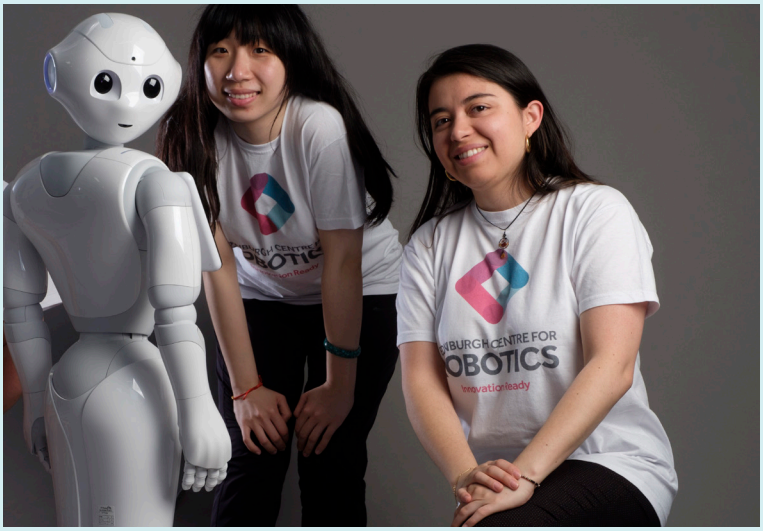
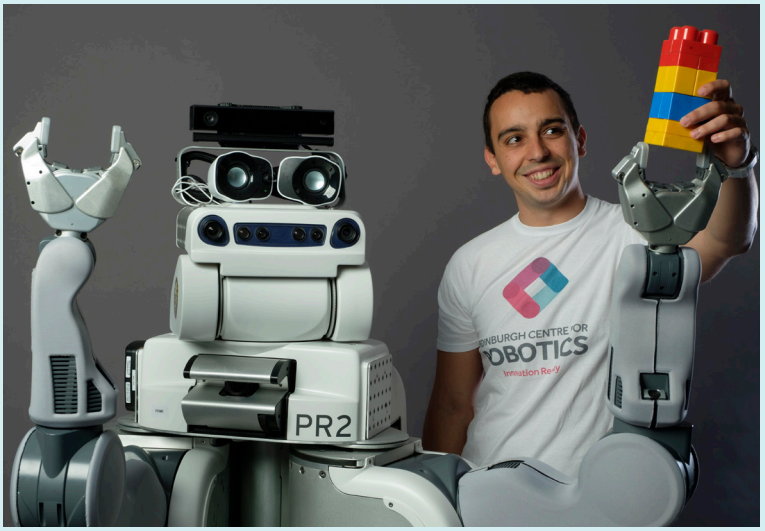
EDINBURGH CENTRE FOR
ROBOTICS
Innovation Ready





Annual Review 2020/2021

EPSRC Centre for Doctoral Training in Robotics and Autonomous Systems

HERIOT WATT UNIVERSITY

THE UNIVERSITY of EDINBURGH

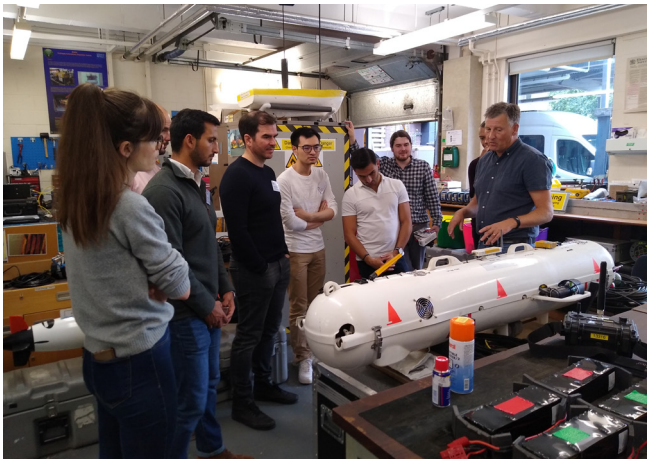
UKRI Engineering and Physical Sciences Research Council

Contents

The majority of images reproduced in this Annual Review pre-date January 2020

The Centre in Numbers 2014 -2021

Figures correct as at 30th September 2021



2 Centres for Doctoral Training

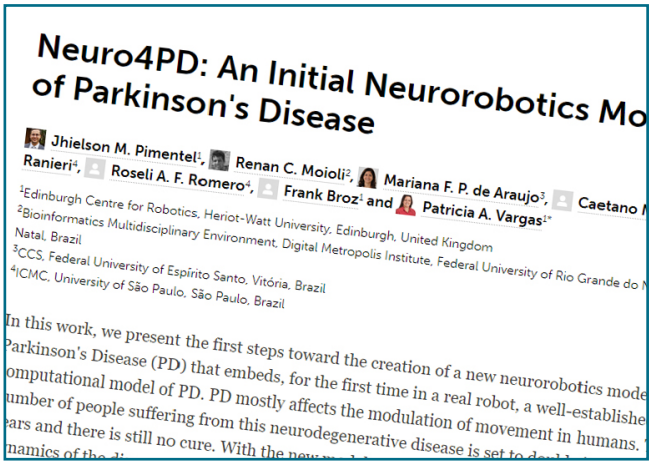
8 Cohorts

81 Students

15 Alumni

10 Initial thesis submissions

67 Academics



Neuro4PD: An Initial Neurorobotics Mo of Parkinson's Disease

Jhielson M. Pimentel[1], Renan C. Moioli[2], Mariana F. P. de Araujo[3], Caetano Ranieri[4], Roseli A. F. Romero[4], Frank Broz[1] and Patricia A. Vargas[1*]

[1]Edinburgh Centre for Robotics, Heriot-Watt University, Edinburgh, United Kingdom
[2]Bioinformatics Multidisciplinary Environment, Digital Metropolis Institute, Federal University of Rio Grande do N Natal, Brazil
[3]CCS, Federal University of Espírito Santo, Vitória, Brazil
[4]ICMC, University of São Paulo, São Paulo, Brazil

In this work, we present the first steps toward the creation of a new neurorobotics mode Parkinson's Disease (PD) that embeds, for the first time in a real robot, a well-establishe computational model of PD. PD mostly affects the modulation of movement in humans. umber of people suffering from this neurodegenerative disease is set to
ears and there is still no cure. With the new
namics of the

125 Conference Publications

38 Journal Publications

35 Workshop Papers

Copyright © BAE Systems

52 Industry partners

13 Industry projects

Foreword

Welcome to our 2020/21 Annual Review featuring the latest news and developments from students and staff in our EPSRC Centre for Doctoral Training in Robotics and Autonomous Systems.

We are now coming to the end of the second year of our second CDT programme, which has been a challenging time for students and staff due to ongoing Covid-19 restrictions. However, despite the challenges and uncertainties, we were delighted to welcome 12 enthusiastic students to the programme in September 2020. With academic and administrative staff still required to work from home where possible, these students mainly worked remotely following the 'Responsive Blended Learning' approach (Heriot-Watt University) and the 'Hybrid learning and teaching' programme (University of Edinburgh). They were able to meet in person once a week during Semester 1 to undertake the Autonomous Systems Research course, with the Centre facilitating regular online meetups on Gathertown to encourage cohort building.

Despite the difficulties of the last year, we do have lots of positive news to report. A further ten students from our first CDT programme have now graduated and progressed to full employment in industry and academia, with ten of their peers ready to submit their final theses and graduate in the next few months. Students have continued to submit and have papers accepted for high profile conferences, which they have attended online. Kai Yuan has received a UK-RAS Network Rising Star award, and Paola Ardon has won a best workshop presentation award. Four students have secured prestigious internships with Amazon, Facebook and Schlumberger, which will allow them to develop and hone their research skills. Students in year two of the programme spent early Semester 2 working together on their group projects, which resulted in three prototype robotic systems that were demonstrated at an industry showcase event in March. Three different teams of students have been awarded a budget from the Centre's Innovation Fund to allow them to build a hardware and/or software prototype that could lead to a commercial idea.

A number of academic staff have received well deserved promotions during the last year. Professors Helen Hastie and Yvan Petillot have been appointed academic leads for the National Robotarium, due to open in early 2022. In addition, Professor Yvan Petillot has been elected Fellow of the Royal Society of Edinburgh in recognition of his pioneering work in marine robotics and his role in turning research into industrial innovation. Academics have won significant funding for research into a range of fields including trustworthy autonomous systems, the fluid dynamics of dandelion-inspired drones and grounded multi-modal interaction.

Work on the National Robotarium building has progressed well during the last year despite lockdown, and several new robots have been procured in preparation for the state of the art facility opening. A four-legged robot from the Boston Dynamics Spot range has already been deployed on the Robotarium building site, where it collected data and measurements in real time. Three ARI robots were delivered to Heriot-Watt University in July, and work is now underway to prepare a Furhat robot for its role as a receptionist in the National Robotarium which will advance research into verbal multi-party human-robot interaction.

Our sixth Annual Conference was held online in October 2020 and although students and academics missed out on in-person networking opportunities, the change in format allowed us to engage keynote speakers from overseas, who otherwise might not have been able to join us in Edinburgh. Professor Metin Sitti from the Max Planck Institute spoke about soft bodied small scale robotics, Professor Sara Bernardini from Royal Holloway University discussed robotics in extreme environments, while Rich Walker from Shadow Robots gave students practical advice for founding a robotics company. The day ended with an inspiring talk about socially assistive robots from Professor Maja Mataric from the University of Southern California, and a virtual robot themed cocktail/mocktail making party and contest. A number of interesting entries were submitted with Helmi Fraser's cocktail creation 'An Robot Air Leth-Mhisg' ('The Tipsy Robot' in Gaelic) declared the winner.

With Covid-19 restrictions hopefully continuing to ease, and the imminent opening of the National Robotarium, we know that the next year will be eventful. Keep up to date with news via the National Robotarium newsletters.

Professor Helen Hastie
Director
Heriot-Watt University

Professor Michael Mistry
Director
University of Edinburgh

About us

The Edinburgh Centre for Robotics (ECR) is a £120m plus joint venture between Heriot-Watt University and the University of Edinburgh, supported by EPSRC, Industry and the Universities.

It captures the expertise of over 65 principle investigators of international standing from 12 cross-disciplinary research groups and institutes across the School of Engineering and Physical Sciences and the Department of Computer Science at Heriot-Watt University, and the Schools of Informatics and Engineering at the University of Edinburgh.

The Centre includes two consecutive EPSRC Centres for Doctoral Training (CDT) in Robotics and Autonomous Systems which train innovation–ready postgraduates, a £9m capital equipment facility, the £19m ORCA Hub and the £26m National ROBOTARIUM.

The Centre includes affiliated students engaged in related EU, EPSRC and UK-MoD research programmes, and local EPSRC/UKRI CDTs in Data Science, Applied Photonics, Natural Language Processing, Biomedical Artificial Intelligence and Pervasive Parallelism, as well as the NERC/EPSRC CDT in Next Generation Unmanned System Science.

The strategic aim of the Centre is to supply the urgent need for skilled, industry and market aware researchers in Robotics and Autonomous Systems. Interactions between robots, autonomous systems, their environments and people present some of the most sophisticated scientific challenges we must solve to realise productive and useful assistive or remote systems in our homes, workplaces and industries.

EDINBURGH CENTRE FOR ROBOTICS
Innovation Ready

The Edinburgh Centre for Robotics is training a new generation of researchers to take a key role in solving such problems. These innovation-ready PhD students are being prepared to enter, lead and create the UK's innovation pipeline in this area for jobs and growth.

The Centre focuses on autonomous robot interaction with environments, people, systems and each other. We also research and develop work on Interaction Enablers, applying such fundamental theoretical methods to real-world problems, using real robots to solve vital commercial and societal needs.

Research is conducted using state of the art humanoid and field robotic platforms, in interactive spaces with fabrication facilities for soft embodiments, embedded microsensors and dedicated computing. Centre partners include companies in the energy, assisted living, transport, defence, medical and space sectors.

Management Structure

The Executive

The Executive is chaired by the Directors and is responsible for day-to-day operations of the Centre. Membership of the Executive is made up from the leadership teams from each University, Centre Administrators and student representatives. The Executive is responsible for student recruitment, progress and pastoral matters, public outreach, administering budgets, supervisor selection, organisation of annual conference and guest lectures, #Cauldron training programme, and commercialisation processes. It is also the first arbiter in the conflict resolution process with partners and students.

The Steering Group

The Steering Group consists of the Directors, senior academics from the Postgraduate Studies Committees at Heriot-Watt University and the University of Edinburgh, as well as a representative from industry (the Chair), EPSRC and from the RAS CDT student body. The remit of the Steering Group is to monitor the progress of the Centre, IP and licensing arrangements and relations with industry members, and to review and propose strategy and policy. The Steering Group will also act as final arbiter in the conflict resolution process for students and partners.

The External Advisory Board

The External Advisory Board reports to the Steering Group and comprises representatives from the Industry Members engaged with the Centre, plus two international academics and the Centre Management team. It meets at least annually to monitor the work of ECR, provide strategic advice, support development of new business relationships and promote best practice. Members of the External Advisory Board serve in a non-executive capacity.

The Academic Board

An Academic Board involving all active supervisors and both Universities' representatives will also report to the Steering Group. Meeting annually, and chaired by the Directors, it will monitor the academic quality and delivery of both the taught courses and the research projects and will deal with formal student progression.

Equality, Diversity and Inclusion (ED&I) Statement

The CDT in Robotics and Autonomous Systems is committed to facilitating a shift in the culture and diversity of the robotics research community through pro-active practices to support equality, diversity and inclusion at all levels.

A principle aim is to promote wider gender diversity in the field of RAS. More generally, the CDT will ensure all students and staff are respected and valued for their unique perspectives and contributions, and that no-one is treated differently or less favourably on the basis of age, disability, gender reassignment, marriage and civil partnership, pregnancy and maternity, race, religion or belief, gender or sexual orientation.

Positive actions we are taking include:
Student recruitment - The CDT actively encourages applications from groups who are underrepresented in the Centre. We have clear guidelines for student recruitment and all academic staff are encouraged to participate in the recruitment process through interview panels or at the regular consensus meetings when student appointments are made. We ensure diversity on our interview panels to make the selection process fair and transparent for all candidates. We will continue to monitor our marketing materials and website to ensure that we include female students and those from diverse backgrounds. Our future recruitment strategy includes visits to universities by female staff, including the centre director, and female-only student open days.

Training - We are creating a culture of awareness at the Centre to increase diversity by providing Unconscious Bias Training for academics and professional support staff, and a mandatory on-line Diversity in the Workplace training course for all students in the first year of their PhD. Speakers at our Annual Conference and Gateway training seminars from academia and industry will be selected to reflect our commitment to diversity.

Support - We will promote increased student satisfaction by creating an inclusive, supportive learning environment. We will address the issue of potential isolation that frequently arises from low representation in small cohorts by supporting cross-cohort activities, cross-CDT events and links to the wider PhD student communities within the institutions, which have sufficient mass to overcome this issue.
Inclusion will be enhanced by providing female-only events (e.g. hackathons) and support groups, such as Women in Robotics Edinburgh (WiRE). The personalised Technical Learning Portfolio approach for CDT2 students is specifically designed to provide students with a flexible working pattern, thus maximising retention for students with personal circumstances e.g. for carers or those with health-related issues.
We recognise that ED&I is a matter for all staff and students within the Centre but to ensure that we are able to provide the required level of support, Professor Barbara Webb is primarily responsible for ED&I and Dr Michael Herrmann will provide pastoral care.

The CDT is a partnership between Heriot-Watt University and the University of Edinburgh and is fully aligned with the ED&I policies of these institutions which can be found at the below links.
Heriot-Watt University
University of Edinburgh

Equality, Diversity and Inclusion Activities

The Centre Executive has been working hard during the last academic year to ensure that we actively address ED&I matters at all stages of the student life cycle.

