltese Text Recognition Tool for those with Disability to Access Text
STUDENT: Emma Fenech
SUPERVISOR: Dr Alexandra Bonnici
CO-SUPERVISOR: Dr Ing. Stefania Cristina

PROJECT TITLE: A Robotic Training Partner for Track Runners
STUDENT: Christian von Brockdorff
SUPERVISOR: Dr Ing. Marvin Bugeja

PROJECT TITLE: Control of Connected and Autonomous Vehicles (CAVs)
STUDENT: Shawn Darmanin
SUPERVISOR: Dr Kenneth Scerri

PROJECT TITLE: Multi-Robot Coverage Control
STUDENT: Luke Scicluna
SUPERVISOR: Dr Ing. Marvin Bugeja

PROJECT TITLE: Iris Segmentation and Centre Localisation using Deep Learning
STUDENT: Emily De Munck
SUPERVISOR: Dr Ing. Stefania Cristina
CO-SUPERVISOR: Prof. Ing. Kenneth Camilleri

4.2.2 M.Sc. by Research Students

PROJECT TITLE: Development of the Control Framework for a Minimal Anthropomorphic Prosthetic Hand
STUDENT: Ms Rachel Cauchi
SUPERVISOR: Prof. Ing. Kenneth P. Camilleri
CO-SUPERVISOR: Prof. Ing. Michael A. Saliba [1]

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: Anomaly Detection on Smart Meter Data
STUDENT: Mr Michael Farrugia
SUPERVISOR: Dr Kenneth Scerri
CO-SUPERVISOR: Dr Andrew Sammut [2]

PROJECT TITLE: Design and Implementation of the Control System for a Physical Motorcycle Simulator
STUDENT: Mr. Daniel Cassar
SUPERVISOR: Prof. Ing. Simon Fabri

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[1]Department of Industrial and Manufacturing Engineering
[2]Department of Electronic Systems Engineering

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 [3]

PROJECT TITLE: Stability and Optimisation of a High Dynamic Motor Starter Prototype's Current Control Algorithm
STUDENT: Mr Daniel Lendi [4]
SUPERVISOR: Dr. Reiko Raute [4]
CO-SUPERVISOR: Prof. Ing. Simon Fabri

PROJECT TITLE: Identification of Pigments Using Multispectral Image Analysis
STUDENT: Mr Nathan Magro
SUPERVISOR: Dr Alexandra Bonnici
CO-SUPERVISOR: Dr Ing. Stefania Cristina

PROJECT TITLE: Detection of Sexually Explicit Content in Images Using Deep Learning
STUDENT: Mr Andre Tabone
SUPERVISOR: Dr Alexandra Bonnici
CO-SUPERVISOR: Dr Ing. Stefania Cristina

PROJECT TITLE: Hand Pose Estimation using Deep Learning
STUDENT: Ms Michaela Spiteri
SUPERVISOR: Dr Ing. Stefania Cristina

PROJECT TITLE: Pedestrian Detection and Pose Estimation for Intention Recognition in Autonomous Vehicles
STUDENT: Mr Gilbert Vassallo
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 [5]
SUPERVISOR: Prof. Cristiana Sebu [5]
CO-SUPERVISOR: Prof. Ing. Kenneth Camilleri

PROJECT TITLE: Switching Multiple Models for SSVEP-Based Brain-Computer Interfaces
STUDENT: Ing. Rosanne Zerafa
SUPERVISOR: Dr Tracey Camilleri
CO-SUPERVISORS: Prof. Ing. Kenneth Camilleri

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[3]Department of Microelectronics and Nanoelectronics
[4]Department of Industrial and Electrical Power Conversion
[5]Department of Mathematics

PROJECT TITLE: Gaze Angle Estimation using a Dense Multi-Channel EOG Electrode Configuration with Varying Head Pose Compensation
STUDENT: Mr Nathaniel Barbara
SUPERVISOR: Dr Tracey Camilleri
CO-SUPERVISOR: Prof. Ing. Kenneth Camilleri

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: Mr Jean Gauci [6]
SUPERVISOR: Dr Owen Falzon [6]
CO-SUPERVISOR: Prof. Ing. Kenneth Camilleri

PROJECT TITLE: An Enhanced Wearable System for Kinematic and Kinetic Gait Analysis
STUDENT: Mr Nikiforos Okkalidis [6]
SUPERVISOR: Dr Owen Falzon [6]
CO-SUPERVISORS: Dr Ing. Marvin Bugeja, Dr Alfred Gatt [7]
ADVISOR: Prof. Ing. Kenneth P. Camilleri

PROJECT TITLE: Towards More Compact Chip to Chip Communication Methods
STUDENT: Mr Andre Micallef [8]
SUPERVISOR: Dr. Ing. Marc Anthony Azzopardi [8]
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 [8]
SUPERVISOR: Dr Ing. Marc A. Azzopardi [8]
CO-SUPERVISOR: Dr Ing. Marvin Bugeja
CO-SUPERVISOR: Prof. Ing. Simon G. Fabri

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)
- 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)

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[6]Centre for Biomedical Cybernetics
[7]Department of Podiatry, Facuty of Health Sciences, University of Malta
[8]Department of Electronic Systems Engineering

- M.Sc. in Artificial Intelligence (Faculty of ICT)

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	6
SCE5103	Continuous-time Control Systems	5
SCE5104	Discrete-time Control Systems	5
SCE5105	Advanced Signal Processing	5
SCE5106	Research Methods for Systems and Control Engineering	4
SCE5201	Machine Learning and Pattern Recognition	10
SCE5202	Nonlinear Systems and Control	5
SCE5203	System Optimisation and Control	4
SCE5204	Adaptive and Intelligent Control	5
SCE5205	Computer Vision	5
SCE5301	Research Project in Systems and Control Engineering	30
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 Virtual Final Year Project Presentations

On the 5th of July, the Department organised a virtual exhibition celebrating the achievements of the seven final year students who carried out their final year projects under the supervision of the Department academics. The evening was chaired by Dr Tracey Camilleri. Dr Alexandra addressed the group, praising the students for their work and providing some advice and encouragement for their future. Ms Emma Fenech then addressed the group, providing the student perspective of the four years spent following the course. The students were then given the opportunity to present their work to families and friends. This was followed by a free and leisurely chat with students, friends and colleagues.

4.4.2 Engineering Students Summer Training Course

Between the 5th of July and the 19th August 2021, Ing. Rachael Duca and Mr Noel Agius delivered a four-day summer training course as part of Faculty's summer training program for the Electrical and Mechancial Engineering degree students. Due to the Covid-19 pandemic, this training program was followed by students in their second-year of studies, with the training being repeated over a seven-week period to accomodate all students.

Training in Robotics

Ing. Rachael Duca provided the students with an introduction to robotics, going briefly into the main components of a ground mobile robot, general robotics concepts and sensors. Furthermore some

programming concepts were also explained in the context of programming a robot. The students then had substantial hands-on programming experience where they programmed the newly-purchased VEX Robot kits to perform a variety of tasks. Mainly the tasks involved presetting a navigational path, picking and carrying objects and also making use of the vision sensor to perform obstacle avoidance and picking objects of specific colour.

Training in Servomotors and PLCs

Mr Noel Agius started the training by giving the students a brief description on laboratory workbench equipment, using this equipment to generate a pulse-width modulation signal which was used to drive a servomotor at different angles by changing the PWM ratio. Students were then shown the function of a contactor incorporating a set of contacts and a hold-coil; an auxiliary contact block; an emergency stop switch; a start/stop switch, double-pole single-throw (DPST) switch; miniature circuit breaker (MCB); residual current device (RCD); thermal overload relay; and mechanical and electrical interlocks; indicating the voltage rating, and current rating of each device.

Students were then shown the working principle of a direct-on-line (DOL) starter and how to read an electrical schematic diagram, using a schematic diagram to wire a direct-on-line (DOL) starter to supply a DC motor. A demonstration on how to operate a DOL starter from a programmable logic controller (PLC) using a ladder diagram (LD) was also given. Finally, the students utilised the schematic diagram to wire an automatic changeover switch.

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. Five students successfully completed this Certificate programme during the 2020/21 academic year and these are now enrolled in the undergraduate courses offered by the Faculty of Engineering, and the Faculty of ICT.

4.4.4 The ACM Symposium on Document Engineering

Document engineering is the computer science discipline that investigates systems for documents in any form and in all media. As with the relationship between software engineering and software, document engineering is concerned with principles, tools and processes that improve our ability to create, manage, and maintain documents. The ACM Symposium on Document Engineering is an annual meeting of researchers active in document engineering. Throughout this academic year, department members were actively involved in the Symposium as follows:

- On Tuesday 6th October 2020, Dr Alexandra Bonnici and Prof. Ing. Kenneth Camilleri delivered a tutorial on the "Machine Interpretation of Sketches". During the tutorial, they looked at the use of sketches in the product design and manufacturing industry. Specifically, they discussed the difficulties associated with the machine interpretation of sketches. They then described a sketch-based interface which allows the creation of a 3D model from a 2D, annotated drawing. Next, they described how Gabor filters can be used to obtain clean drawings from rough, over-sketched line strokes. They then looked at how a convolutional neural network can be used to attain similar results. Throughout the tutorial, Dr Bonnici and Prof. Camilleri illustrated the concepts and theory presented with Python code examples.

- Dr Alexandra Bonnici was entrusted with the role of Program Chair for DocEng 2021. The conference attracted 65 paper submissions, eight of which were accepted as full papers and a further 20 as short papers. The conference was held online, with 100 participants sharing their work and ideas

via Zoom and Slack discussions.

4.4.5 COST Action CA19121 "GoodBrother"

The GoodBrother COST Action aims to create an interdisciplinary community of researchers and industrial partners, from the different fields of computing, engineering, healthcare, law and sociology, as well as relevant stakeholders, to raise awareness on the ethical, legal and privacy issues of audio- and video-based monitoring for assisted living. Its objective is to increase user acceptance and exploitation of these new solutions, increasing their market reach. The COST Action was kicked-off in February 2021.

Prof. Kenneth P. Camilleri and Dr Stefania Cristina are participating in this COST Action as members of WG3: Audio- and video-based AAL applications, and as Management Committee members.

4.4.6 COST Action CA18232 "Mathematical Models for Interacting Dynamics on Networks"

Many physical, biological, chemical, financial or even social phenomena can be described by dynamical systems. It is quite common that the dynamics arises as a compound effect of the interaction between sub-systems in which case we speak about coupled systems. This Action shall study such interactions in particular cases from three points of view:

- the abstract approach to the theory behind these systems,
- applications of the abstract theory to coupled structures like networks, neighbouring domains divided by permeable membranes, possibly non-homogeneous simplicial complexes, etc.,
- modelling real-life situations within this framework.

The purpose of this Action is to bring together leading groups in Europe working on a range of issues connected with modelling and analysing mathematical models for dynamical systems on networks. It aims to develop a semigroup approach to various (non-)linear dynamical systems on networks as well as numerical methods based on modern variational methods and applying them to road traffic, biological systems, and further real-life models. The Action also explores the possibility of estimating solutions and long time behaviour of these systems by collecting basic combinatorial information about underlying networks.

Dr Kenneth Scerri is participating in this COST Action as a member of WG5: Numerical Methods and Applications, and as a Management Committee member.

4.5 Publications

Book Chapters

1. L. Buttigieg, H. Grech, S.G. Fabri, J. Attard, P. Farrugia, "Automated Speech Recognition in the Assessment of Child Speech", in M.J. Ball, editor, Manual of Clinical Phonetics, Part 4, Ch 35, pp. 508-514, Routledge, 2021

Editorials

1. A. Bonnici, R. B. Dannenberg, S. Kemper, K. P. Camilleri (Editors), "Music and AI", Frontiers in Artificial Intelligence, 2021

Journal Publications

1. N. Okkalidis, K.P. Camilleri, A. Gatt, M.K. Bugeja, O. Falzon, A review of foot pose and trajectory estimation methods using inertial and auxiliary sensors for kinematic gait analysis, Biomedical Engineering/Biomedizinische Technik, vol. 65, (6), pp. 653-671, Nov 18, 2020.
2. S. Griffin, O. Falzon, K. P. Camilleri, and V. Valdramidis, "Bacterial and fungal contaminants in caprine and ovine cheese: a Meta-analysis assessment," Food Research International, November 2020.

3. J. Farrugia, S. Griffin, V. O. Valdramidis, K. P. Camilleri, O. Falzon, "Principal component analysis of hyperspectral data for early detection of mould in cheeselets," Current Research in Food Science, vol. 4, pages 18-27, January 2021.

4. R. Zerafa, T. Camilleri, O. Falzon, and K. P. Camilleri, "Idle State Detection with an Autoregressive Multiple Model Probabilistic Framework in SSVEP-based Brain-Computer Interfaces," Biomedical Engineering Systems and Technologies (pp.263-288), March 2021.