Staff closely involved in advertising for recruitment attended a workshop led by Equate Scotland on inclusive recruitment practices. After the workshop, the language used in our main application sites was revised to be more welcoming and encouraging to a range of applicants. The next phase will include providing guidance to academics responsible for writing research project descriptions including good practice examples.

We were aware that there was potential for unconscious bias in our recruitment process and we have addressed this by requiring all academics involved to undertake unconscious bias training and ensuring that we have a female academic on interview panels for female students. A core interview panel, standardised interview questions and a clear written record of the interview proceedings ensure consistency in our recruitment practices.

Students are asked to complete online Diversity in the Workplace training when they start the CDT programme, and it is proposed that we organise a student workshop to explore EDI issues in robotics as soon as possible. The CDT also collaborates with CDTs from the School of Informatics at the University of Edinburgh to survey students on how well the ED&I policies work and we act on feedback provided.

The CDT-RAS Female Mentorship Programme was created in February 2021 to empower and inspire female students and to help combat feelings of isolation. It supports the student-led WiRE (Women in Robotics Edinburgh) group, and was set up in response to the WiRE Group identifying a need for advice and guidance. The Mentorship Programme connects CDT-RAS female students to inspirational women in the field of robotics and AI through seminars and mentorship sessions, complemented by networking opportunities. This programme is currently being trialled with our female students and we intend to make this available to all students in the CDT in the future.

The Centre has submitted an application to the Minerva Informatics Equality Award which recognises best practices in European Universities and Research Labs that encourage and support the careers of women in Informatics research and education. We expect to hear the outcome of our application later in 2021.

Going forward, we will be highlighting the successful trajectories of our female graduates as inspiration for future applicants to the programme.

Student staff picnic August 2021 followed by a game of rounders

Centre Impact

In the 8 years since the Edinburgh Centre for Robotics (ECR) commenced operations in 2013, over £120m of core investment has been secured from the Research Councils, Industry and the Universities. This has established the buildings, equipment, staff, postdocs and students of a research and innovation Centre of international standing, providing an enhanced platform for additional project work in EU, EPSRC and MoD funded projects for a number of academics, postdocs and over 100 PhD students.

Beyond the scientific impact through high quality international publications, ECR uniquely operates a spiral approach to innovation with its industrial partners in programmes such as the EPSRC ORCA Hub (https://orcahub.org/). Industrial partners develop use cases and requirements for novel technologies in their planned products and services. From these, capability demonstrations are identified for applied researchers to attempt through a series of short term sprints. As these develop, so the industrial requirements evolve also, to converge on a final set of demonstrations with commercial relevance. Where the market conditions are right, this can then release resources for product development through industrial or venture investment.

Using this approach, the Centre's technologies and skills have created and supported successful international businesses including SeeByte, Coda-Octopus, Hydrason and Ice Robotics, alongside licensing for example with Touch Bionics. Recently Centre staff have supported the creation and growth of spin-out Alana and start-ups Robotical (through the Royal Academy of Engineering Enterprise Fellowship scheme) and Consequential Robotics with the international designer Sebastian Conran and the University of Sheffield. This approach will be further developed as the National Robotarium gets underway.

Our businesses have developed autonomous drones now commercially carrying out inspection of critical infrastructure, especially offshore in deep water. New forms of dolphin-inspired acoustic sensing are externally inspecting inside pipelines and tubular structures. New designs of prosthetic hands have benefited from advanced control system design using machine learning.

From our work, affordable fully programmable, customisable walking robots are revolutionising how robotics, AI and STEM subjects are taught in schools and universities. New generations of companion and assistive robots are changing the way we support an ageing and isolated population. Shared-autonomy developments are reducing costs for renewable energy and order fulfilment in distribution warehouses and manufacturing.

Creating autonomous systems that are trustworthy will be key for generating impact. The Centre is playing a key role in the UKRI Programme on Trustworthy Autonomous Systems (TAS) with two Node projects working closely with industry partners. One of these is on Governance and Regulation and led by Professor Ramamoorthy, and the other is on Trust, led by Professor Helen Hastie.

Another significant project with industry is the EPSRC Prosperity Partnership funding (£2.2m) for collaboration between Heriot-Watt University and SeeByte to explore human-machine teaming in the maritime environment.

During the coronavirus pandemic, teams have utilised Digital Twin technology to develop and test prototypes from their homes before progressing to testing in the real world. This makes it

much faster to re-purpose smart machines for new applications or customers. Achieving this increases resilience to large economic shocks, and creates new market opportunities. Smart machines can play an essential role improving our resilience in the low-touch economy of our post-Covid world. They can assist humanity by disinfecting hospitals, moving and organising goods in warehouses, maintaining offshore energy infrastructures, supporting surgical procedures, food preparation and even serving in restaurants and coffee bars. The centre is currently identifying and working on such initiatives to assist society and aid economic recovery in this challenging time.

The success of this research translation methodology has been recognised and resourced by the new National ROBOTARIUM institute scheduled to open early in 2022. It will bring a purpose built 5,000sqm building with living labs as the pivot for translation from research to products, co-located with international companies, startups and an incubator/accelerator.

The Centre is closely linked with the Alan Turing Institute through Programme Directorship of the RAI programme within the UK national centre for Data Science and AI. We engage at the highest levels of Government in both the UK and Scotland, with a ministerial appointment as co-chair of the Robotic Growth Partnership and through participation in the UK AI Council and staff in the AI Strategy Working Group for Scottish Government. These engagements allow the Centre to continue to develop and support the evolution of the UK as an international innovative economic force and a place where businesses and people come to develop their skills and technology.

Contacts - Academic
CDT RAS 2019-2027

Prof Helen Hastie
Director
Heriot-Watt University
h.hastie@hw.ac.uk

Prof Michael Mistry
Director
University of Edinburgh
michael.mistry@.ed.ac.uk

Prof Nick Taylor
Deputy Director
Heriot-Watt University
n.k.taylor@hw.ac.uk

Dr Adam Stokes
Deputy Director
University of Edinburgh
adam.stokes@ed.ac.uk

Contacts - Academic
CDT RAS 2014-2022

Prof Helen Hastie
Director
Heriot-Watt University
h.hastie@hw.ac.uk

Prof Sethu Vijayakumar
Director
University of Edinburgh
sethu.vijayakumar@ed.ac.uk

Prof Nick Taylor
Deputy Director
Heriot-Watt University
n.k.taylor@hw.ac.uk

Dr Michael Herrmann
Deputy Director
University of Edinburgh
michael.herrmann@ed.ac.uk

Contacts - Business Development

Claire Ordoyno
Heriot-Watt University
C.Ordoyno@hw.ac.uk

Dr Grant Sellar
Heriot-Watt University
G.Sellar@hw.ac.uk

Cristian Novotny
University of Edinburgh
cnovotny@ed.ac.uk

Contacts - Administration

Anne Murphy
Heriot-Watt University
anne.murphy@hw.ac.uk

Neil Heatley
University of Edinburgh
neil.heatley@ed.ac.uk.

Jacqueline McCarthy
Heriot-Watt University
j.mccarthy@hw.ac.uk

Zoe McGonigle
University of Edinburgh
z.mcgonigle@ed.ac.uk

Contacts - Technical

Len McLean
Heriot-Watt University
L.McLean@hw.ac.uk

Dr Vladimir Ivan
University of Edinburgh
v.ivan@ed.ac.uk

EPSRC Centre for Doctoral Training
Robotics and Autonomous Systems

TRAINING
EDINBURGH CENTRE FOR ROBOTICS

Robots that can learn, adapt and make decisions will revolutionise our economy and society over the next 20 years. They will work for us, beside us, assist us and interact with us. It is estimated that by 2025 such advanced robotic and autonomous systems (RAS) could have a worldwide economic impact of $1.7 trillion to $4.5 trillion annually, with an emerging market value of €15.5 billion.

The Edinburgh Centre for Robotics is advancing the UK's industrial potential in this revolution by producing a new generation of highly skilled researchers, trained to take a leading role. They are technically skilled, industry and market aware, and prepared to create and lead the UK's innovation pipeline for jobs and growth.

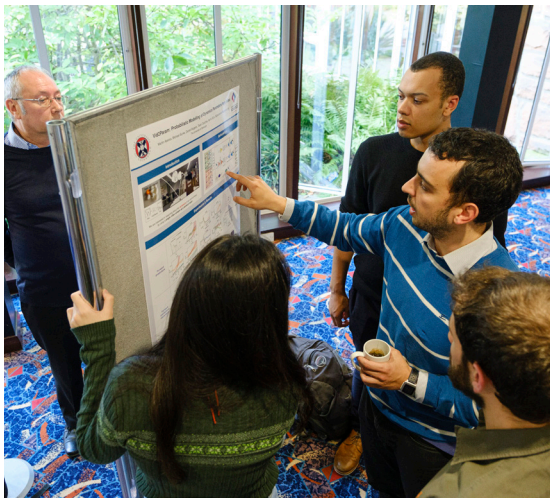
Our Doctoral students are part of a multi-disciplinary enterprise, requiring sound knowledge of physics (kinematics, dynamics), engineering (control, signal processing, mechanical design), computer science (algorithms for perception, planning, decision making and intelligent behaviour, software engineering), as well as allied areas ranging from biology and biomechanics to cognitive psychology. Our students specialise in one of these areas, gaining a deep understanding of technical aspect and theoretical foundations. They also receive broad training across these fields so as to meaningfully engage with a wide cross section of the robotics community.

Achieving impact with robotics also requires non-technical skills, for example an understanding of technology translation, creativity and entrepreneurial processes. These are an essential component of the CDT programme, captured in the #Cauldron training programme.

We offer around 15 studentships per year. Funding comes from EPSRC, Industrial Partners, Heriot-Watt University and the University of Edinburgh.

Key Benefits
EPSRC Centre for Doctoral Training
Robotics and Autonomous Systems

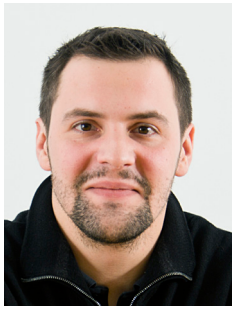
- Fully funded 4-year studentships covering tuition fees and maintenance at prevailing EPSRC rates and project related costs.
- Access to our world class infrastructure, enhanced through our £9m capital equipment facility and the £26m National ROBOTARIUM.
- Students benefit from supervision by academic experts from both institutions and graduate with a joint PhD from Heriot-Watt University and the University of Edinburgh.
- Excellent training opportunities, including some masters level courses in year one, supplemented by the #Cauldron programme, which includes training in commercial awareness, social challenges and innovation.
- Innovation funding available to support development of early commercialisation prototypes.
- Opportunities for international placements in prestigious labs with industry or international partners.
- Opportunities to work on group project, and compete in international robot competitions (e.g. RoboCup Search and Rescue, SAUC-E Autonomous Underwater Vehicle Challenge Europe), European Robotics League, Amazon Alexa Challenge.
- Opportunity for competitive selection for funding from Cambridge IGNITE and MIT Sloan School of Management Entrepreneurship Programmes.



Academic Supervisors

We are indebted to the academic supervisors of all cohorts, who are fundamental to the success and direction of the research undertaken in the Centre.

Dr Stefano Albrecht
s.albrecht@ed.ac.uk
University of Edinburgh



Dr Yoann Altmann
y.altmann@hw.ac.uk
Heriot-Watt University

Dr Morteza Amjadi
m.amjadi@hw.ac.uk
Heriot-Watt University

Professor Lynne Baillie
l.baillie@hw.ac.uk
Heriot-Watt University

Dr Vaishak Belle
vaishak@ed.ac.uk
University of Edinburgh

Dr Keith Brown
k.e.brown@hw.ac.uk
Heriot-Watt University

Professor Mike Chantler
m.j.chantler@hw.ac.uk
Heriot-Watt University

Dr Mauro Dragone
m.dragone@hw.ac.uk
Heriot-Watt University

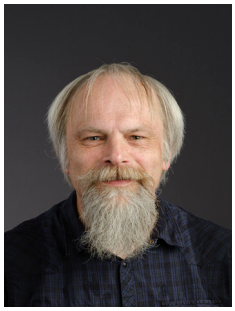
Dr Mustafa Suphi Erden
m.s.erden@hw.ac.uk
Heriot-Watt University

Dr Francesco Giorgio-Serchi
f.giorgio-serchi@ed.ac.uk
University of Edinburgh

Academic Supervisors

We are indebted to the academic supervisors of all cohorts, who are fundamental to the success and direction of the research undertaken in the Centre.

Professor Helen Hastie
h.hastie@hw.ac.uk
Heriot-Watt University



Dr Michael Herrmann
michael.herrmann@ed.ac.uk
University of Edinburgh

Professor Katya Komendantskaya
e.komendantskaya@hw.ac.uk
Heriot-Watt University

Dr Ioannis Konstas
i.konstas@hw.ac.uk
Heriot-Watt University

Professor Oliver Lemon
o.lemon@hw.ac.uk
Heriot-Watt University

Dr Zhibin Li
zhibin.li@ed.ac.uk
University of Edinburgh

Dr Katrin Lohan
k.lohan@hw.ac.uk
Heriot-Watt University

Dr Michael Lones
m.lones@hw.ac.uk
Heriot-Watt University

Professor Michael Mistry
michael.mistry@ed.ac.uk
University of Edinburgh

Professor Yvan Petillot
y.r.petillot@hw.ac.uk
Heriot-Watt University

Academic Supervisors

We are indebted to the academic supervisors of all cohorts, who are fundamental to the success and direction of the research undertaken in the Centre.

Dr Ron Petrick
R.Petrick@hw.ac.uk
Heriot-Watt University

Professor Subramanian Ramamoorthy
s.ramamoorthy@ed.ac.uk
University of Edinburgh

Professor Verena Rieser
v.t.rieser@hw.ac.uk
Heriot-Watt University

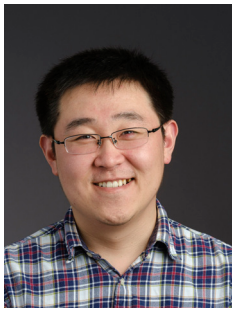
Dr Laura Sevilla
lsevilla@inf.ed.ac.uk
University of Edinburgh

Dr Adam Stokes
adam.stokes@ed.ac.uk
University of Edinburgh

Professor Nick Taylor
n.k.taylor@hw.ac.uk
Heriot-Watt University

Dr Patricia Vargas
p.a.vargas@hw.ac.uk
Heriot-Watt University

Professor Sethu Vijayakumar
sethu.vijayakumar@ed.ac.uk
University of Edinburgh



Dr Sen Wang
s.wang@hw.ac.uk
Heriot-Watt University

Professor Barbara Webb
bwebb@inf.ed.ac.uk
University of Edinburgh

Our students - 2016 cohort

Martin Asenov
m.asenov@ed.ac.uk
Robot Learning Using Physics-Informed Models

Ioannis Chalkiadakis
ic14@hw.ac.uk
Efficient and scalable statistical approaches to Natural Language Processing

Siobhan Duncan
sd246@hw.ac.uk
Swarm Robotics Applied to Search and Rescue Scenarios

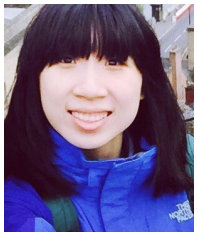
Francisco Mendonça
fm39@hw.ac.uk
Journeying from Embodiment to Emotions and Feelings in Artificial Cognitive Systems

Jamie Roberts
s1686485@ed.ac.uk
Task Decomposition in Multi-Robot Systems

Hugo Sardinha
hs20@hw.ac.uk
Merging Swarm Intelligence and Probabilistic Motion techniques in Search and Rescue missions

Joshua Smith
s1686489@sms.ed.ac.uk
Human-Robot Collaboration and Robotic Dynamic Identification

William Smith
ws8@hw.ac.uk
'Deep Learning for Visual Navigation and Place Recognition