5. I. Garba, F. Zarb, M.F. McEntee, S.G. Fabri, "Computed tomography diagnostic reference levels for adult brain, chest and abdominal examinations: A systematic review", Radiography, Volume 27, Issue 2, pp. 673-681, May 2021.

6. M. Aquilina, C. Galea, J. Abela, K. P. Camilleri and R. Farrugia, "Improving Super-Resolution Performance using Meta-Attention Layers," in IEEE Signal Processing Letters, September 2021.

Conferences Publications (Peer Reviewed)

1. P. Blanco-Medina, E. Fidalgo, E. Alegre, R. Alaiz-Rodríguez, F Jáñez-Martino, and A. Bonnici, "Rectification and Super-Resolution Enhancements for Forensic Text Recognition", Selected Papers from the 9th International Conference on Imaging for Crime Detection and Prevention (ICDP-19), October 2020.

2. S. Cristina, K. P. Camilleri, "Sequential Non-Rigid Factorisation for Head Pose Estimation", 25th International Conference on Pattern Recognition (ICPR), pp. 4528-4535, January 2021.

3. P. A. C. Varley, S. Cristina, A. Bonnici, K. P. Camilleri, "As Plain as the Nose on Your Face?", 16th International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications, VISIGRAPP 2021, February 2021.

4. D. Lendi, R. Raute, S.G. Fabri, R. Galea, "Stability Analysis of a Non-Linear PWM-Controlled Buck Converter with LC Input Filter", in 22nd IEEE International Conference on Industrial Technology (ICIT 2021), pp. 240-245, March 2021.

5. P. A. C Varley, S. Cristina, K. P. Camilleri, A. Bonnici, "Limitations of Local-minima Gaze Prediction", Proceedings of the International Conference on Image Processing and Vision Engineering (IMPROVE 2021), pages 46-57, April 2021.

6. N. Barbara, T. Camilleri, and K. P. Camilleri, "Modelling of Blink-Related Eyelid-Induced Shunting on the Electrooculogram," Proceedings of the ACM Symposium on Eye Tracking Research and Applications, May 2021.

7. L. Chetcuti Zammit, S. G Fabri, K. Scerri, "Self-tuning model predictive control for signalized traffic junctions," Proceedings of the European Control Conference, June 29-July 2, Virtual Conference, Rotterdam, The Netherlands, 2021.

8. A. Tabone, K. P. Camilleri, A. Bonnici, S. Cristina, R. Farrugia, M. Borg, "Pornographic content classification using deep-learning," DocEng '21: Proceedings of the 21st ACM Symposium on Document Engineering, pages 1-10, August 2021.

9. N. Magro, A. Bonnici and S. Cristina, "Hyperspectral Image Segmentation For Paint Analysis," 2021 IEEE International Conference on Image Processing (ICIP), September 2021, pp. 1374-1378, doi: 10.1109/ICIP42928.2021.9506558.

4.5.1 Non-peer reviewed articles

1. M. Borg, K. P. Camilleri, "Vision-based Automatic Sign Language Recognition using Deep Neural Networks", Newspoint 19th October 2020.

2. D. Cassar, "Lab to Life: Controlling the Unpredictable on the Road" in THINK magazine, November 2020

3. T. Camilleri, K. Camilleri, M. Mifsud, N. Barbara, "EyeCon - Controlling applications using EOG-based eye gaze tracking", Newspoint 2nd February 2021.

4. L. Chetcuti Zammit, "Increasing productivity with smart systems" The Malta Business Weekly, 1st March 2021.

5. S. Agius, "Motorcycle accidents – What is happening on our roads?" The Malta Independent, 18th April 2021.

6. T. Camilleri, K. Camilleri, R. Zerafa, "BrainApp – Development of a Brain Controlled Motorised Bed Application", PlumTri web portal, 26th May 2021.

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 Foundations of University Teaching and Learning

Dr Ing. Stefania Cristina has completed the *Foundations of University Teaching and Learning* course offered by the University of Malta, aimed to support early career academics in their continuous development of teaching strategies and effective learning. The course covered several topics throughout the year, ranging from the design of study units, to incorporating technology in teaching, academic integrity, and the supervision of dissertations and projects. The course also included a microteaching session, where each participant delivered a brief lecture and received feedback from fellow attendees, and a mini action research project, where each participant implemented various improvements to a study unit of choice and presented their results to the other course participants.

5.2 Invited Lectures

Prof. Steven Simske

Dr Alexandra Bonnici invited Prof. Steven Simske to deliver two guest lectures which were held on Wednesday 14th April, 18:00 - 20:00 and Thursday 15th April, 18:00 - 20:00. During his lectures, Prof. Simske covered topics related to image binarisation, edge detection and convolution, applying these concepts to image profligacy.

Prof. Simske is a Professor with the Department of Systems, Mechanical and Biomedical Engineering at the Colorado State University, Colorado, US.

5.3 ISO Training for Technical Staff

From September 2020 until April 2021, the technical staff, Ing. Lucianne Gauci, Ing. Rachael Duca and Mr Noel Agius, were engaged in a series of courses that discussed ISO standards. During these courses, the technical staff was given a formal introduction to ISO9001, ISO14001, ISO17025 and ISO45001 standards. Detail about each standard was given, together with some examples of where each standard should be implemented. During this course, the staff were made aware that should an ISO standard be put in place, a person certified to so would see to its implementation and a foreign body would see to its auditing process.

5.4 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.

5.4.1 7th January 2021: Dr Peter Ashley Clifford Varley

During this session, Dr Varley delivered a talk on the following three topics:

- Machine Interpretation of Engineering Design Sketches: The ability to Interpret line drawings as 3D solid objects is innate, but it is also a skill which improves with practice. Top designers in many fields still use freehand sketches to conceive and communicate their ideas. Such sketches are outside the design chain, which starts with CAD models and runs through to physical objects. What is wanted is a means of incorporating freehand sketches into the design chain, automatically translating initial concept sketches into 3D CAD models.
- Camera-holding Robot for Laparoscopic Cholecystectomies: Laparoscopic cholecystectomies (gallbladder removals) require three tools: a knife, a cauteriser, and a camera. A second surgeon is required whose job is to hold and move the camera. This is a poor use of resources as well as being tedious, and bored junior surgeons do not hold the camera steady, so the camera image is poor. What is wanted is an automated device for holding and moving the laparoscope which surgeons can control without using their hands.
- Computer Modelling of Seasonal Storage of Solar Power for District Heating Systems in the UK: Decarbonisation of domestic space heating is currently the number 1 priority if Wales is to meet its decarbonisation commitments. Ideally, we would use solar energy for this. The problem is that it is sunny in the summer and cold in the winter. What is wanted is a means of storing heat from the summer and using it in the winter. The idea has been proven to work, but the question is whether it is financially viable.

5.4.2 4th February 2021: Mr Nathan Magro and Mr Andre Tabone

This session was delivered by Mr Nathan Magro and Mr Andre Tabone on their respective MSc work.

Mr Nathan Magro explained a region merging-based segmentation algorithm for hyperspectral images for paintings, showing the advantages of applying such algorithms over clustering-based ones, such as Canny Edge segmentation, and superpixel-based ones, such as SLIC. This was followed by a discussion on the advantages of using the HSI colour space rather than RGB, followed by a comparison between the proposed algorithm and SLIC superpixels.

Mr Andre Tabone presented a system capable of fast and accurate detection of sexually exploitative imagery. Tracking such data to curtail the sharing of pornography and prosecute perpetrators is a critical aspect of cyber-crime activities, thus software capable of fast detection of pornographic content is essential to law enforcement agencies (LEAs). Mr Tabone explained how the developed system provides descriptions of the content within explicit images, by applying a deep learning model that performs object detection aimed at sexual organs and classifies the image using 19 possible descriptions.

5.4.3 4th March 2021: ACM Tech Talk

During this session participants attended the ACM TechTalk on *Agent-Human Collaboration and Learning for Improving Human Satisfaction* delivered by Sarit Kraus. During the talk, Prof. Kraus considered environments where a set of human workers needs to handle a large set of tasks while interacting with human users. The arriving tasks vary: they may differ in their urgency, their difficulty, and the required knowledge and time duration in which to perform them. Prof. Kraus described how the goal is to decrease the number of workers, which we refer to as operators that are handling the tasks while increasing the users' satisfaction. During the talk, she presented automated intelligent agents that will work together with the human operators in order to improve the overall performance of such systems and increase both operators' and users' satisfaction. Examples provided included: home hospitalization environments where remote specialists will instruct and supervise treatments that are carried out at the patients' homes; operators that tele-operate autonomous vehicles when human intervention is needed, and bankers that provide online service to customers. Prof. Kraus discussed how the automated agents could support the operators: the machine learning-based agent follows the operator's work and makes recommendations, helping them interact proficiently with the users. Prof. Kraus also discussed how the agents can learn from the operators and eventually replace the operators in many of their tasks.

5.4.4 16th April 2021: Final Year Projects Seminar

During this session, final year project students supervised by various members of the Department were invited to deliver a 10-minute presentation of their work. Following these presentations, students were given academic feedback on their work as well as additional feedback on their communication skills.

5.4.5 6th May 2021: ACM Tech Talk

During this session participants attended the ACM TechTalk on *An Industry Perspective on What We Should Be Teaching Our Next Generation of Software Practitioners in the Universities* by Prof. Paul E. McMahon. Prof. McMahon started the talk by making an interesting observation that the way future software practitioners are taught in universities is significantly different from what practitioners often experience when they leave the university and go into industry. As an example, Prof. McMahon said that while students are given requirements and ask them to develop software to meet those requirements, these differ from the ambiguous requirements that are likely to be given by real stakeholders in industry.

Prof. McMahon then went on to explore an approach to help bridge this gap utilising actual, common industry situations along with the Essence framework to better prepare the next generation of software professionals for the challenges they are certain to face in industry. Specific examples discussed include the critical areas of stakeholder management, requirements management, defect management, and cybersecurity. Prof. McMahon also highlighted the need for improved critical thinking skills along with practical examples that can be used today in the universities to help students strengthen these essential skills and be better prepared for future challenges.

5.4.6 16th May 2021: Final Year Projects Seminar

This session was a follow up of the earlier seminar for final year students and provided a second opportunity for the students to practice their presentation and communication skills prior to the final project presentations.

5.4.7 8th July 2021: Ms Rachel Cauchi and DW Documentary on Artificial Intelligence and Algorithms

During the first part of this session, Ms Rachel Cauchi presented her MSc work concerning prosthetic hand control, which is aimed towards creating an intent interpretation system for upper-limb amputees to instruct an anthropomorphic prosthetic hand. Rachel explained how the trade-off problem between

simplicity, dexterity and usability of such a system was mainly addressed by utilising surface elec-
tromyography (sEMG) as the intent interpretation interface, which has enabled the exploitation of the
human sense of intuition. She, further, discussed the developed algorithms in order to reliably detect
and classify movements, as well as identifying grasping intensities.

During the second part of this session, a documentary produced by Deutsche Welle that speaks
about the pros and cons of AI and algorithms, was streamed. The documentary looked at the revolu-
tionary developments that are currently taking place around the world, along with their opportunities
and dangers, and the resulting implications on society.

5.5   Team Building Activities

Coming together is a beginning, staying together is progress, and working together is success.

- Henry Ford

Ms. Sanchia Cila Lentini organised a team-building event which took place on Wednesday 5th May.
The event was held in a blended manner with some Department members meeting at Ta' Qali park while
others participated online. During the activity, Department members participated in group games and
quizzes, allowing all members to interact in a lighthearted manner.

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

6.1.1 International Funding

4NSEEK - Forensic Analysis for Child Sexual Abuse

MAIN INVESTIGATORS: Prof. Ing. Kenneth P. Camilleri, Dr Alexandra Bonnici, Dr Ing. Stefania Cristina, and Prof. Ing. Reuben Farrugia [1]
RESEARCH SUPPORT OFFICERS: Mr. Andre Tabone, Dr Mark Borg
FUNDING BODY: European Commission
FUNDING AMOUNT: €94,780

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

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

Through this project, We created a labelled dataset in which pornographic images were manually labelled with the location and label of the exposed private body part. This labelled data-set has been used to train various deep-learning architectures. In this project, We investigated different deep learning classifiers using transfer learning and fine-tuning techniques based on Imagenet pre-trained models of VGG-19, Inception-V3 and MobileNet architectures, using the TensorFlow GPU module and later

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[1] Department of Communications and Computer Engineering

exploited the YOLO architecture to label the regions of interest in the image. Another aspect of this work was concerned with the analysis video data wherein the pornographic sections of the video were automatically labelled. This project also provided us with the opportunity to work with the Malta Police Force who have validated the deep net models developed in this work both on general pornographic/benign images as well as on sensitive child abuse images.

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. This project will use computer vision techniques to reduce user calibration, hence increasing the usability of eye-gaze tracking and visualisation in the collaborative design process.