Xinnuo Xu
xx6@hw.ac.uk
User Simulator for Social Dialogue Generation

Our students - 2017 cohort

Èric Pairet Artau
eric.pairet@ed.ac.uk
Behaviour-driven Motion Synthesis

Yaniel Carreno
y.carreno@hw.ac.uk
Long-Term Autonomy for Multi-Agent Systems in the Maritime Domain

Henrique Ferrolho
henrique.ferrolho@ed.ac.uk
Robust Trajectory Optimisation for Constrained Dynamic Systems

Helmi Fraser
hmf30@hw.ac.uk
Semantically Augmented Deep Learning for Mobile Robots

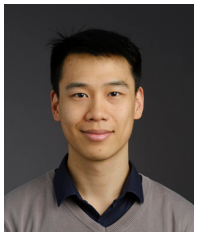
Billy Lyons
billy.lyons@ed.ac.uk
information Geometry and Reflexive Reinforcement Learning

Christopher McGreavy
c.mcgreavy@ed.ac.uk
Feasible and Robust Dynamic Motion for Legged Robots

Jun Hao Alvin Ng
alvin.ng@hw.ac.uk
Efficient Relational Reinforcement Learning

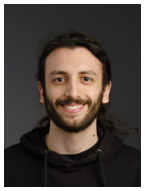
Paola Ardón Ramírez
paola.ardon@hw.ac.uk
Towards Robust Robotic Grasp Affordances

Alessandro Suglia
as247@hw.ac.uk
Deep Learning models for Interactive Grounded Language Learning



Kai Yuan
kai.yuan@.ed.ac.uk
Control and Learning of Versatile Legged Mobility on Complex Terrain

Our students - 2018 cohort



Filippos Christianos
f.christianos@ed.ac.uk
Deep Multi-agent Reinforcement Learning

Traiko Dinev
traiko.dinev@ed.ac.uk
Computational Co-design and Motion Planning

Ian Johnson
ij15@hw.ac.uk
Object-Level Semantic Mapping, Localisation and Navigation in Complex Challenging Environments

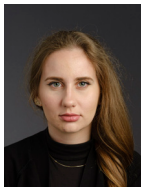
Mateusz Ochal
mo29@hw.ac.uk
Few-Shot Learning for Underwater Optical and Sonar Images

Jhielson Montino Pimentel
jm210@hw.ac.uk
Towards More Biological Plausible Models Applied to Robot Control Systems using Spiking Neural Network

Gary Smith
gbs2@hw.ac.uk
Probabilistic Logic Programming for Intent Recognition

Artūras Straižys
A.Straizys@sms.ed.ac.uk
Force Feedback in Manipulation of Deformable Objects

Nathan Western
nw29@hw.ac.uk
Computer Vision and Automation for Industrial Application



Miruna Clinciu
mc191@hw.ac.uk
Explainable Artificial Intelligence (XAI)

Evripidis Gkanias
ev.gkanias@ed.ac.uk
Memory Acquisition and Retrieval in the Insect Brain

Borja Marin
bm86@hw.ac.uk
Computer Vision Based Damage Assessment in Civil Structures

Georgios Papoudakis
g.papoudakis@ed.ac.uk
Unsupervised and Reinforcement Learning in Multi-Agent Systems

Karin Sevegnani
karin.sevegnani@hw.ac.uk
Topic Transitions in Open-domain Dialogue

Ronnie Smith
ronnie.smith@ed.ac.uk
Adaptation of Multi-Agent Systems in Ambient Assisted Living

Eleftherios Triantafyllidis
eleftherios.triantafyllidis@ed.ac.uk
Multi-Modal Interaction and Manipulation

Our students - 2019 cohort

Fazl Barez
F.Barez@sms.ed.ac.uk
Constrained Machine Learning for Interpretability and Robustness

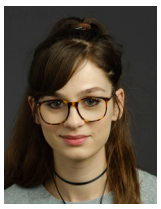
Alexandre Colle
ac385@hw.ac.uk
The Role of Aesthetics in Social Robotic Design

Elliot Fosong
e.fosong@ed.ac.uk
Safe and Efficient Exploratory Probing in Multi-Agent Systems

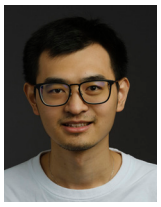
Daniel Layeghi
d.layeghi@sms.ed.ac.uk
Behaviour Discovery by Combining Learning-Based Control and Trajectory Optimisation

Shreyank Narayana Gowda
s1960707@ed.ac.uk
Holistic Video Understanding Integrating Vision and Language

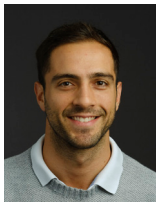
Emily Rolley-Parnell
emily.rolley-parnell@ed.ac.uk
Robotic Control Inspired by the Object Manipulation Performed by Harvester Ants



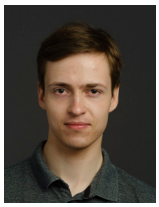
Robin Trute
rjt3@hw.ac.uk
Visual Cues Of Soft Tissue Behaviour In Robotic Surgery



Wei Yu
wy27@hw.ac.uk
A Novel Lifelong Learning Method Applied to Real-Life settings



Andreas Christou
andreas.christou@ed.ac.uk
Enhancing Gait Rehabilitation with Robotic Assistance and Functional Electrical Stimulation



Paulius Dilkas
p.dilkas@sms.ed.ac.uk
Probabilistic Inference via Weighted Model Counting: Algorithms, Encodings, and Random Instances

Konstantinos Gavriilidis
kg47@hw.ac.uk
Explainable Autonomy in the Maritime Domain

Emilyann Nault
en27@hw.ac.uk
Socially Assistive Robots and Sensory Feedback for Mild Cognitive Impairment and Dementia Cognitive Rehabilitation

Pierre Nicolay
pon1@hw.ac.uk
Lifelong Learning for Vision based AUV Control

Ioannis Skottis
s1408689@sms.ed.ac.uk
Design & Control of Fluidic Machines

Liam Wellacott
lw88@hw.ac.uk
A Neurorobotics and Spiking Neural Networks Approach to Cognitive Faculties of Reasoning and Planning

Carlos Zapico
cs377@hw.ac.uk
Adaptive Interaction Control for Underwater Manipulation

Our students - 2020 cohort

Fernando Acero
fernando.acero@ed.ac.uk
Meta-learning of Multiple Motor Control Skills for Autonomous Robots

Paul Baisamy
P.Baisamy@sms.ed.ac.uk
Variable Stiffness Actuation for Bioinspired Underwater Propulsion

Ted Ding
yd2007@hw.ac.uk
Joint Defogging and Stereo Reconstruction for Automotive Applications

Mhairi Dunion
mhairi.dunion@ed.ac.uk
Causal Inference in Deep Reinforcement Learning

Fraser Garrow
fg28@hw.ac.uk
Genetic Program Synthesis and Improvement for Robotics Systems

Supun Hemanthage
hsb2000@hw.ac.uk
Language Grounding In Conversational Agents

Georgios Kamaras
g.kamaras-1@sms.ed.ac.uk
Data-Driven Modelling and Simulation of Deformable Materials

Malvina Nikandrou
mn2002@hw.ac.uk
Continual Learning in Multimodal Interactive Settings

Emanuele De Pellegrin
ed50@hw.ac.uk
Learning Epistemic Actions Effects in a Human Collaborative Environment

Isobel Voysey
i.a.voysey@sms.ed.ac.uk
Development of a Minimal Animate Robot for Animal Welfare Education

Simon Wanstall
sw31@hw.ac.uk
Development of Soft Robotic Prosthetic Technologies

Our students - 2021 cohort

Carl Bettosi
cb54@hw.ac.uk
Prof Lynne Baillie

Dany Fung
cf2026@hw.ac.uk
Dr Wei Pang

Maks Gepner
m.gepner@ed.ac.uk
Dr Adam Stokes

Gen Li
li.gen@ed.ac.uk
Dr Laura Sevilla

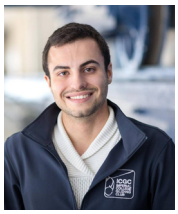
Meriam Moujahid
mm470@hw.ac.uk
Dr Christian Dondrup

Aruna Raman
A.Raman-1@sms.ed.ac.uk
Prof Barbara Webb

Alex Swift
as184@hw.ac.uk
Dr Matt Dunnigan

Hao Yu
hy2020@hw.ac.uk
Dr Suphi Erden

Fangqiang Ding
F.Ding-1@sms.ed.ac.uk
Dr Chris Xiaoxuan Lu



Samuel Garcin
s.garcin@ed.ac.uk
Dr Stefano Albrecht/ Dr Chris Lucas

Craig Hamilton
ch40@hw.ac.uk
Dr Yoann Altmann

Ruaridh Mon-Williams
ruaridh.mw@ed.ac.uk
Prof Sethu Vijayakumar

Georgios Pantazopoulos
gmp2000@hw.ac.uk
Dr Arash Eshghi

Weronika Sieinska
wms2000@hw.ac.uk
Prof Oliver Lemon

Nikolas Vitsakis
nv2006@hw.ac.uk
Prof Verena Rieser

Our Alumni

Dr Marian Andrecki (2015 cohort)
Supervisor: Professor Nick Taylor
Marian successfully defended his thesis titled "Predictive and Reactive Reinforcement Learning from Images" in January 2021.
Marian is now working as a Machine Learning Engineer at Proportunity in London.

Dr Daniel Angelov (2015 cohort)
Supervisor: Professor Subramanian Ramamoorthy
Daniel successfully defended his thesis titled " Composing Diverse Policies for Long-Horizon Tasks" in April 2021.
Daniel is currently CTO and co-founder of Efemarai.com, a platform for testing and improving ML continuously.

Dr Andrew Brock (2015 cohort)
Supervisor: Dr Theo Lim
Andrew successfully defended his thesis titled "Machine Analysis of Engineering Drawings" in February 2020.
Andrew now works at DeepMind in London.

Dr Iordanis Chatzinikolaidis (2016 cohort)
Supervisor: Dr Zhibin Li
Iordanis successfully defended his thesis titled " Optimization-based Multi-contact Motion Planning for Legged Robots" in May 2021.
Iordanis now works as a software engineer at CMR Surgical providing minimal access surgery.

Dr Emmanuel Kahembwe Mbabazi (2014 cohort)
Supervisor: Professor Subramanian Ramamoorthy
Emmanuel successfully defended his thesis titled " Efficient Methods and Architectures for Deep Neural Network Sequence Models" in March 2021.
Emmanuel plans to continue researching manifold transduction as it may offer a way to deeply merge the current work in adaptive robot control and online machine learning.

Dr Teun Krikke (2014 cohort)
Supervisor: Dr Frank Broz
Teun successfully defended his thesis titled "Speech Dereverberation and Speaker Separation Using Microphone Arrays in Realistic Environments" in December 2020.

Our Alumni

Dr Ross McKenzie (2015 cohort)
Supervisor: Dr Adam Stokes
Ross successfully defended his thesis titled " Modular Robotics for Sorting" in November 2019.
Ross is currently working on localisation and mapping at Dynium Robot, a farming robot start-up.

Dr Wolfgang Merkt (2014 cohort)
Supervisor: Professor Sethu Vijayakumar
Wolfgang successfully defended his thesis titled " Experience-driven Optimal Motion Synthesis in Complex and Shared" in December 2019.
Wolfgang now works at the Oxford Robotics Institute as a post-doctoral researcher.

Dr Boris Mocialov (2015 cohort)
Supervisor: Professor Helen Hastie
Boris successfully defended his thesis titled " Data Mining and Modelling for Sign Language" in October 2020.
Boris now works for SINTEF in Norway as a research scientist in the smart sensor systems research group focusing on 3D computer vision.

Dr João Moura (2015 cohort)
Supervisor: Dr Suphi Erden
João successfully defended his thesis "Controlling and Learning Constrained Motions for Manipulation in Contact" in February 20210. He has now joined the Statistical Machine Learning and Motor Control (SLMC) research group at the University of Edinburgh.

Dr Christian Rauch (2015 cohort)
Supervisor: Professor Sethu Vijayakumar
Christian successfully defended his thesis entitled "Visual Articulated Tracking in Cluttered Environments" in March 2020.
Christian has joined the Statistical Machine Learning and Motor Control (SLMC) research group at University of Edinburgh.

Dr Raluca Scona (2014 cohort)
Supervisor: Professor Yvan Petillot
Raluca successfully defended her thesis entitled "Robust Dense Visual SLAM Using Sensor Fusion and Motion Segmentation" in February 2020.
Raluca has joined the Dyson Robotics Lab led by Professor Andrew Davison at Imperial College London as a Dyson Fellow.

Our Alumni

Dr Eli Sheppard (2015 cohort)
Supervisor: Dr Katrin Lohan
Eli successfully defended his thesis titled " Multimodal Representation Learning: An Unsupervised Approach to Symbol Grounding" in June 2020.
Eli is currently working as a computer vision engineer for Living Optics, a start-up developing hyperspectral imaging.

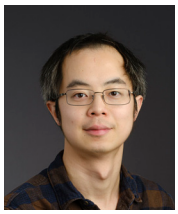
Dr Jan Stankiewicz (2015 cohort)
Supervisor: Professor Barbara Webb
Jan successfully defended his thesis titled "Using a Quadcopter to Model the Visual Navigation Behaviours of Flying Insects" in November 2020.
Jan is working as a research assistant in the Insect Robotics Group at the University of Edinburgh.

Dr Theodoros Stouraitis
Supervisors: Professor Sethu Vijayakumar and Dr Michael Gienger
Theo successfully defended his thesis titled "A Dyadic Collaborative Manipulation Formalism for Optimising Human Robot Teaming" in February 2021.
Theo is now working as a Research Associate at the Statistical Machine Learning and Motor Control group at the University of Edinburgh.

Students who have submitted initial thesis

Vibhav Bharti
vb97@hw.ac.uk
Detection and Tracking of Subsea Pipelines from an AUV

Mark Campbell
mc318@hw.ac.uk
Autonomous Sensor Fusion For Space Situational Awareness



Derek Chun
derek.chun@ed.ac.uk
Energy Based Control in Soft Robotic Systems for Physical Robot-Human Interaction

James Garforth
James.Garforth@ed.ac.uk
Monocular SLAM for UAVs in Natural Environments

Daniel Gordon
daniel.gordon@ed.ac.uk
Design, Control and Evaluation of Exoskeletons and Prostheses

Calum Imrie
calum.imrie@ed.ac.uk
Low Level Controller Schemes for Swarms and Simple Agents

Iris Kyranou
ik5@hw.ac.uk
Machine Learning Methods for Upper Limb Prosthesis Control Under the Presence of EMG Concept Drift

Thibault Lacourtablaise
tl3@hw.ac.uk
Manipulation of Uncooperative Objects in Zero-Gravity with Modular Self-Reconfigurable Robots

Tatiana Lopez
tl201@hw.ac.uk
Intuitive Physics, Robotic Manipulation of Fluids

Jose L. Part
jose.part@ed.ac.uk
Situated Interactive Lifelong Learning

Our Affiliated students

Group Photo from our 2018 conference

Alissa Potekhina
Amanda Cercas Curry
Amani Mansur Benhalem
Benjamin Gautier
Chris Mower
Christos Maniatis
Darius Roman
Francisco Javier Chiyah Garcia
Georgios Savva
Hanz Cuevas Velasquez
Ingo Keller
Ioannis Papaioannou
Ioannis Pisokas
Jack Geary
Jaiyi Wang
Jizbel Abel Johnson
Keyhan Kouhkiloui Babarahmati
Kirsty Duncan
Kyle Walker
Lucas Kirschbaum
Martin Ross
Matt Pugh
Max Marlon Randolph Baird
Miltiadis Katsakioris
Nanbo Li
Oguzhan Cebe
Puneet Chhabra
Ross Dickie
Saptarshi Mukherjee
Scott MacLeod
Shubham Agarwal
Todor Davchev
Yurdusev Yakup Akan
Ziyang Hong

Research Themes

RESEARCH
EDINBURGH CENTRE FOR ROBOTICS

Research in the Centre is underpinned by established bodies of theoretical work. We apply fundamental theoretical methods to real-world problems on real robots to solve pressing commercial and societal needs.

The central theme running throughout our research at the Centre for Doctoral Training is Safe Interaction, which is broken down into the following four themes:

1. **Physical Interactions** deals with the interaction between the robot and the environment and includes studies in control, actuation, compliance, sensing, mapping, planning, embodiments, swarms.
2. **People Interactions** deals with interactions between robots and humans in a variety of settings and applications, and includes studies in human-robot interaction, affective robotics, smart spaces, human-robot teaming, collaborative decision-making, cobots, multimodal interfaces.
3. **Self-Interactions** deals with introspection for condition monitoring, prognosis, explainable AI, certification, verification, safety, security, multi-agent interactions.
4. **Interaction Enablers** deals with core technologies for Robotics and Autonomous Systems and includes studies in vision, embedded and parallel computing, novel and soft fabrication methods, optimisation, (transparent) machine learning, deep reinforcement learning and other AI techniques inc. natural language processing (NLP).

Research and innovation in the Centre focuses on new ways to make robots interact: with the **environments** around them, seeing, mapping, touching, grasping, manipulating, balancing; with **people**, understanding mood or emotion, using different sensory pathways including sight, touch, speech, gesture while predicting intentions and sharing plans; with **each other,** working collaboratively to achieve a task or capability; and with **themselves**, monitoring their self-health and performance.

We study the sensing, world modelling, planning and control architectures that can make these robots **persistently autonomous**, operating in unknown environments for extended periods adapting their plans in response to events to complete tasks. We also investigate **shared autonomy** where people and robots operate in highly synergistic ways to complete tasks.

We study nature to develop **bio-inspired** systems that sense and process data using the methods that have evolved in biological organisms. Finally, we also think about **ethical issues**, the decisions robots should and shouldn't be allowed to make, and the **regulatory** environments they work in.

Our Research Laboratories

Adaptive Intelligent Mechanisms and Robotics Group

The research activities in the Adaptive Intelligent Mechanisms and Robotics (AIMRobotics) Group include mechanisms, robotics, mechatronics and their industrial, biomedical and renewable energy applications. We have extensive expertise in parallel mechanisms and robotics, reconfigurable robots, adaptive robotic grippers, compliant mechanisms and deployable systems.
The group currently hosts several cutting-edge facilities such as a Force Dimension Dual Sigma 7 haptic device, a PI photonics alignment system, a PI miniature hexapod, a Mecademic MECA500 ultracompact robot, UFACTORY xArm 7 and xArm 6 collaborative robots, a SOLOMON Solscan 3D Scanner, and Robotiq adaptive grippers.
In an ongoing EPSRC project, we are developing a smart assembly system for a digital twin-driven smart manufacturing system for high value-added products.

Autonomous Agents Research Group

The Autonomous Agents Research Group is a research unit within the School of Informatics, University of Edinburgh. Research in the group is centred on the development of artificial intelligence and machine learning technologies toward the realisation of intelligent agents (such as software agents and robots) which can act autonomously to solve tasks in complex environments. The group has a strong focus on problems of coordination and cooperation in multi-agent systems, in which multiple autonomous agents interact in a shared environment. Current research focuses on inference and planning in multi-agent systems and algorithms for multi-agent deep reinforcement learning. The group is also active in the development of agent technology applications, including the areas of autonomous driving, warehouse logistics, and cyber security.
https://agents.inf.ed.ac.uk

Bioinspired Robotics Laboratory

Bioinspired robotics draws on solutions found in nature for robotics problems, such as efficient locomotion control, effective navigation over short and long distances and adaptive learning to flexible and noisy environments. In this lab we focus on understanding how insects, with their tiny brains, can support a range of capacities that easily outclass state-of-the-art robots. The lab carries out behavioural studies, in the lab and in the field, but principally develops computational models of the underlying neural mechanisms, which are tested on robot hardware. Recent projects include a neural model of odometry in the bee brain, tested on a flying robot platform and an exploration of the learning capacities of maggots, which led to development of a novel learning algorithm that has proved effective on several benchmark robotics tasks.

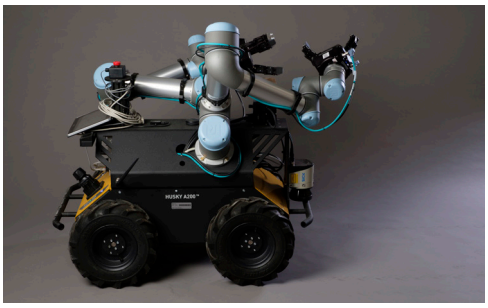
CyberBuild Research Laboratory

The construction sector, which represents between 5 and 10% of the GDP of modern economies, is undergoing a digital revolution that will transform the way we build and maintain our buildings and infrastructure. The CyberBuild Lab, based in the School of Engineering at the University of Edinburgh, supports this transformation by researching and developing technologies in the areas of scene understanding for environment modelling and monitoring, digital twinning, human-robot interaction and more. Examples of on-going research include: 3D asset modelling from point clouds and images (including using AI), automated dimensional quality control, human-robot interaction using AR. Our work is primarily conducted in multi-disciplinary settings and in collaboration with industry partners.
https://cyberbuild.eng.ed.ac.uk/

Our Research Laboratories

Field Robotics Laboratories

Our research at Robotarium West focuses on enabling mobile robots and autonomous systems to understand real-world complex environments and achieve persistent autonomy in them. Research areas include robotic vision, simultaneous localisation and mapping (SLAM), autonomous navigation, 3D mapping and reconstruction, robot learning, computer vision and machine (deep) learning. The Lab has a Clearpath Husky mobile robot, a highly advanced and adaptable mobile robotics platform which is equipped with a variety of state-of-the-art sensors and manipulators (dual UR5 arms, LIDAR, Inertial Measurement Unit, stereo camera), to fulfil field missions even across challenging terrains. Our work on aerial swarm robots for autonomy and efficiency also addresses robot coordination tasks in critical activities. The industrial applications of our research range from smart transport and delivery systems to outdoor inspection and emergency response challenges.



Our lab at Robotarium East houses field robots designed to work in extreme and hazardous environments. It includes construction of mock-ups for the offshore and built environment infrastructure asset inspection sector based around the Total Argos Challenge mock up with ANYmal quadruped robot for sensor deployment. The lab is also equipped with fuselage co-assembly and manipulation mock up using a mobile Husky robot with multi arm manipulators for the airline assembly and maintenance, offshore asset inspection, and manufacturing sectors. The space also houses the Valkyrie humanoid robot (collaboration with NASA JSC) with additional mock-ups being constructed to replicate uneven terrain loco-manipulation tasks on the Mars mission. The loco-manipulation platform is a modular scaffolding structure conceived to simulate industrial real-life environment in the robotic field-laboratory, which includes ramps and stairs that can be reconfigured to simulate a multitude of scenarios. This will be expanded with a high precision KUKA IIWA dual arm system including integrated force sensing for precise manipulation and safe human robot collaboration. The setup will incorporate real-time Sigma.7 haptic devices with high fidelity for users to sense interaction forces and teleoperate better the torque controlled robots. Together with the VR/AR display and computing units, this will also provide intuitive and versatile controls to the robot during multi-contact and multi-modal operations in extreme and/or hazardous settings. All of this will be supported by a Vicon motion tracking system using 24 cameras along with a variable speed dual x-y-z heavy duty gantry system for support of dynamic locomotion on uneven terrain.

Our Research Laboratories

Gait Laboratory

This laboratory houses the Motek split treadmill with a force plate setup to carry out human lower limb prosthesis motion tests and Exoskeleton support experiments. Data capture is supported through a 12 camera Vicon tracking system along with wireless EMG and Xsens inertial tracking systems. Experiments here are run in collaboration with the NHS Astley Ainslie Hospital and the NHS Newcastle Gait labs, expanding our existing collaboration with local partners.

Human-Robot Interaction (HRI) Laboratory

The Human Robot Interaction (HRI) Laboratory is located within the Robotarium West – a collaboration partnership with the University of Edinburgh. Research in this lab focuses on developing intelligent interactive systems which can collaborate effectively and adaptively with humans, by combining a variety of interaction modalities, such as speech, graphics, gesture, vision, augmented reality and Natural Language. Our systems combine statistical and symbolic information processing, and we are developing data-driven machine learning approaches to build robust agents which can adapt autonomously in uncertain and dynamic interactions. These techniques are applied in a variety of domains, such as conversational assistants (e.g. Alexa, Siri etc), conversational search, emergency response, technology enhanced learning, healthcare with a special interest in robot assisted rehabilitation in the home environment.

Facilities in the HRI lab and also in the Robotic Assistive Living lab allows us to take the evaluation in terms of performance of our models and algorithms from simulations to trials with real users with uninterrupted observation. This lab also has a variety of state-of-the-art robots, which were custom built for research (such as an iCub, Tiago and a Flash MKII) and commercially available social robots (such as Peppers, Naos, and MiROs). Having a wide miscellany of robots with different abilities and capabilities allows us to conduct research ranging from: Interactive Object Learning (IOL) in the area of Teachable Robots, to Robot-assisted Social Skill Training for Adults with ASD, and rehabilitation coaching of stroke survivors in the home environment.

For more information visit our website: https://www.macs.hw.ac.uk/hrigroup/

Integrated Soft Machines Lab

The Integrated Soft Machines Lab is part of the Institute of Mechanical, Process and Energy Engineering (IMPEE) at Heriot-Watt University. The lab aims to design multifunctional soft machines utilizing novel mechanical designs, advanced materials, bioinspired structures and digital manufacturing processes. Such soft systems have many applications, ranging from wearable medical devices for healthcare monitoring to non-invasive surgical tools and soft robots for safe human-robot interaction. The main research themes of the lab are soft robotics, wearable sensors for healthcare, bioinspired structures and digital manufacturing of soft machines. https://sites.google.com/view/ismlab

Our Research Laboratories

Interaction Laboratory

Our research focuses on conversational AI, Natural Language Processing and machine learning. We are developing intelligent interactive systems which can collaborate effectively and adaptively with humans, by combining a variety of interaction modalities, such as speech, graphics, gesture, vision, augmented reality and Natural Language. Our systems combine statistical and symbolic information processing, and we are developing data-driven machine learning approaches to build robust agents which can adapt autonomously in uncertain and dynamic interactions. These techniques are applied in a variety of domains, such as conversational assistants (e.g. Alexa, Siri etc), conversational search, emergency response, technology enhanced learning, healthcare informatics and human-robot interaction (HRI).

We evaluate the performance of our models and algorithms both in simulation and in trials with real users. The Interaction Lab was one of only three teams to reach the finals of the Amazon Alexa Challenge, both in 2017 and 2018. We lead the human-machine interaction work on the EPSRC ORCA Hub for interacting with robots and autonomous systems in remote, hazardous environments. Furthermore, trustworthy interaction is being explored by the UKRI Trustworthy Autonomous Systems Node on Trust.

Our projects include the H2020 MuMMER project, which focuses on interactive human-robot navigation around large indoor spaces such as shopping malls, and the H2020 SPRING project on social robotics for elderly care. Both of these projects also entertain and inform users via our Alexa challenge system, Alana.

We are also pushing the boundaries in Natural Language Generation, including open-domain response generation in conversational systems, multimodal grounding, and task-based data-to-text generation, where our team organised the highly subscribed E2E NLG Challenge. Projects in this area include 2 EPSRC funded projects on bias and security, industry collaborations with Adobe, Facebook and Google, as well as a senior research fellowship awarded by the Royal Society.

http://www.macs.hw.ac.uk/interactionlab/

Machine learning and symbolic systems Lab

The lab carries out research in artificial intelligence, by unifying ideas from machine learning and symbolic systems (logics, programs and plans), with a recent emphasis on explainability and ethics. We are motivated by the need to augment learning and perception with high-level structured, commonsensical knowledge, to enable systems to learn faster and more accurate models of the world. We are interested in developing computational frameworks that are able to explain their decisions, modular, re-usable and robust to variations in problem description. A non-exhaustive list of topics include: ethics and explainability in AI (e.g. fairness, moral reasoning, post-hoc explainability), unifying deep learning and probabilistic learning methods, probabilistic programming, automated planning, high-level programming, reinforcement learning, cognitive robotics, multi-agent systems and epistemic planning.

https://vaishakbelle.com/lab/

Our Research Laboratories

Ocean Systems Laboratory

This is a multidisciplinary science and engineering research centre that innovates, applies and teaches world class advances in autonomous systems, sensor modelling/processing, and underwater acoustic system theory/design for offshore, marine science, renewable energy and security applications.

In Autonomous Systems, we have developed novel planning, obstacle avoidance, world modelling, operator dialog and visual servoing methods for Autonomous Underwater Vehicles and integrated them within open system architectures.
In Sensor modelling and analysis, novel navigation algorithms have been developed sharing information from multiple sensors. Model-based detection and classification algorithms have been successfully developed and trialled seeking mine like objects, seabed trawling impact and marine mammals in acoustic and video data. Our method has always been to have a three point approach to research problems by linking theoretical analysis, software simulations and experimental validation. Our tank facilities and vehicles enable us to validate the theory and simulation findings in real experiments.
http://osl.eps.hw.ac.uk/

RAS Rapid Manufacturing and Design Studio

This facility (RMDS) encourages innovation and creation facilitated by digital and collaborative manufacturing tools. The Maker approach brings concepts and scientific principles to physical realisation facilitated by VR/AR, haptics, optical tracking, 3D scanning, 3D printing and laser cutting equipment. Besides research in digital manufacturing, concurrent engineering, collaborative design and review systems, we also research its associated human factors. RMDS has researched and implemented interactive systems using brain control, cyber-physical systems and body-area networks. RMDS is currently involved in an EU H2020 project to design and develop highly interactive mixed reality training environments. Supported by a bespoke multimodal data capture and synchronisation framework RMDS can offer innovative, versatile and comprehensive solutions in the area of knowledge/security/asset management, operational training and assessment, including functional art.
https://www.hw.ac.uk/uk/schools/engineering-physical-sciences/institutes/mechanical-process-energy-engineering/rapid-manufacturing-design-studio-rmds-.htm

Our Research Laboratories

Robotic Assisted Living Testbed

The Robotic Assisted Living Testbed (RALT) at Robotarium West is a fully sensorised 60m2 homelike environment where our roboticists and computer scientists work alongside usability and health experts, psychologists and people with assisted living needs to co-design and test innovative solutions for healthy ageing and independent living.

The research focus is on the combination of Robotics, AI and connected data systems to assist humans and triage issues and also to facilitate communication and connectivity as part of personalised and connected social care practices. The laboratory participates in international initiatives promoting the certification and systematic evaluation and comparison of assistive service robots and user-centred, open innovation ecosystems for the integration of R&D results into real life communities and settings.

The testbed, soon to be transferred to the National Robotarium, is instrumented to facilitate the creation of datasets capturing complex, interleaved and hierarchical naturalistic activities, collected in a very rich sensor environment. Datasets are curated using dedicated post-processing tools to annotate heterogeneous sensor tracks in order to facilitate the development of machine learning solutions for interpreting sensed data into activities of daily living and data analytics and data visualisation tools for the analysis of health and wellness data. In this sense, the RALT is a fundamental enabler of the Health & Social Care aspect of the Data Driven Innovation initiative, part of the Edinburgh and South East Scotland City Region Deal.