The project has progressed remotely, until the RSO could relocate to Malta in July 2021, as soon as this was permitted by the COVID-19 restrictions. During the past year, the research work has explored methods for the detection and localisation of salient facial features, based on which the eye and head pose angles could be resolved geometrically. This has led to several conference publications and presentations. The research work is presently reviewing deep learning-based methods for head/eye pose estimation, to investigate how these compare to the results that we have thus far obtained and explore avenues for improvement.

6.1.2 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.
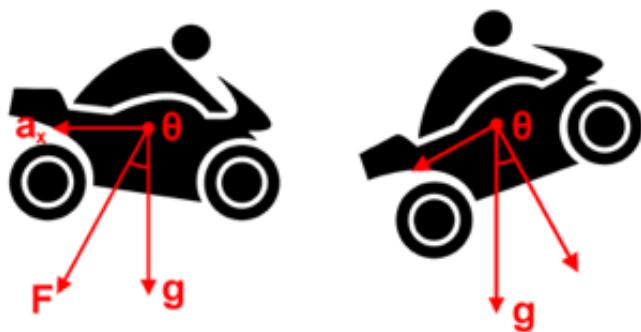
Figure 6.1: Motion cueing to physically emulate the motorcycle ride

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

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

In the proposed platform, eye and head movements will be captured in a stream of image frames acquired by a webcam, and subsequently processed by a computer (and possibly mobile devices) in

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[2] Department of Microelectronics and Nanoelectronics

order to estimate the gaze direction according to the eye and head pose components. Mapping the eye-gaze to a computer screen will permit commands to be issued by the selection of icons on a suitably designed user interface. This project will be addressing challenges associated with eye-gaze tracking under uncontrolled daily life conditions, including handling of head and non-rigid face movements, and reduction or elimination of user calibration for more natural user interaction.

The project work has been concluded during the past year with the implementation of a Graphical User Interface (GUI) designed by the commercial partner, Seasus Ltd, that incorporates the research work that has been carried out at the University of Malta. A set of trials has also been carried out on the finalised GUI, following the design of a protocol, which has 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. The last phase of this project concerns the compilation of the end-of-project reports.

BrainApp - Brain Controlled Applications

MAIN INVESTIGATORS: Dr Tracey Camilleri, Prof. Ing. Kenneth P. Camilleri and Dr Owen Falzon
RESEARCH SUPPORT OFFICER: Ing. Rosanne Zerafa
FUNDING BODY: MCST FUSION R&I Technology Development Programme
FUNDING AMOUNT: €136,335 (out of the total project funding €181,793 for the consortium)
AWARDEE: Dr Tracey Camilleri

A Brain Computer Interface (BCI) gives a person the ability to communicate with and control machines using brain signals instead of peripheral muscles as demonstrated in Figure 6.2. BCIs allow people with severely restricted mobility to control devices around them, increasing level of independence and improving quality of life. BCIs may also be used by healthy individuals, for example, in gaming, and are expected to become a ubiquitous alternative means of communication and control.

The project was officially completed at the end of May 2021 with the public engagement event being held at Esplora on 7th October 2021. The work carried out in the past months included the testing of the prototype system on a number of healthy patients and the connection of the new customised headset with the BrainApp platform, among other work related to publications which are described in more detail in Sections 4.5.

Figure 6.2: Brain controlled motorised bed

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 6.3. 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 now in its second stage. Algorithms to determine the user's point of gaze from EOG data have been developed and recently these have also been updated to take into consideration the user's change in head pose. The developed algorithms will now be tested using a number of human subjects and the external partner will start re-writing these algorithms onto the EyeCon platform.

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.
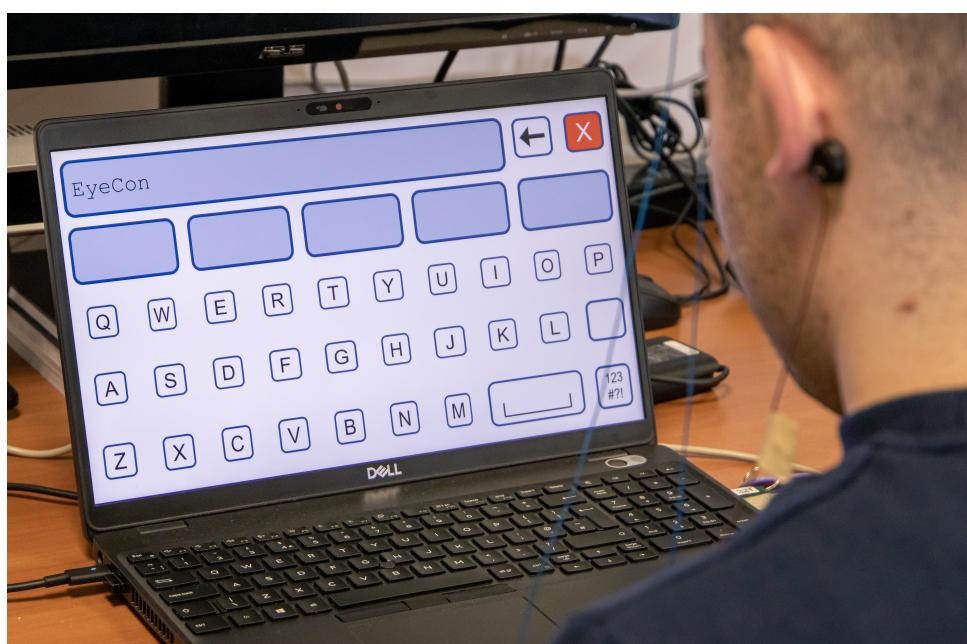
Figure 6.3: Typing using an EOG-based interface.

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.

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

MAIN INVESTIGATORS: Dr Lisa Tabone, Prof. Kenneth P. Camilleri, Dr Tracey Camilleri,
                    Prof. Dr Geert Verheyden [5]
FUNDING BODY: Reach High Scholars Programme
FUNDING AMOUNT: €198,000 [6]
AWARDEES: Dr Lisa Tabone, Professor Kenneth P. Camilleri, Prof. Dr Geert Verheyden

Somatosensation includes exteroception (e.g. touch and pain), proprioception (e.g. position sense) and higher cognitive somatosensation (e.g. stereognosis). In a prospective longitudinal study involving 70 people with stroke which were assessed on admission to an acute ward and at two, four and six months' post-stroke, Upper Limb (UL) stereognosis (which was associated with UL motor performance) and proprioception were more frequently impaired than tactile sensations. In the aforementioned and other, but smaller longitudinal studies on somatosensory dysfunction, only clinical measures were used. Clinical measures do not allow the investigation of underlying mechanisms of brain dysfunction. One safe, non-invasive and portable method that can be used to monitor brain activation is electroencephalography (EEG) which records the electrical activity of the brain at the scalp. It has been suggested that oscillatory EEG rhythms between sensorimotor cortices might have an important function post stroke. Furthermore, a relationship was found between severity of UL motor impairment and event-related desynch7 ronization in the unaffected hemisphere. Thus, further longitudinal studies exploring changes in brain activation in relation to the clinical manifestation of somatosensory impairments from the early to the chronic stage are warranted. Such studies can provide a more thorough understanding of whether over-activity in the unaffected cortex is a contributor to sensorimotor impairments and subsequently, when being an independent predictor for motor outcome, provide a rationale for novel treatment options.

This project has been investigating the changes in brain activation of upper limb (UL) somatosensory impairments post stroke. EEG measurements of UL somatosensory brain activation from healthy subjects and people with UL somatosensory impairments due to stroke using a standardised protocol were collected. Data was collected over two sessions to investigate longitudinal recovery pattern of clinical somatosensory measurements and corresponding changes in cortical EEG activity for UL somatosensory impairments in the early, sub-acute and chronic stage of stroke. Recently, investigations focused on

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[3] Department of Mechanical Engineering
[4] Department of Podiatry
[5] Katholieke Universiteit Leuven
[6] In collaboration with the University of Malta, Centre for Biomedical Cybernetics, and Katholieke Universiteit Leuven

the longitudinal relationship of changes in cortical EEG activity for UL somatosensory impairments and clinical somatosensory measurements with UL motor impairment and function, spasticity and stroke impact in the early, sub-acute and chronic stage of stroke.

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 [7], Dr Fausto Caruana [7]

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.

6.2 Internally Funded Projects

Combining Gaze and Body Pose for Multimodal User-Environment Interaction

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

FUNDING BODY: University of Malta Research Grant

FUNDING AMOUNT: €2,000

AWARDEE: Dr Ing. Stefania Cristina

This project builds on our long-standing work on vision-based eye-gaze tracking, which thus far has considered the interaction of a user with a computer by estimating the point-of-regard on a monitor screen. In this project, the aim is to extend the interaction space to the user's 3D environment in order to permit persons with impaired mobility, due to disability or ageing, to remotely activate electronic devices within their environment. User interaction in the 3D environment will be enabled by directing one's head pose or eye-gaze, or by pointing one's arm towards the device of interest to signify attention.

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[7] University of Parma, Italy

In this manner, the user interaction will be as natural as possible and will not require the typical use of wearable devices.

Control, Robotics and Automated Systems

Main investigators: Prof. Ing. Simon G. Fabri, Dr Ing. Marvin Bugeja
Research Students: Various
Funding Body: University of Malta Research Grants
Funding Amount: €4,000
Awardee: Prof. Ing. Simon G. Fabri, Dr Ing. Marvin Bugeja

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 wheeled mobile robot to serve as a training partner for track runners. The aim is to have the robot move along the running track (by following the lane lines) at some user-specified speeds for given distances (refer to Figure 6.4 (a)). This year's work primarily focused on the design, implementation and testing of a new encoder-based speed control system (refer to 6.4 (b)), and on the tuning and rigorous testing of the previously designed infrared-sensors-based lane following steering system.

The second project consisted of a simulation study on the coverage control problem for mobile robots. The most basic task in coverage control is to direct a number of robots to collectively cover a given space in some optimal manner. This idea has many real-life applications, such as for autonomous surveillance and search-and-rescue operations. During this project the student designed, implemented and tested an algorithm that uses Voronoi diagrams and cost-function minimisation to distribute a small group of holonomic mobile robots to cover a 2D area in a distance-optimal manner, even when a non-uniform region of importance is assigned to the area. The result from one of these simulation experiments is depicted in Figure 6.5.
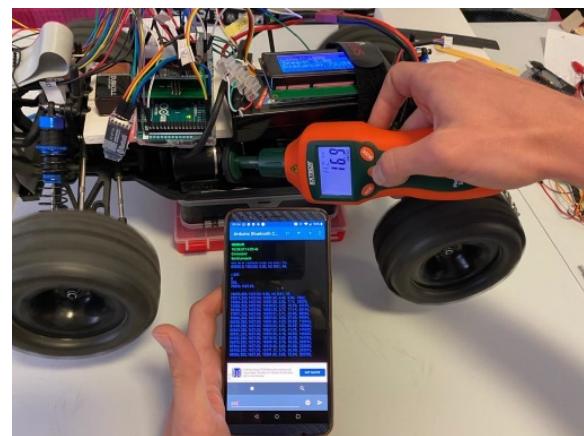
(a)   (b)

Figure 6.4: (a) The robotic pacer (under construction) on a running track. (b) Testing the speed feedback mechanism
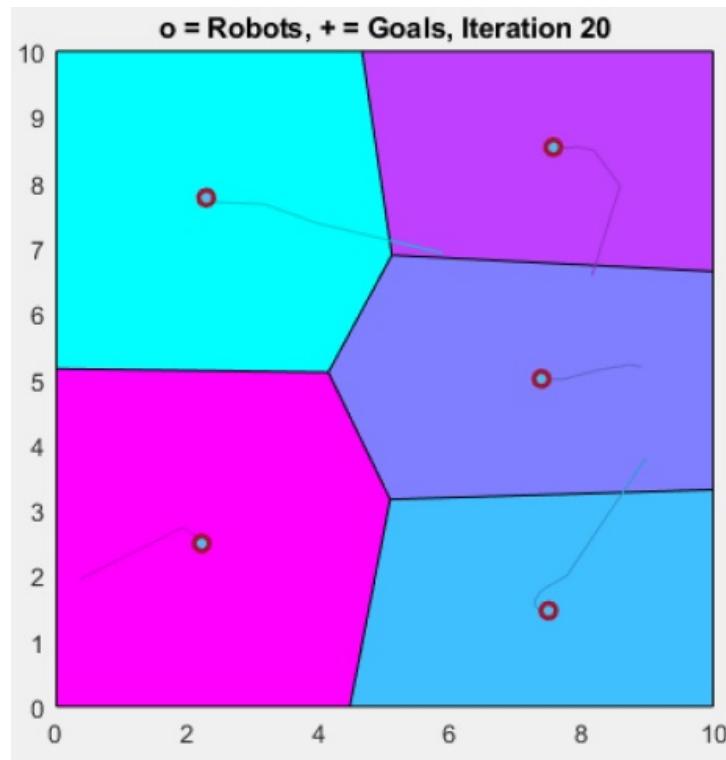
Figure 6.5: Coverage control of a 2D space with five mobile robots.