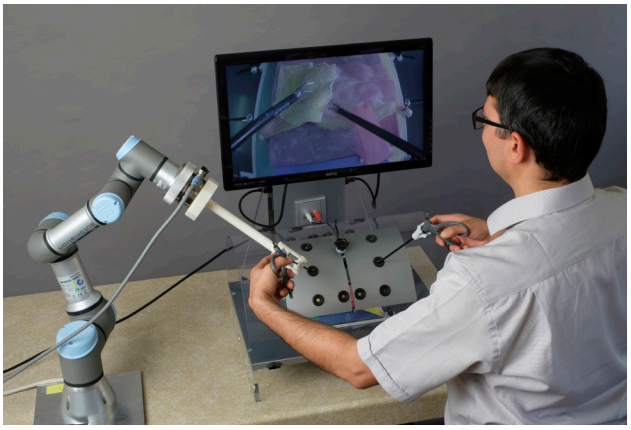
Robotic Micromanipulation and Microassembly Laboratory

The Robotic Micromanipulation and Microassembly Laboratory (RMML) develops techniques and solutions for fabrication and manufacturing of microdevices, microsensors, microsystems and microrobots. The capabilities are based on two decades of research in microsystem technology, especially methods and processes of microscale bonding and joining for interconnection, integration and packaging of sensors and microsystems. The current activities include the development of microgrippers which have been used to demonstrate assembly of 3D microstructures with an industrial partner. In an EPSRC funded project, we are developing microassembly methods for high temperature sensors and electronics capable of operation beyond 300°C. The research and knowledge have been transferred to postgraduate teaching in the EU funded Erasmus Mundus Joint Master Degree (EMJMD) Programme in Smart Systems Integration (https://ssi-master.eu/)

Our Research Laboratories

Skill Assistance Laboratory

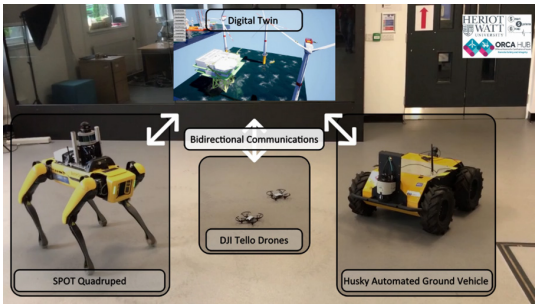
The research activities in this Lab include physical human-robot interaction, assistive robotics, skill assistance, mechatronics design, medical robotics, walking robots and machine learning. Specifically, our research has been focused on identifying what "skill" is in manipulation tasks, such as manual-welding in industry and laparoscopy in medicine, through analysing data of novice versus professional subjects in four different modalities: trajectories of tool movement, robotised measurement of mechanical hand impedance, EMG recording of arm muscle activities and near-infra-red spectroscopy recording of cortical brain activity. These data are analysed to find out the patterns of muscle activity that relate to the level of human skill. Brain activity monitoring provides a path-way to identify the skill level of subjects through criteria that cannot be consciously manipulated by the trainees. This might prove to be useful as a basis for making objective assessments and ultimately for providing individualised assistance in a variety of human-robot cooperative tasks.



https://researchportal.hw.ac.uk/en/persons/mustafa-suphi-erden

Smart Systems Group

The Smart Systems Group (SSG) facilities enable the design, implementation and lifecycle analysis of materials, components, systems and complex systems of systems. We have created a Symbiotic Systems of Systems Approach, through the utilisation of pre-existing robotic platforms coupled with our Symbiotic Digital Architecture and innovative sensing methods. This ensures we can support the increasing demands on vital critical infrastructure such as food, water and energy generation, telecommunications, the built environment, healthcare and transport. As these demands increase, the systems within each sector grow ever more complex and interdependent. The aim of the SSG is to transform raw data into actionable information. The insights generated create innovative, data informed Smart Systems that can assess, adapt and respond to dynamic conditions, with systems which collaborate, corroborate and cooperate. Our multidisciplinary team, with expertise in data analysis, artificial intelligence, prognostics, manufacturing, energy systems and sensing technologies, are focused on the design, manufacture and characterisation of transformative Smart Systems. Continuity of service from critical infrastructure and technology as a service trends are fuelling global demand for Smart Systems across all sectors of industry and services to society. We work with a global network of academic and industrial partners to deliver the flexibility, resilience and sustainability that our global infrastructure requires.



https://smartsystems.hw.ac.uk

Our Research Laboratories

Soft Systems Group

The Soft Systems Group is part of the Institute for Integrated Micro and Nano Systems in The School of Engineering at The University of Edinburgh. The group uses a wide range of bioinspired engineering approaches to tackle the most challenging issues faced by society.
The research group has an ever growing range of interests including: bioinspired engineering, sensors, robotics, microfluidics, micro/nano fabrication, wearable technology, diagnostics, bioelectronics and metamaterials. https://softsystemsgroup.com/

Strategic Futures Laboratory

Our research focuses on the use of AI tools to provide strategic overviews of large repositories of unstructured documents in order to aid high-level, evidence-based decision making. We use advanced machine learning and visualisation approaches to provide intuitive, hierarchical maps of large to vast document sets. Statistical data and easy drill-down are also provided for deep exploration, quantitative analysis and automated decision making. Examples of use include providing strategic level comparison of national UK, US and EU research portfolios (circa 200,000 projects), comparing strengths and complementarities of eight sister organisations and analysing trends in free of financial transactions.
http://strategicfutures.org

Virtual Reality Laboratory

High fidelity capture of human motion for work in collaboration with computer graphics and animation companies is carried out in this space which will host a range of cutting edge 3D real-time motion sensing and tracking capabilities. A 20+12 camera Vicon system is installed in addition to a more specialised motion capturing system with advanced software for tracking multiple subjects at the same time as well as hand gesture tracking. The lab also includes a high-frame rate 3dMD3D body scanner and facial motion tracking system, and Oculus Rift AR/VR displays. This facility will focus on state of the art animation, graphics, and augmented reality with applications to robotics, construction, remote inspection, entertainment and simulation and training for both research and the industry.

Watch our video of ARI introducing itself here

Student Research Outputs - Conference Publications

Wenbin Hu, **Iordanis Chatzinikolaidis, Kai Yuan,** Zhibin Li
Comparison Study of Nonlinear Optimization of Step Durations and Foot Placement for Dynamic Walking. Proceedings of IEEE International Conference on Robotics and Automation (ICRA), 2018, DOI 10.1109/ICRA.2018.8461101

Qingbiao Li, **Iordanis Chatzinikolaidis**, Yiming Yang, Sethu Vijayakumar, Zhibin Li
Robust Foot Placement Control for Dynamic Walking using Online Parameter Estimation, Proceedings of IEEE-RAS International Conference on Humanoid Robots, 2017, DOI 10.1109/HUMANOIDS.2017.8239552

A. Vanzo, **J. L. Part,** Y. Yu, D. Nardi and O. Lemon
Incrementally Learning Semantic Attributes through Dialogue Interaction, to appear in Proceedings of the 17th International Conference on Autonomous Agents and Multiagent Systems (AAMAS), Stockholm, Sweden, July 2018

J. L. Part and O. Lemon
Incremental Online Learning of Objects for Robots Operating in Real Environments, in Proceedings of the 7th Joint IEEE International Conference on Development and Learning and on Epigenetic Robotics (ICDL-EPIROB), Lisbon, Portugal, September 2017

J. L. Part and O. Lemon
Teaching Robots through Situated Interactive Dialogue and Visual Demonstrations, in Proceedings of the 26th International Joint Conference on Artificial Intelligence (IJCAI), Melbourne, Australia, August 2017

Artjoms Šinkarovs, Sven-Bodo Scholz, Robert Stewart, and **Hans-Nikolai Vießmann**
Recursive Array Comprehensions in a Call-by-Value Language. In IFL 2017: 29th Symposium on the Implementation and Application of Functional Programming Languages, August 30-September 1, 2017, Bristol, United Kingdom.

Henderson, Graham, **Daniel Gordon,** and Sethu Vijayakumar
Identifying Invariant Gait Metrics for Exoskeleton Assistance. In Proceedings of IEEE Robio 2017, IEEE International Conference on Robotics and Biomimetics

Raluca Scona, Simona Nobili, Yvan R. Petillot, Maurice Fallon
Direct Visual SLAM Fusing Proprioception for a Humanoid Robot
In Proceedings of International Conference on Intelligent Robots and Systems (IROS) 2017
DOI: 10.1109/IROS.2017.8205943

Raluca Scona, Mariano Jaimez, Yvan R. Petillot, Maurice Fallon, Daniel Cremers
StaticFusion: Background Reconstruction for Dense RGB-D SLAM in Dynamic Environments
In Proceedings of International Conference on Robotics and Automation (ICRA) 2018
DOI: 10.1109/ICRA.2018.8460681

Wolfgang Merkt, Yiming Yang, **Theodoros Stouraitis,** Christopher Mower, Maurice Fallon, Sethu Vijayakumar
Robust Shared Autonomy for Mobile Manipulation with Continuous Scene Monitoring. Proc. 13th IEEE Conference on Automation Science and Engineering, Xian, China (2017)

Yiming Yang, Vladimir Ivan, **Wolfgang Merkt** and Sethu Vijayakumar
Scaling Sampling–based Motion Planning to Humanoid Robots. Proc. IEEE International Conf. on Robotics and Biomimetics (ROBIO 2016), Qingdao, China (2016).

Wolfgang Merkt, Vladimir Ivan, and Sethu Vijayakumar
Leveraging Precomputation with Problem Encoding for Warm-Starting Trajectory Optimization in Complex Environments. Proc. IEEE International Conf. on Intelligent Robots (IROS 2018), Madrid, Spain (2018)

Student Research Outputs - Conference Publications

Kai Yuan, Zhibin Li
A Unified Model Predictive Control Framework for Gait Planning and Feedback Control of Legged Locomotion. Proceedings 2018 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)

Gordon, D. F. N., Matsubara, T., Noda, T., Morimoto, J., and Vijayakumar, S.
Bayesian Optimisation of Exoskeleton Design Parameters. Biomedical Robotics (BIOROB), 2018 IEEE International Conference on. IEEE, 2018.

Christian Rauch, Timothy Hospedales, Jamie Shotton, Maurice Fallon
Visual Articulated Tracking in the Presence of Occlusions, 2018 IEEE International Conference on Robotics and Automation (ICRA), Brisbane, Australia, 2018, pp. 643-650.
doi: 10.1109/ICRA.2018.8462873

È. Pairet, J. D. Hernández, M. Lahijanian, and M. Carreras
"Uncertainty-based Online Mapping and Motion Planning for Marine Robotics Guidance," in IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2018.

M. Campbell, I. Schlangen, E. Delande, and D. Clark
Image Registration Using Single Cluster PHD Methods, in Advanced Maui Optical and Space Surveillance Technologies Conference, 2017.

K. S. Lohan, **E. Sheppard,** G. E. Little, G. Rajendran
Distinguishing Children with ASD Using Pupil Diameter Metrics. 6th Joint IEEE International Conference on Development and Learning and on Epigenetic Robotics 2016

Tugal, H., **Gautier, B.**, Kircicek, M. & Erden, M. S.
Hand-Impedance Measurement During Laparoscopic Training Coupled with Robotic Manipulators 28 Jun 2018 (Accepted/In press) Proceedings of the 2018 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2018). IEEE

C. Yang, **K. Yuan, W. Merkt**, T. Komura, S. Vijayakumar, and Z. Li,
"Deep Reinforcement Learning of Locomotion Skills for the Humanoid Valkyrie" , IEEE International Conference on Humanoid Robots (Humanoids), 2018

Yiming Yang, **Wolfgang Merkt,** Vladimir Ivan, Sethu Vijayakumar
Planning in Time-Configuration Space for Efficient Pick-and-Place in Non-Static Environments with Temporal Constraints, Accepted to IEEE-RAS International Conference on Humanoid Robots, 2018.

Henrique Ferrolho, Wolfgang Merkt, Yiming Yang, Vladimir Ivan, Sethu Vijayakumar
Whole-Body End-Pose Planning for Legged Robots on Inclined Support Surfaces in Complex Environments, Accepted to IEEE-RAS International Conference on Humanoid Robots, 2018.

Y. Hristov, A. Lascarides, S. Ramamoorthy
Interpretable Latent Spaces for Learning from Demonstration, Conference on Robot Learning (CoRL), 2018.

Erden, M. S. & **Chun, H-T.**
Muscle Activity Patterns Change with Skill Acquisition for Minimally Invasive Surgery: A Pilot Study 31 May 2018 (Accepted/In press) Proceedings of the 7th IEEE RAS/EMBS International Conference on Biomedical Robotics and Biomechatronics (BioRob 2018).

João Moura, Mustafa Suphi Erden
Formulation of a Control and Path Planning Approach for a Cab Front Cleaning Robot . In Procedia CIRP, 5th International Conference on Through-life Engineering Services (TESConf), 2017, DOI: 10.1016/j.procir.2016.09.024.

Student Research Outputs - Conference Publications

Leopoldo Armesto, **João Moura,** Vladimir Ivan, Antonio Salas, and Sethu Vijayakumar
Learning Constrained Generalizable Policies by Demonstration. In Robotics: Science and Systems XIII (RSS), 2017, DOI: 10.15607/RSS.2017.XIII.036.

T. López-Guevara, N.K. Taylor, M.U. Gutmann, S. Ramamoorthy, K. Subr
Adaptable Pouring: Teaching Robots not to Spill Using Fast but Approximate Fluid Simulation, Conference on Robot Learning (CoRL), 2017.

S. Penkov, A. Bordallo, S. Ramamoorthy
Physical Symbol Grounding and Instance Learning through Demonstration and Eye Tracking, IEEE International Conference on Robotics and Automation, 2017.

Frost, Gordon, David M. Lane, **Nikolaos Tsiogkas,** Daniele Spaccini, Chiara Petrioli, Maarja Kruusmaa, Victoria Preston, and Taavi Salumäe
MANgO: federated world Model using an underwater Acoustic NetwOrk. In OCEANS 2017-Aberdeen, pp. 1-6. IEEE, 2017.

Tsiogkas, Nikolaos, Valerio De Carolis, and David M. Lane
Towards an Online Heuristic Method for Energy-constrained Underwater Sensing Mission Planning. In Intelligent Robots and Systems (IROS), 2017 IEEE/RSJ International Conference on, pp. 6801-6808. IEEE, 2017.

Mocialov, B., Vargas, P. A., & Couceiro, M. S.
Towards the Evolution of Indirect Communication for Social Robots. In Computational Intelligence (SSCI), 2016 IEEE Symposium Series on (pp. 1-8). IEEE.

HC Lin, **J Smith,** KK Babarahmati, N Dehio, M Mistry
A Projected Inverse Dynamics Approach for Multi-arm Cartesian Impedance Control - ICRA 2018

N Dehio, **J Smith,** D Leroy, G Xin, HC Lin, JJ Steil, M Mistry
Modeling & Control of Multi-Arm and Multi-Leg Robots: Compensating for Object Dynamics during Grasping - ICRA 2018

G Xin, HC Lin, **J Smith, O Cebe,** M Mistry
A Model-based Hierarchical Controller for Legged Systems subject to External Disturbances - ICRA 2018

A Brock, T Lim, JM Ritchie, N Weston
SMASH: One-Shot Model Architecture Search through HyperNetworks. ICLR 2018

A Brock, T Lim, JM Ritchie, N Weston
Neural Photo Editing with Introspective Adversarial Networks. ICLR 2017

Ardón P, S. Ramamoorthy, K.S. Lohan
Object Affordances by Inferring on the Surroundings, In Proc. IEEE Workshop on Advance Robotics and its Social Impact, 2018.

Brock, A., Lim, T., Ritchie, J. M. & Weston, N.
ConvNet-Based Optical Recognition for Engineering Drawings. ASME IDETC/CIE 2017

Brock, A., Lim, T., Ritchie, J. M. & Weston, N.
Context-Aware Content Generation for Virtual Environments. ASME IDETC/CIE 2016

È. Pairet, P. Ardón, F. Broz, M. Mistry, and Y. Petillot.
Learning and Generalisation of Primitives Skills Towards Robust Dual-arm Manipulation, in AAAI Fall Symposium Series, Reasoning and Learning in Real-World Systems for Long-Term Autonomy (AAAI-FSS), 2018.

M. Burke, **Y. Hristov,** S. Ramamoorthy
Hybrid System Identification using Switching Density Networks, Conference on Robot Learning (CoRL), 2019.

Student Research Outputs - Conference Publications

P. Ardón, È. Pairet, S. Ramamoorthy, and K. S. Lohan.
Towards Robust Grasps, Using the Environment Semantics for Robotic Object Affordances, in AAAI Fall Symposium Series, Reasoning and Learning in Real-World Systems for Long-Term Autonomy (AAAI-FSS), 2018.

J. L. Part and O. Lemon
Towards a Robot Architecture for Situated Lifelong Object Learning, to appear in Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), Macau, China, November 2019

J. H. Ng, R. Petrick
Incremental Learning of Action Models in Model-based Reinforcement Learning, International Joint Conferences on Artificial Intelligence (2019).

D. Angelov, Y. Hristov, S. Ramamoorthy
Using Causal Analysis to Learn Specifications from Task Demonstrations, In Proc. International Conference on Autonomous Agents and Multiagent Systems (AAMAS), 2019.

D. Angelov, Y. Hristov, S. Ramamoorthy
DynoPlan: Combining Motion Planning and Deep Neural Network based Controllers for Safe HRL, In Proc. The Multi-disciplinary Conference on Reinforcement Learning and Decision Making (RLDM), 2019.

È. Pairet, P. Ardón, M. Mistry, and Y. Petillot
Learning and Composing Primitive Skills for Dual-arm Manipulation, in Annual Conference Towards Autonomous Robotic Systems (TAROS19). Advanced Robotics at Queen Mary (ARQ) best paper award.

P. Ardón, È. Pairet, R. Petrick, S. Ramamoorthy, and K. S. Lohan
Reasoning on Grasp-Action Affordances, in Annual Conference Towards Autonomous Robotic Systems (TAROS19). Best paper award finalist.

È. Pairet, P. Ardón, X. Liu, J. Lopes, H. Hastie, and K. S. Lohan
A Digital Twin for Human-Robot Interaction, in ACM/IEEE International Conference on Human-Robot Interaction (HRI), 2019.

Carreno, Y., Petrick, R.P. and Petillot, Y.
Multi-Agent Strategy for Marine Applications via Temporal Planning. In 2019 IEEE Second International Conference on Artificial Intelligence and Knowledge Engineering (AIKE) (pp. 243-250). IEEE. June 2019.

Carreno, Y., Petrick, R.P. and Petillot, Y.
Towards Long-Term Autonomy Based on Temporal Planning. In Annual Conference Towards Autonomous Robotic Systems (pp. 143-154). Springer, Cham. July 2019.

Daniel E. Clark, **Mark Campbell**
Joint Multi-Target Tracking and Parameter Estimation with the Second-Order Factorial Cumulant Filter. 2019 22nd International Conference on Information Fusion (FUSION). Ottawa, Canada.

Ben Krause, **Emmanuel Kahembwe**, Iain Murray, and Steve Renals
Dynamic Evaluation of Neural Sequence Models. Proceedings of the 35th International Conference on Machine Learning, PMLR 80:2766-2775, 2018.

João Moura, Vladimir Ivan, Mustafa Suphi Erden, and Sethu Vijayakumar
Equivalence of the Projected Forward Dynamics and the Dynamically Consistent Inverse Solution. Robotics: Science and Systems XV (RSS), 2019, DOI: 10.15607/RSS.2019.XV.036. [Best Paper Award Finalist]

Y. Hristov, D. Angelov, A. Lascarides, M. Burke, S. Ramamoorthy
Disentangled Relational Representations for Explaining and Learning from Demonstration, Conference on Robot Learning (CoRL), 2019.

Student Research Outputs - Conference Publications

Wolfgang Merkt, Vladimir Ivan and Sethu Vijayakumar
Continuous-Time Collision Avoidance for Trajectory Optimisation in Dynamic Environments, Proc. IEEE Intl. Conf. on Intelligent Robots and Systems (IROS 2019), Macau, China (2019).

Chris Mower, Wolfgang Merkt, Aled Davies and Sethu Vijayakumar
Comparing Alternate Modes of Teleoperation for Constrained Tasks, Proc. 15th IEEE Intl. Conf. on Automation Science and Engineering (CASE 2019), Vancouver, BC, Canada (2019).

Wolfgang Merkt, Vladimir Ivan, Yiming Yang and Sethu Vijayakumar
Towards Shared Autonomy Applications using Whole-body COntrol Formulations of Locomanipulation, Proc. 15th IEEE Intl. Conf. on Automation Science and Engineering (CASE 2019), Vancouver, BC, Canada (2019).

H.-N. Vießmann, A. Šinkarovs, and S.-B. Scholz
Extended Memory Reuse: An Optimisation for Reducing Memory Allocations. In Proceedings of the 30th Symposium on Implementation and Application of Functional Languages (IFL 2018), Lowell, MA, USA, September 2018.

A. Šinkarovs, R. Bernecky, **H.-N. Vießmann**, and S.-B. Scholz
A Rosetta Stone for Array Languages. In Proceedings of the 5th ACM SIGPLAN International Workshop on Libraries, Languages, and Compilers for Array Programming (ARRAY 2018). New York, NY, USA, June 2018.

A. Šinkarovs, S.-B. Scholz, R. Stewart, and **H.-N. Vießmann**
Recursive Array Comprehensions in a Call-by-Value Language. In Proceedings of the 29th Symposium on the Implementation and Application of Functional Programming Languages (IFL 2017). New York, NY, USA, September 2017. https://doi.org/10.1145/3205368.3205373

James Garforth, Barbara Webb
Visual Appearance Analysis of Forest Scenes for Monocular SLAM. Proceedings of IEEE International Conference on Robotics and Automation (ICRA), 2019, DOI:10.1109/ICRA.2019.8793771

M. Burke, **S.V. Penkov,** S. Ramamoorthy
From Explanation to Synthesis: Compositional Program Induction for Learning from Demonstration, Robotics: Science and Systems (R:SS), 2019.

S.V. Penkov, S. Ramamoorthy
Learning Programmatically Structured Representations with Perceptor Gradients, In Proc. International Conference on Learning Representations (ICLR), 2019.

E. Nault, L. Baillie, and F. Broz
Auditory and Haptic Feedback in a Socially Assistive Robot Memory Game, in Companion of the 2020 ACM/IEEE International Conference on Human-Robot Interaction, 2020, pp. 369–371.

R. Smith, Y. Ding, G. Goussetis, and M. Dragone
A COTS (UHF) RFID Floor for Device-Free Ambient Assisted Living Monitoring. In Proceedings of the 11th International Symposium on Ambient Intelligence (ISAmI), 2020.

Ardón, P.; Pairet, È.; Y. Petillot; Petrick, R.; Ramamoorthy, S.; and Lohan, K. S.
Self-Assessment of Grasp Affordance Transfer. IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). October 2020.

D. Robb, M. Ahmad, C. Tiseo, S. Aracri, A. C. McConnell, V. Page, C. Dondrup, F. Garcia, H. Nguyen, **È. Pairet, P. Ardón**, T. Semwal, H. Taylor, L. Wilson, D. Lane, H. Hastie, and K. Lohan
Robots in the Danger Zone: Exploring Public Perception through Engagement, in ACM/IEEE International Conference on Human-Robot Interaction (HRI), 2020.

W. Hu, **I. Chatzinikolaidis, K. Yuan**, and Z. Li
Comparison Study of Nonlinear Optimization of Step Durations and Foot Placement for Dynamic Walking , IEEE International Conference on Robotics and Automation (ICRA), 2018

Student Research Outputs - Conference Publications

Y. Carreno, È. Pairet, Y. Petillot, and R. Petrick
A Decentralised Strategy for Heterogeneous AUV Missions via Goal Distribution and Temporal Planning, in International Conference on Automated Planning and Scheduling (ICAPS), 2020.

Y. Carreno, È. Pairet, Y. Petillot, and R. Petrick
Task Allocation Strategy for Heterogeneous Robot Teams in Offshore Missions, in International Conference on Autonomous Agents and Multiagent Systems (AAMAS), 2020.

Henrique Ferrolho, Wolfgang Merkt, Vladimir Ivan, Wouter Wolfslag, Sethu Vijayakumar
Optimizing Dynamic Trajectories for Robustness to Disturbances Using Polytopic Projections, in IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), Las Vegas, USA, 2020.

Z. Sun, **K. Yuan,** W. Hu, C. Yang, and Z. Li
Learning Pre-Grasp Manipulation for Objects in Un-graspable Poses, IEEE International Conference on Robotics and Automation (ICRA), 2020

C. McGreavy, K. Yuan, D. Gordon, K. Tan, W. Wolfslag, S. Vijayakumar, and Z. Li
Unified Push Recovery Fundamentals: Inspiration from Human Study, IEEE International Conference on Robotics and Automation (ICRA), 2020

K. Yuan and Z. Li
An Improved Formulation for Model Predictive Control of Legged Robots for Gait Planning and Feedback Control, IEEE-RAS International Conference on Intelligent Robots and Systems (IROS), 2018

Paulius Dilkas, Vaishak Belle
Generating Random Logic Programs Using Constraint Programming. Proceedings of the 26th International Conference on Principles and Practice of Constraint Programming (CP), 2020

Z Hong, Y Petillot, S Wang
RadarSLAM: Radar based Large-Scale SLAM in All Weathers. In Proceedings of International Conference on Intelligent Robots and Systems (IROS) 2020

Yaniel Carreno, Yvan Petillot, and Ronald P. A. Petrick
Towards Robust Mission Execution via Temporal and Contingent Planning. In Proceedings of the 21st Towards Autonomous Robotic Systems (TAROS) Conference, 2020.

Caetano Ranieri, Renan Moioli, Roseli Romero, Mariana Araújo, Maxwell Santana, **Jhielson Pimentel** and Patrícia Vargas
Unveiling Parkinson's Disease Features from a Primate Model with Deep Neural Networks. Proceedings of IEEE World Congress on Computational Intelligence (WCCI)/International Joint Conference on Neural Networks (IJCNN), 2020.

Wouter Wolfslag, **Christopher McGreavy,** Guiyang Xin, Carlo Tiseo, Sethu Vijayakumar, Zhibin Li
Optimisation of Body-ground Contact for Augmenting Whole-Body Loco-manipulation of Quadruped Robots IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2020

Hugo Sardinha, Mauro Dragone, Patricia A. Vargas
Combining Lévy Walks and Flocking for Cooperative Surveillance using Aerial Swarms
(To appear in) Proceedings of the 17th European Conference on Multi-Agent Systems (EUMAS 2020)

Hugo Sardinha, Mauro Dragone, Patricia A. Vargas
Towards an Adaptive Lévy Walk using Artificial Endocrine Systems
(To appear in) Proceedings of the 12th International Conference on Adaptive and Self-Adaptive Systems and Applications (ADAPTIVE 2020)

Student Research Outputs - Conference Publications

Paulius Dilkas, Vaishak Belle
Weighted Model Counting with Conditional Weights for Bayesian Networks
Conference on Uncertainty in Artificial Intelligence (UAI), 2021

Shreyank N. Gowda, Panagiotis Eustratiadis, Timothy M. Hospedales, Laura Sevilla-Lara
ALBA: Reinforcement Learning for Video Object Segmentation.
In Proceedings of the 31st British Machine Vision Conference, 2020 (BMVC-20)

Shreyank N. Gowda, Marcus Rohrbach, Laura Sevilla-Lara
SMART Frame Selection for Action Recognition.
In Proceedings of the Thirty-Fifth AAAI Conference on Artificial Intelligence, 2021 (AAAI-21)

Henrique Ferrolho, Vladimir Ivan, Wolfgang Merkt, Ioannis Havoutis, Sethu Vijayakumar
Inverse Dynamics vs. Forward Dynamics in Direct Transcription Formulations for Trajectory Optimization,
in IEEE International Conference on Robotics and Automation (ICRA), Xi'an, China, 2021

Lyons, B. I., and J. Michael Herrmann
Reflexive Reinforcement Learning: Methods for Self-Referential Autonomous Learning.
IJCCI. 2020.

Suglia, Alessandro, et al.
CompGuessWhat?!: A Multi-task Evaluation Framework for Grounded Language Learning.
Proceedings of the 58th Annual Meeting of the Association for Computational Linguistics. 2020.

Suglia, Alessandro, et al.
Imagining Grounded Conceptual Representations from Perceptual Information in Situated Guessing Games.
Proceedings of the 28th International Conference on Computational Linguistics. 2020.

Suglia, Alessandro, et al.
An Empirical Study on the Generalization Power of Neural Representations Learned via Visual Guessing Games.
Proceedings of the 16th Conference of the European Chapter of the Association for Computational Linguistics: Main Volume. 2021.

Foulds, Olivia, **Alessandro Suglia**, Leif Azzopardi, Martin Halvey.
Predicting Perceptual Speed from Search Behaviour.
Proceedings of the 43rd International ACM SIGIR Conference on Research and Development in Information Retrieval. 2020.

Theodoros Stouraitis, Lei Yan, **João Moura**, Michael Gienger and Sethu Vijayakumar
Multi-mode Trajectory Optimization for Impact-aware Manipulation
In IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2020, DOI: 10.1109/IROS45743.2020.9341246.

Christopher E. Mower, **João Moura**, and Sethu Vijayakumar
Skill-based Shared Control.
In Robotics: Science and Systems XVII (R:SS), 2021, DOI: 10.15607/RSS.2021.XVII.028.

E. Triantafyllidis and Z. Li
The Challenges in Modeling Human Performance in 3D Space with Fitts' Law
in CHI Conference on Human Factors in Computing Systems (CHI '21). Association for Computing Machinery, May 8–13, 2021, Yokohama, Japan. ACM, New York, NY, USA. DOI: 10.1145/3411763.3443442

Student Research Outputs - Conference Publications

Miruna Adriana Clinciu, Arash Eshghi, H. Hastie
A Study of Automatic Metrics for the Evaluation of Natural Language Explanations
In Proceedings of the 16th Conference of the European Chapter of the Association for Computational Linguistics: Main Volume (EACL), 2021.

David Howcroft, Anya Belz, **Miruna Clinciu**, Dimitra Gkatzia, Sadid A. Hasan, Saad Mahamood, Simon Mille, Emiel van Miltenburg, Sashank Santhanam, and Verena Rieser
Twenty Years of Confusion in Human Evaluation: NLG Needs Evaluation Sheets and Standardised Definition
In Proceedings of the 14th International Conference on Natural Language Generation (INLG), 2020.

Jonatan Scharff Willners, **Yaniel Carreno**, Shida Xu, Tomasz Luczynski, Sean Katagiri, Joshua Roe, **Eric Pairet,** Yvan Petillot, and Sen Wang
Robust underwater SLAM using Autonomous Relocalistion.
IFAC Conference on Control Applications in Marine Systems, 2021.

Christianos Filippos, Schäfer Lukas, and Albrecht Stefano
Shared Experience Actor-Critic for Multi-Agent Reinforcement Learning
In Advances in Neural Information Processing Systems (NeurIPS), 2020.

Christianos Filippos, Papoudakis Georgios, Rahman Arrasy, and Albrecht Stefano
Scaling Multi-Agent Reinforcement Learning with Selective Parameter Sharing
In Proceedings of the 38th International Conference on Machine Learning (ICML), 2021.

Rahman Arrasy, Hopner Niklas, **Christianos Filippos**, and Albrecht Stefano.
Open Ad Hoc Teamwork Using Graph-Based Policy Learning.
In Proceedings of the 38th International Conference on Machine Learning (ICML), 2021.