Intelligent Transportation Systems

MAIN INVESTIGATORS: Ing. Luana Chetcuti Zammit
FUNDING BODY: University of Malta Research Grant
FUNDING AMOUNT: €2,000
AWARDEE: Ing. Luana Chetcuti Zammit

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

Intelligent Traffic Junctions

MAIN INVESTIGATORS: Dr Kenneth Scerri
RESEARCH STUDENTS: Various
FUNDING BODY: University of Malta Research Grants
FUNDING AMOUNT: €2,000
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: €2,000
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 from 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 preform 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 preform 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: €2,000
AWARDEE: Dr Tracey Camilleri

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

This research grant is being used to support two PhD students, Ing. Rosanne Zerafa and Mr. Nathaniel Barbara, as well as MSc student Mr. Jeanluc Mangion. In different ways, all three students are working on improving the practicality of the difference human machine interface systems they are working

on. Specifically, Ing. Zerafa is working on the use of switching autoregressive models for SSVEP based brain computer interface systems, Mr Barbara is focussing on modelling of eye movements captured through EOG (electrooculography), for improved point of gaze estimation, while Mr. Mangion is considering an SSVEP based system which also exploits eye movement information captured in real time from EEG electrodes. Jeanluc has submitted his dissertation in October 2020 but the PhD students are still ongoing.

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: €2,000
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 maximizes efficiency and enhances robustness, based on the capabilities of the individual robots in the team. Such systems have several real-life applications such as in: persistent surveillance, disposal of hazardous waste, warehouse management, and autonomous exploration. To this end, this doctoral research programme (started Oct 2016) is investigating how the coordination and cooperation between autonomous agents in a multi-robot system can be made more efficient, robust, and reconfigurable. This work aims to contribute an optimal framework that allows for task division, allocation and execution for multi-robot systems. This framework shall then be applied to address a real-life relevant problem. The results of the reviewing stage of this project has been published in a review paper at an international peer-reviewed conference in July 2017. More recently, a novel solution to the energy-restricted coverage problem, where a team of robots with energy restrictions is required to optimally cover an environment with time-varying importance regions, has been published in one of the major conferences in the field, the 21st IFAC World Congress. Due to the COVID-19 pandemic, this conference was held virtually.

The work published in the IFAC conference is currently undergoing a mathematical study. Mathematical tools and control stability theory are being applied to prove that such control systems are stable.

Such theory extends to Control Lyapunov Functions and Control Barrier Functions. At the moment the research to mathematically prove the optimization problem when we have a dynamic environment and energy-restricted robotic team is still ongoing.

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

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

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

This doctoral research program started in June 2018 and the student is now expected to submit his dissertation in January 2021. In the past year the work focused on having a robust EOG-based point of gaze estimation system which takes into consideration the user's head pose. This work has led to the successful publication of two conference papers and the submission of a journal publication which is still under review.

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 Duca [8], Dr Kenneth Scerri and Dr Daniel Micallef [9]
FUNDING BODY: EU H2020 LC-CLA-11-2020
AWARDEE: Dr. Kenneth Scerri

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 JUSTNature 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

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[8] Centre for Entrepreneurship and Business Incubation
[9] Faculty for the Built Environment

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 Micallef [10], Dr. Edward Duca [11] 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 Azzopardi [12]
RESEARCH STUDENT: Mr Darren Debattista [12]

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 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.
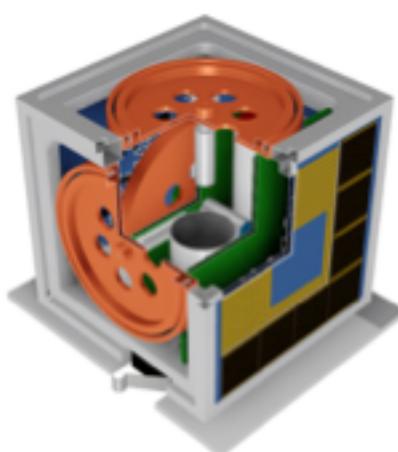

Figure 6.6: Cutaway drawing of the UoMBSat-1 pico-satellite

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[10] Faculty for the Built Environment
[11] Centre for Entrepreneurship and Business
[12] Department of Electronic Systems Engineering

DeepFIR - Restore Very Low-Resolution Facial Images

MAIN INVESTIGATORS: Dr Reuben A. Farrugia [13], Prof. Ing. Kenneth Camilleri, Prof. John M. Abela [14]

RESEARCH SUPPORT OFFICERS: Dr Christian P. Galea [13], Mr Matthew Aquilina [13]

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 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.

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 [15]

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.

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[13] Department of Communications and Computer Engineering
[14] Department of Computer Information Systems
[15] Centre for Biomedical Cybernetics

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

MAIN INVESTIGATORS: Prof. Alfred Gatt [16], Prof. Cynthia Formosa [16] and Dr. Ing. Marvin Bugeja
FUNDING BODY: MCST FUSION R&I Technology Development Programme

This project aims to further develop and validate an intelligent foot offloading device that has been previously developed to TRL5 under a TOSFA grant by the same research team. This technology is unique as it assesses a diabetic patient's risk of developing an ulcer on the foot using sensors which monitor pressure and temperature in real-time during walking, and then 'intelligently' changes shape to offload at-risk areas of the foot. The proposed solution will replace traditional offloading techniques, which have been shown to be ineffective in reducing amputation rates in practice.

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[16] 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.

Vex Robots Six VEX robots were acquired through Faculty funds to support the summer training.

Servomotor and contactor kits These kits were assembled in-house to serve as the workstations for the training in servomotors and PLCs workshop during the summer training course.

GPU-equipped computers An NVIDIA Quadro RTX5000 was acquired to facilitate research in machine learning and artificial intelligence. This computer was acquired through combined resources from the TRAKE "EyeDesign" project, the "4NSEEK" project and Department funds.

Sennheisser Stereo-pair Microphones The microphones and corresponding amplifier interface were acquired through the internal research grant SCERP02-21. These microphones enable the live acquisition of audio signals including but not limited to the digital piano already available in the Transport, Signal and Image Processing laboratory.

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.

Autonomous Vehicles Research Studio This includes a complete setup to automate one or more autonomous vehicles such as ground mobile robots and drones. In this research studio, an unmanned aerial vehicle called the QDrone was purchased. This system has a ground control station which can be used to program the QDrone and also monitor its navigation in the designated flying area. The QDrone is equipped with its own cameras and onboard processor. The research studio also comprises a set of localization cameras used to obtain effective navigation in the environment. This research studio was acquired through funds dedicated to TRAKE project.