Georgios Pantazopoulos, Jeremy Bruyere, **Malvina Nikandrou**, Thibaud Boissier, **Supun Hemanthage**, Sachish Binha, Vidyul Shah, Christian Dondrup, and Oliver Lemon
ViCA: Combining visual, social, and task-oriented conversational AI in a healthcare setting
International Conference on Multimodal Interaction (ICMI) 2021 (to appear)

Alessandro Suglia, Yonatan Bisk, Ioannis Konstas, Antonio Vergari, Emanuele Bastianelli, Andrea Vanzo and Oliver Lemon
An Empirical Study on the Generalization Power of Neural Representations Learned via Visual Guessing Games Proceedings of EACL 2021

Nancie Gunson, **Weronika Sieinska**, Yanchao Yu, Daniel Hernandez Garcia, **Jose L. Part**, Christian Dondrup, Oliver Lemon
Coronabot: A Conversational AI System for Tackling Misinformation.
ACM International Conference on Information Technology for Social Good (GoodIT 2021)

Jose Part, Daniel Hernandez-Garcia, Yanchao Yu, Nancie Gunson, Christian Dondrup, Oliver Lemon
Towards Visual Dialogue for Human-Robot Interaction,
Human-Robot Interaction (HRI 2021), video demonstration

Daniel Hernandez Garcia, Yanchao Yu, **Weronika Sieinska, Jose Part**, Nancie Gunson, Oliver Lemon and Christian Dondrup
Explainable Representations of the Social State: A Model for Social Human-Robot Interactions
AAAI Fall Symposium on AI for HRI, 2020

Nancie Gunson, **Weronika Sieinska**, Christian Dondrup, and Oliver Lemon
It's Good to Chat? Evaluation and Design Guidelines for Combining Open-Domain Social Conversation with Task-Based Dialogue in Intelligent Buildings
in Proc. 20th ACM International Conference on Intelligent Virtual Agents (IVA) 2020

Student Research Outputs - Conference Publications

Weronika Sieinska, Nancie Gunson, Christopher Walsh, Christian Dondrup, and Oliver Lemon
Conversational Agents for Intelligent Buildings. Proceedings of SIGDIAL 2020

Xinnuo Xu, Ondřej Dušek, Verena Rieser, Ioannis Konstas
AGGGEN: Ordering and Aggregating while Generating
Proceedings of the 59th Annual Meeting of the Association for Computational Linguistics and the 11th International Joint Conference on Natural Language Processing (Volume 1: Long Papers). ACL 2021

Karin Sevegnani, David M. Howcroft, Ioannis Konstas, Verena Rieser.
OTTers: One-turn Topic Transitions for Open-Domain Dialogue
Proceedings of the 59th Annual Meeting of the Association for Computational Linguistics and the 11th International Joint Conference on Natural Language Processing (Volume 1: Long Papers)

Xinnuo Xu, Ondřej Dušek, Jingyi Li, Verena Rieser, Ioannis Konstas
Fact-based Content Weighting for Evaluating Abstractive Summarisation
Proceedings of the 58th Annual Meeting of the Association for Computational Linguistics. ACL 2020.

Xinnuo Xu, Ondřej Dušek, Ioannis Konstas, Verena Rieser
Better Conversations by Modeling, Filtering, and Optimizing for Coherence and Diversity
Proceedings of the 2018 Conference on Empirical Methods in Natural Language Processing. EMNLP 2018.

P. Ardón, È. Pairet, K. Lohan, S. Ramamoorthy, and R. Petrick
Building Affordance Relations for Robotic Agents - A Survey - A Survey
in Intl. Joint Conf. on Artificial Intelligence. 2021.

Christopher E. Mower, **Joao Moura,** Aled Davies and Sethu Vijayakumar
Modulating Human Input for Shared Autonomy in Dynamic Environments
2019 28th IEEE International Conference on Robot and Human Interactive Communication (RO-MAN), 2019, pp. 1-8.

Christopher E. Mower, **Joao Moura**, and Sethu Vijayakumar
Skill-based Shared Control. Robotics: Science and Systems (R:SS), 2021.

Traiko Dinev, Wolfgang Xaver Merkt, Vladimir Ivan, Ioannis Havoutis and Sethu Vijayakumar
Sparsity-Inducing Optimal Control via Differential Dynamic Programming
Proc. IEEE International Conference on Robotics and Automation (ICRA 2021), Xian, China (2021)

Traiko Dinev, Songyang Xin, **Wolfgang Merkt**, Vladimir Ivan and Sethu Vijayakumar
Modeling and Control of a Hybrid Wheeled Jumping Robot
Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS 2020), Las Vegas, USA (2020)

Josiah P. Hanna, Arrasy Rahman, **Elliot Fosong**, Francisco Eiras, Mihai Dobre, John Redford, Subramanian Ramamoorthy, Stefano V. Albrecht
Interpretable Goal Recognition in the Presence of Occluded Factors for Autonomous Vehicles
IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2021

Ibrahim H. Ahmed, Josiah P. Hanna, **Elliot Fosong**, Stefano V. Albrecht
Towards Quantum-Secure Authentication and Key Agreement via Abstract Multi-Agent Interaction
International Conference on Practical Applications of Agents and Multi-Agent Systems (PAAMS), 2021

Nathan Western, Xianwen Kong, Mustafa Suphi Erden
Design of a Train Cleaning Robot for the Train Carriage Interior
31st CIRP Design Conference 2021 (CIRP Design 2021), DOI 10.1016/j.procir.2021.05.040

Student Research Outputs - Conference Publications

Mateusz Ochal, Jose Vazquez, Yvan Petillot, Sen Wang
A Comparison of Few-Shot Learning Methods for Underwater Optical and Sonar Image Classification
Global Oceans 2020: Singapore – U.S. Gulf Coast

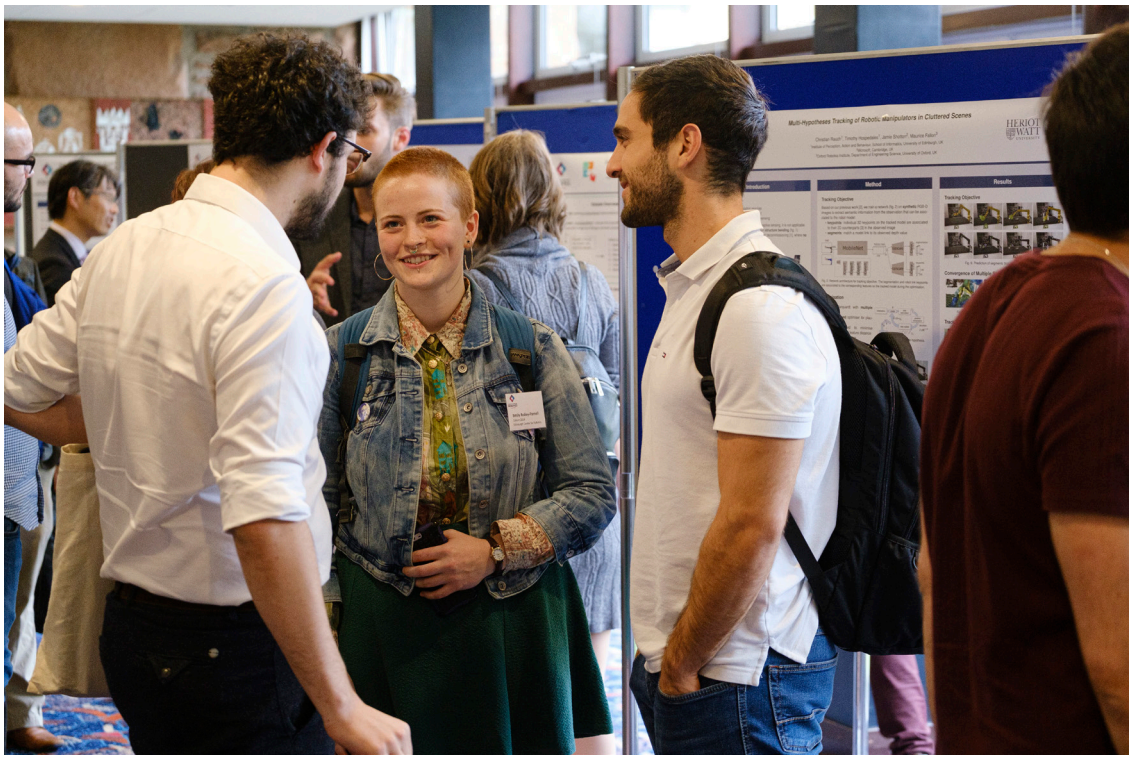
H. Fraser and S. Wang
DeepBEV: A Conditional Adversarial Network for Bird's Eye View Generation,
2020 25th International Conference on Pattern Recognition (ICPR), 2021, pp. 5581-5586, doi: 10.1109/ICPR48806.2021.9412516.

Papoudakis Georgios, Christianos Filippos, Schäfer Lukas, and Albrecht Stefano V.
Benchmarking Multi-Agent Deep Reinforcement Learning Algorithms in Cooperative Tasks
In Proceedings of the Neural Information Processing Systems Track on Datasets and Benchmarks, 2021

Jan Stankiewicz and Barbara Webb
Using the Neural Circuit of the Insect Central Complex for Path Integration on a Micro Aerial Vehicle.
Conference on Biomimetic and Biohybrid Systems. Springer, Cham, 2020.

Borja Marin, Keith Brown, Mustafa Suphi Erden
Automated Masonry Crack Detection with Faster R-CNN
To appear in Proc. 17th IEEE Intl. Conf. On Automation Science and Engineering (CASE 2021), Lyon, France (2021).

Wellacott, L., Nault, E., Skottis, I., Colle, A., Gowda, S. N., Nicolay, P., Rolley-Parnell, E. (2021). Test Framework for a Virtual Competition Testbed
UKRAS21 Conference: Robotics at home Proceedings, 11-12. doi: 10.31256/Iq9Ki4X preprint



Student Research Outputs - Journal Publications

Leopoldo Armesto, **João Moura,** Vladimir Ivan, Mustafa Suphi Erden, Antonio Salas, and Sethu Vijayakumar
Constraint-aware Learning of Policies by Demonstration. In International Journal of Robotics Research (IJRR), 2018 DOI: 10.1177/0278364918784354

João Moura, William McColl, Gerard Taykaldiranian, Tetsuo Tomiyama, Mustafa Suphi Erden
Automation of Train Cab Front Cleaning with a Robot Manipulator. In IEEE Robotics and Automation Letters, 2018, DOI: 10.1109/LRA.2018.2849591. (selected for presentation at the 14th IEEE International Conference on Automation Science and Engineering - CASE)

Gordon D.F.N, Henderson G and Vijayakumar S
Effectively Quantifying the Performance of Lower-Limb Exoskeletons Over a Range of Walking Conditions. Front. Robot. AI 5:61 doi 10.3389/frobt.2018.00061

Yiming Yang, **Wolfgang Merkt,** Vladimir Ivan, Zhibin Li, and Sethu Vijayakumar
HDRM: A Resolution Complete Dynamic Roadmap for Real-Time Motion Planning in Complex Scenes. IEEE Robotics and Automation Letters, 2018, In Press. DOI: 10.1109/LRA.2017.2773669

Yiming Yang, **Wolfgang Merkt, Henrique Ferrolho**, Vladimir Ivan, and Sethu Vijayakumar
Efficient Humanoid Motion Planning on Uneven Terrain Using Paired Forward-Inverse Dynamic Reachability Maps. IEEE Robotics and Automation Letters, 2017, In Press. DOI: 10.1109/LRA.2017.2727538

Krasoulis, A., **Kyranou, I.,** Erden, M. S., Nazarpour, K., & Vijayakumar, S.
Improved Prosthetic Hand Control with Concurrent Use of Myoelectric and Inertial Measurements. Journal of neuroengineering and rehabilitation, 14(1), 71.

Tsiogkas, Nikolaos, and David M. Lane
An Evolutionary Algorithm for Online, Resource-Constrained, Multivehicle Sensing Mission Planning. IEEE Robotics and Automation Letters 3, no. 2 (2018): 1199-1206.

Kyranou, I., Vijayakumar, S. & Erden, M. S
Causes of Performance Degradation in Electromyographic Pattern Recognition in Upper Limb Prostheses. 27 Aug 2018 (Accepted/In press) In: Frontiers in Neurorobotics.

Ardón P., Dragone, M. & Erden, M. S
Reaching and Grasping of Objects by Humanoid Robots through Visual Servoing. 6 Jun 2018 Haptics: Science, Technology, and Applications. Springer, p. 353-365 13 p. (Lecture Notes in Computer Science; vol. 10894)

M. Burke, **Y. Hristov,** S. Ramamoorthy, Hybrid system identification using switching density networks, Conference on Robot Learning (CoRL), 2019.

M. Burke, **S.V. Penkov**, S. Ramamoorthy
From Explanation to Synthesis: Compositional Program Induction for Learning from Demonstration, Robotics: Science and Systems (R:SS), 2019.

E. Sheppard, K. S. Lohan, G.E. Little, G. Rajendran
Towards Improved Child Robot Interaction by Understanding Eye Movements,IEEE TCDS Special Issue A sense of interaction in humans and robots: from visual perception to social cognition 2018

Mahon, S.T.; Roberts, J.O.; Sayed, M.E.; **Chun, D.** H.-T.; Aracri, S.; **McKenzie, R.M.**; Nemitz, M.P.; Stokes, A.A.
Capability by Stacking: The Current Design Heuristic for Soft Robots. Biomimetics 2018, 3, 16.

G. I. Parisi, R. Kemker, **J. L. Part,** C. Kanan and S. Wermter
Continual Lifelong Learning with Neural Networks: A Review, in Neural Networks, 2019

Student Research Outputs - Journal Publications

M. Asenov, M. Rutkauskas, D.T. Reid, K. Subr, S. Ramamoorthy
Active Localization of Gas Leaks using Fluid Simulation, IEEE Robotics and Automation Letters, Vol 4(2): 1776 - 1783, 2019. Presented at the IEEE International Conference on Robotics and Automation, 2019.

M. Rutkauskas, **M. Asenov,** S. Ramamoorthy, D.T. Reid
Autonomous Multi-species Environmental Gas Sensing using Drone-based Fourier-transform Infrared Spectroscopy, Optics Express, Vol. 27, Issue 7, pp. 9578-9587, 2019.

È. Pairet, P. Ardón, M. Mistry, and Y. Petillot
Learning Generalisable Coupling Terms for Obstacle Avoidance via Low-dimensional Geometric Descriptors, in IEEE Robotics and Automation Letters (RA-L), 2019.

P. Ardón, È. Pairet, R. Petrick, S. Ramamoorthy, and K. S. Lohan
Learning Grasp Affordance Reasoning through Semantic Relations, in IEEE Robotics and Automation Letters (RA-L), 2019.

K. Yuan, I. Chatzinikolaidis, and Z. Li
Bayesian Optimisation for Whole-Body Control of High Degrees of Freedom Robots through Reduction of Dimensionality, Robotics and Automation Letters (RA-L), 2019

E. Triantafyllidis, C. Mcgreavy, J. Gu and Z. Li
Study of Multimodal Interfaces and the Improvements on Teleoperation, in IEEE Access, vol. 8, pp. 78213-78227, 2020, DOI: 10.1109/ACCESS.2020.2990080.

K. Yuan, C. McGreavy, C. Yang, W. Wolfslag, and Z. Li
Decoding Motor Skills of AI and Human Policies: A Study on Humanoid and Human Balance Control. IEEE Robotics and Automation Magazine (RAM), 2020

R. Wen, **K. Yuan**, Q. Wang, S. Heng, and Z. Li
Force-guided High-precision Grasping Control of Fragile and Deformable Objects using sEMG-based Force Prediction, IEEE Robotics and Automation Letters (RA-L), 2020

C. Yang, **K. Yuan,** S. Heng, T. Komura, and Z. Li
Learning Natural Locomotion Behaviors for Humanoid Robots using Human Bias, IEEE Robotics and Automation Letters (RA-L), 2020

I. Chatzinikolaidis, Y. You, and Z. Li
Contact-Implicit Trajectory Optimization Using an Analytically Solvable Contact Model for Locomotion on Variable Ground, IEEE Robotics and Automation Letters, 2020, DOI: 10.1109/LRA.2020.3010754

D. Angelov, S. Ramamoorthy
Learning from Demonstration of Trajectory Preferences through Causal Modeling and Inference, In Proc. Robotics: Science and Systems Workshop on Causal Imitation in Robotics (RSS18-CIR), 2018.