Data storage Six additional hard disks were acquired to expand the Department's existing NAS storage device hosted at the IT Services building. These additional hard disks expand the usable data storage space for the Department by 24 TB to a total of 28 TB of usable storage capacity. These hard disks were acquired through Department funds, the TRAKE "EyeDesign" project and the internal research grant SCERP02-21.

8. Public Outreach

Despite of the ongoing Covid-19 pandemic, the Department kept its commitment to engage with society for the dissemination of research results as well as for science appreciation and education. The following lists the public engagement activites carried out by department members during the academic year.

8.1 Technology Clubs Online

In order to adapt to the Covid-19 pandemic which prevented the Faculty from hosting students on campus, Dr Bonnici launched the Online Engineering Technology Clubs. Video recordings of the various workshops typically offered for the Technology Clubs were mare availalbe to schools and students on a newly created website: `https://www.engineeringtechclubs.com/`. Dr Alexandra Bonnici further contributed to the clubs providing a video workshop on Robotics using LegoMindstorms, while Dr Tracey Camilleri and Mr Matthew Mifsud provided a second workshop with their project "EyeCon".

8.2 Career talks

Dr Bonnici was invited to deliver career talks to various students in different primary, secondary and post-secondary schools as follows:

- St Martin's College Sixth form - 1st December, 2020
- St Ignatius Middle School - 2nd March, 2021
- Gzira Primary School - 3rd March, 2021
- St Monica Secondary School, Birkirkara - 11th March, 2021
- St Thomas More Middle School - 19th April, 2021

The focus of these talks was to describe the various disciplines and opportunities that an Engineering career may lead to as well as the entry routes towards becoming an Engineer. The talks also serve to break stereotype of Engineering as a male-centric career.

8.3 Participation in the "Freedom to Learn" Program

On Wednesday 30th June, Dr Alexandra Bonnici participated in the Zabbar Primary School challenge to learn something interesting about flying and to create something that flies. The challenge was part of the school's Freedom to Learn program and involved children from ISC Borgo Solestà- Cantalamessa (Italy) and IG Warszawa (Poland) as well as the Maltese students from the Zabbar Primary School. Dr Bonnici explained the forces that come to play when aeroplanes travel and with the students, built a sling-launched paper helicopter.

8.4 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.

8.4.1 Opening of Valletta Design Cluster

On the 24th of March 2021, the Department participated in the Opening of the Valletta Design Cluster. This opening was attended to by the Prime Minister and other dignataries who were involved in the restoration of the Valletta Old Abbatoir into an open creativity space. During this opening, Dr Alexandra Bonnici presented some exhibits on a stand, including a computer vision application called "Memory-Lane Photo Booth", which took participants back in time by superimposing their live images onto old scenes from around Valletta, as well as the Smart Wheelchair.

8.4.2 European Girls and Women in ICT Day

On the 22nd April 2021 European countries celebrated the first European Girls and Women in ICT. In celebration of this day, Dr Alexandra Bonnici was invited to participate in an online campaign to motivate and encourage girls to follow STEM related careers.

8.4.3 Public Service Week

On Saturday 5th June 2021 Dr Alexandra Bonnici and Mr Matthew Mifsud participated in the Public Service Week initiatives at the Valletta Design Cluster. Alexandra and Matthew showed the audience how to program the motor of a robot and how to use a touch sensor to detect position.

8.4.4 Science in the City 2021

Team members of the EyeCon and EyeDesign projects were invited to participate in the Meet the Researcher event, during this year's Science in City. This year, the Meet the Researcher event was streamed online, and attendees could follow the discussions on Facebook and Zoom.

In preparation for the main live event, a pre-recording session was held on Wednesday 22nd September at the Valletta Design Cluster. During this session, Dr Tracey Camilleri, Mr Nathaniel Barbara and Mr Matthew Mifsud presented their research work on Eyecon, and similarly, Dr Stefania Cristina, Dr Alexandra Bonnici and Dr Peter Varley presented their work on EyeDesign.

The live event was held on Saturday 25th September, during which Mr Nathaniel Barbara and Mr Matthew Mifsud on behalf of EyeCon, and Dr Stefania Cristina on behalf of EyeDesign, engaged in dis-

Figure 8.1: Left to right: Peter Varley, Alexandra Bonnici, Nathaniel Barbara, Tracey Camilleri, Stefania Cristina and Matthew Mifsud during Science in the City

cussion with the presenter during a 45-minute slot entitled, Watching you Watching me, on the different methods and applications of eye-gaze tracking.

8.5 Media Exposure

8.5.1 Ride&Safe Press Event

On the 20th September 2021, Prof. Simon Fabri participated in a media event which showcased the Ride&Safe project led by Prof. Philip Farrugia from the Department of Industrial and Manufacturing Engineering. The event described the simulator that supports the design of customised and safer motorcycles, allowing for a safe and more ergonomic driving. The event took place at the Faculty of Engineering was attended by Hon. Minister Owen Bonnici and was covered on various news media reports.

9. Prizes, Awards and Appointments

9.1 Funding awards

- In February 2021 Prof. Ing. Simon Fabri was awarded funds for the project "CONAI", as part of the project TRAKE.
- In February 2021 Prof. Ing. Kenneth Camilleri was awarded funds for the project "BrainCon", as part of the project TRAKE.
- In January 2021 Dr. Ing. Marvin Bugeja (as a co-investigator) was awarded funds for the project Sit_Diab - Smart Insole Technology for the Salvage of the Diabetic Foot, by the MCST FUSION R&I Technology Development Programme.

9.2 Recognition of service

- In December 2020, Prof. Ing. Kenneth P. Camilleri was elevated to the grade of Senior Member of the ACM.
- In April 2021, Dr. Ing. Marvin Bugeja was elevated to the grade of Senior Member of the IEEE.
- In July 2021, Dr Bonnici was awarded the Women in STEM Award as part of the National STEM Awards in acknowledgement for work carried out in scientific research, tutoring and outreach.

9.3 Staff appointments

- In October 2020, Dr Alexandra Bonnici was appointed as the Head of Department of Systems and Control Engineering.
- In January 2021, Dr Alexandra Bonnici was promoted to Senior Lecturer with the Department of Systems and Control Engineering.
- In April 2021, Mr Noel Agius was promoted to Assistant Laboratory Manager with the Department of Systems and Control Engineering.
- In June 2021, Mr Nathaniel Barbara was appointed as Systems Engineer with the Department of Systems and Control Engineering.
- In September 2021, Prof Ing Simon G. Fabri was appointed Pro-Rector of the University for Research and Knowledge Transfer.

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

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