T. López-Guevara, R. Pucci, N.K. Taylor, M.U. Gutmann, S. Ramamoorthy, K. Subr
To Stir or Not to Stir: Online Estimation of Liquid Properties for Pouring Actions , In Proc. Robotics: Science and Systems Workshop on Learning and Inference in Robotics: Integrating Structure, Priors and Models (RSS18-LAIR), 2018.

Henrique Ferrolho, Wolfgang Merkt, Carlo Tiseo and Sethu Vijayakumar
Residual Force Polytope: Admissible Task-Space Forces of Dynamic Trajectories, Robotics and Autonomous Systems (RAS), 2021.

Pimentel, J. M., Moioli, R. C., de Araujo, M. F. P., Ranieri, C. M., Romero, R. A. F., Broz, F., & Vargas, P. A. (2021). Neuro4PD: An Initial Neurorobotics Model of Parkinson's Disease. Frontiers in eurorobotics, 15.https://doi.org/10.3389/fnbot.2021.640449

Student Research Outputs - Journal Publications

Pronin, S., **Wellacott, L., Pimentel, J.**, Moioli, R. C., & Vargas, P. A. (2021). Neurorobotic Models of Neurological Disorders: A Mini Review. Frontiers in Neurorobotics, 15. https://doi.org/10.3389/fnbot.2021.634045

Basile, Pierpaolo, Claudio Greco, **Alessandro Suglia**, Giovanni Semeraro
Bridging the Gap between Linked Open Data-based Recommender Systems and Distributed Representations. Information Systems 86 (2019): 1-8

Basile, Pierpaolo, **Alessandro Suglia**, Claudio Greco, Giovanni Semeraro.
Deep Learning and Hierarchical Reinforcement Learning for Modeling a Conversational Recommender System. Intelligenza Artificiale 12.2 (2018): 125-14

E. Triantafyllidis, W. HU, **C. McGreavy** and Z. Li,
Metrics for 3D Object Pointing and Manipulation in Virtual Reality: The Introduction and Validation of a Novel Approach in Measuring Human Performance in IEEE Robotics & Automation Magazine, 2021, doi: 10.1109/MRA.2021.3090070

Cetin, K., **Suárez Zapico, C.,** Tugal, H., Petillot, Y., Dunnigan, M. W., & Erden, M. S.
(2021). Application of Adaptive and Switching Control for Contact Maintenance of a Robotic Vehicle-Manipulator System for Underwater Asset Inspection Frontiers in Robotics and AI. https://doi.org/10.3389/frobt.2021.706558

È. Pairet, C. Chamzas, Y. Petillot, and L. Kavraki
Path Planning for Manipulation using Experience-driven Random Trees in IEEE Robotics and Automation Letters. 2021

P. Ardón, Maria E. Cabrera, **È. Pairet**, R. Petrick, S. Ramamoorthy, K. Lohan, and Maya Cakmak
Affordance-aware Handovers with Human Arm Mobility Constraints in IEEE Robotics and Automation Letters. 2021

J. S. Willners, D. Gonzalez, J. D. Hernández, **È. Pairet,** and Y. Petillot
Online 3-Dimensional Path Planning with Kinematic Constraints in Unknown Environments Using Hybrid-A* with Tree Pruning in Sensors. 2021

Jan Stankiewicz, Barbara Webb
Looking Down: A Model for Visual Route Following in Flying Insects. Bioinspiration & Biomimetics 16.5 (2021): 055007

Garforth, James, Barbara Webb
Lost in the Woods? Place Recognition for Navigation in Difficult Forest Environments. Frontiers in Robotics and AI 7, 2020

Student Research Outputs - Workshop Papers

S. Penkov, S. Ramamoorthy
Using Program Induction to Interpret Transition System Dynamics,, In Proc. ICML Workshop on Human Interpretability in Machine Learning (ICML-WHI), 2017.

T. Davchev, T. Korres, S. Fotiadis, N. Antonopoulos, S. Ramamoorthy
An Empirical Evaluation of Adversarial Robustness under Transfer Learning, In Proc. ICML Workshop on Understanding and Improving Generalization in Deep Learning, 2019.

Yordan Hristov, Svetlin Penkov, Alex Lascarides, Subramanian Ramamoorthy
Grounding Symbols in Multi-Modal Instructions, Language Grounding for Robotics Workshop, Annual Meeting of the Association for Computational Linguistics (ACL), 2017.

I.Papaioannou, A. Cercas Curry, J. L. Part, I. Shalyminov, **X. Xu**, Y. Yu, O. Dušek, V. Rieser, and O. Lemon
An Ensemble Model with Ranking for Social Dialogue, in Workshop on Conversational AI at the Conference on Neural Information Processing Systems (NIPS), Long Beach, CA, USA, December 2017.

M. Campbell and D. Clark
Time-Lapse Estimation for Optical Telescope Sequences, in Geolocation and Navigation in Space and Time, 2018.

E.Sheppard, K. S. Lohan, G.E. Little , L. Bonnar , S. Kelly and G. Rajendran
Understanding the Difference in Pupil Dilation between Children with and without ASD during a Joint Attention Memory Task, 3rd Workshop on Child-Robot Interaction at Human-Robot Interaction 2017

Carreno, Y., Petrick, R.P. and Petillot, Y.
Multi-Vehicle Temporal Planning for Underwater Applications. In ICAPS 2019 Workshop on Planning and Robotics (PlanRob). July 2019.

A Brock, T Lim, JM Ritchie, N Weston
Generative and Discriminative Voxel Modeling with Convolutional Neural Networks. Selected for Oral presentation at 3D Deep Learning Workshop, NIPS 2016

A Brock, T Lim, JM Ritchie, N Weston
FreezeOut: Accelerate Training by Progressively Freezing Layers. Optimization workshop, NIPS 2017

Mocialov, B., Turner, G., Lohan K., Hastie H.
Towards Continuous Sign Language Recognition with Deep Learning. In Proceedings of the Workshop on the Creating Meaning With Robot Assistants: The Gap Left by Smart Devices, 2017.

Mocialov, B., Hastie, Helen., Turner, Graham
Transfer Learning for British Sign Language Modelling (Accepted at the COLING conference, the Fifth Workshop on NLP for Similar Languages, Varieties and Dialects, 2018)

Ben Krause, **Emmanuel Kahembwe**, Iain Murray, and Steve Renals
Exploiting Repetitions in Music with Dynamic Evaluation. Proceedings of the ICML Machine Learning for Music Discovery Workshop (ML4MD), Extended Abstract, Long Beach, 2019

Artjoms Šinkarovs, Robert Bernecky, **Hans-Nikolai Vießmann,** and Sven-Bodo Scholz
2018. A Rosetta Stone for Array Languages. In Proceedings of the 5th ACM SIGPLAN International Workshop on Libraries, Languages, and Compilers for Array Programming/(ARRAY 2018). ACM, New York, NY, USA, 1-10. DOI: https://doi.org/10.1145/3219753.3219754

J. L. Part and O. Lemon
Incremental On-Line Learning of Object Classes using a Combination of Self-Organizing Incremental Neural Networks and Deep Convolutional Neural Networks, in Workshop on Bio-inspired Social Robot Learning in Home Scenarios at the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), Daejeon, Korea, October 2016.

J. H. Ng, R. Petrick
"Incremental Learning of Action Models for Planning", Workshop on Knowledge Engineering for Planning and Scheduling (KEPS) (2019)

Student Research Outputs - Workshop Papers

P. McKenna, F. Broz, I. Keller, **J. L. Part,** G. Rajendran and R. Aylett
Towards Robot-Assisted Social Skills Training for Adults with ASC, in Workshop on the Challenges of Working on Social Robots that Collaborate with People at the ACM Conference on Human Factors in Computing Systems (CHI), Glasgow, UK, May 2019

Carreno, Y., Petrick, R.P. and Petillot, Y.
Multi-Vehicle Temporal Planning for Underwater Applications. In ICAPS 2019 Workshop on Planning and Robotics (PlanRob). July 2019

Colle, A., & Gaudl, S. E. (2020)
Non-Zoomorphic Robots : The Role of Aesthetics in Social Robotic Design. HRI '20 Companion, 23–26.

R. Smith
Adaptivity as a Service (AaaS): Enabling Deep Personalisation for a Heterogeneous Ambient Assisted Living Landscape. In Proceedings of the Workshop on Behavioural Patterns and Interaction Modelling for Personalized Human-Robot Interaction at the ACM/IEEE International Conference on Human-Robot Interaction, 2020.

Pierre Le Bras, **Yaniel Carreno,** Alan Lindsay, Ronald Petrick and Mike Chantler
2020. Plan-Curves: Visualizing Multi-Agent Temporal Plans. In Proceedings of ICAPS Workshop in Knowledge Engineering for Planning and Scheduling (KEPS).

Gavriilidis, K., Carreno, Y., Munafo, A., Pang, W., Petrick, R.P. and Hastie, H.
2021. Plan Verbalisation for Robots Acting in Dynamic Environments
In Proceedings of ICAPS Workshop in Knowledge Engineering for Planing and Scheduling (KEPS)

E. Triantafyllidis and Z. Li,
Considerations and Challenges of Measuring Operator Performance in Telepresence and Teleoperation Entailing Mixed Reality Technologies,
in CHI Conference on Human Factors in Computing Systems Workshop CHI '21 (Evaluating User Experiences in Mixed Reality). Association for Computing Machinery, May 7, 2021, Yokohama, Japan. ACM, New York, NY, USA

Miruna Clinciu, Arash Eshghi and Helen Hastie
I don't understand! Evaluation Methods for Natural Language Explanations
In Proceedings of the SICSA eXplainable Artifical Intelligence Workshop 2021 (SICSA XAI 2021), Aberdeen, United Kingdom, June 1st, 2021.

Miruna Clinciu, Dimitra Gkatzia and Saad Mahamood
It's Common Sense, isn't it? Demystifying Human Evaluations in Commonsense-enhanced NLG systems
In Proceedings of the Workshop on Human Evaluation of NLP Systems (HumEval, EACL), 2021

Miruna-Adriana Clinciu and Helen Hastie
Let's Evaluate Explanations!
In Proceedings of HRI 2020 Workshop on Test Methods and Metrics for Effective HRI in Real World Human-Robot Teams (Extended Abstract), 2020.

Gavriilidis, K., Carreno, Y., Munafo, A., Pang, W., Petrick, R. P. A., Hastie, H.
2021. Plan Verbalisation for Robots Acting in Dynamic Environments
In Proceedings ICAPS Workshop in Knowledge Engineering for Planning and Scheduling (KEPS)

Carreno, Y., Scharff Willners, J., Petillot, Y. R., and Petrick, R. P. A.,
2021. Situation-Aware Task Planning for Robust AUV Exploration in Extreme Environments
In IJCAI Workshop on Robust and Reliable Autonomy in the Wild (R2A W)

Student Research Outputs - Workshop Papers

Carreno, Y., Le Bras, P., **Pairet, E., Ardon, P.,** Chantler, M. J., Petrick, R. P. A.,
2021. An Integrated Framework for Remote Planning
In Proceedings ICAPS Workshop on Integrated Planning, Acting, and Execution (IntEx)

Carreno, Y., Lindsay, A. and Petrick, R.P.A.,
2021. Explaining Temporal Plans with Incomplete Knowledge and Sensing Information
In Proceedings ICAPS Workshop on Explainable AI Planning (XAIP).

Ng, J.H.A., Carreno, Y., Petillot, Y., Petrick, R.P.A.,
2021. Combining Temporal and Probabilistic Planning for Robots Operating in Extreme Environments
In Proceedings ICAPS Workshop on Planning and Robotics (PlanRob)

Alexandre Colle, Ronnie Smith, Scott Macleod, Mauro Dragone
Co-Design of Assistive Robotics with Additive Manufacturing and Cyber-Physical Modularity to Improve Trust
REDOUBLE 2021 Roman-2021 August 8th 2021

E. Triantafyllidis and Z. Li,
Considerations and Challenges of Measuring Operator Performance in Telepresence and Teleoperation Entailing Mixed Reality Technologies
in CHI Conference on Human Factors in Computing Systems Workshop CHI '21 (Evaluating User Experiences in Mixed Reality). Association for Computing Machinery, May 7, 2021, Yokohama, Japan. ACM, New York, NY, USA. Online: https://arxiv.org/abs/2103.12702

Carreno, Y., Petillot, Y., Petrick, R.P.A.,
2021. Compiling Contingent Planning into Temporal Planning for Robust AUV Deployments
In Proceedings ICAPS Workshop on Planning and Robotics (PlanRob)

Antreas Antoniou, Massimiliano Patacchiola, **Mateusz Ochal,** Amos Storkey
Defining Benchmarks for Continual Few-Shot Learning
NeurIPS Workshop on Meta-Learning (MetaLearn 2020)

Mateusz Ochal, Massimilano Patacchiola, Jose Vazquez, Amos Storkey, Sen Wang
How Sensitive are Meta-Learners to Dataset Imbalance?
ICLR 2021 Workshop on Learning to Learn

Student Research Outputs - Book Chapters

Paola Ardon, Mauro Dragone, Mustafa Suphi Erden
Reaching and Grasping Behaviours by Humanoid Robots Through Visual Servoing
Haptics: Science, Technology and Applications.
Chapter to appear in Springer International Publishing AG, part of Springer Nature (2018).

Vladimir Ivan, Yiming Yang, **Wolfgang Merkt,** Michael P. Camilleri, Sethu Vijayakumar
EXOTica: An Extensible Optimization Toolset for Prototyping and Benchmarking Motion Planning and Control, In: Koubaa A. (eds) Robot Operating System (ROS). Studies in Computational Intelligence, Springer, vol. 778, pp. 211-240 [DOI]

K. Lohan, M. Ahmad, C. Dondrup, **P. Ardón, È. Pairet,** and A. Vinciarelli.
Adapting Movements and Behaviour to Favour Communication in Human-Robot Interaction, in Modelling Human Motion: from Human Perception to Robot Design. Springer. In press.

E. Triantafyllidis, C. Yang, **C. McGreavy,** W. Hu and Z. Li,
AI for Emerging Verticals: Human-robot computing, sensing and networking
Book Chapter, Chapter 4.0, IETs, November 2020, DOI: 10.1049/pbpc034e_ch4

Student Research Outputs - Other Publications

I. Papaioannou, A. Cercas Curry, **J. L. Part,** I. Shalyminov, **X. Xu**, Y. Yu, O. Dušek, V. Rieser and O. Lemon
Alana: Social Dialogue using an Ensemble Model and a Ranker trained on User Feedback, in Proceedings of the 1st Alexa Prize, Las Vegas, NV, USA, November 2017.

Ben Krause, Marco Damonte, Mihai Dobre, Daniel Duma, Joachim Fainberg, Federico Fancellu, **Emmanuel Kahembwe**, Jianpeng Cheng, Bonnie Webber
Edina: Building an Open Domain Socialbot with Self-dialogues. Proceedings of the 1st Alexa Prize, Las Vegas, NV, USA, November 2017.

Theodoros Stouraitis, Iordanis Chatzinikolaidis, Michael Gienger, Sethu Vijayakumar
Dyadic Caborative Manipulation through Hybrid Trajectory Optimization, Conference on Robot Learning (CoRL),2018. (Best System Paper Award Finalist - Oral presentation 8% acceptance rate)

Amanda Cercas Curry, Ioannis Papaioannou, **Alessandro Suglia**, Shubham Agarwal, Igor Shalyminov, **Xinnuo Xu**, Ondrej Dušek, Arash Eshghi, Ionnis Konstas, Verena Rieser, Oliver Lemon
Alana v2: Entertaining and Informative Open-domain Social Dialogue using Ontologies and Entity Linking 1st Proceedings of Alexa Prize (Alexa Prize 2018).

Selected projects from across the Centre 2020/2021

Research Area: Trajectory Optimization

Inverse Dynamics vs. Forward Dynamics in Direct Transcription Formulations for Trajectory Optimization

PhD candidate: Henrique Ferrolho
Supervisor: Professor Sethu Vijayakumar
Contributors: Vladimir Ivan, Wolfgang Merkt, Ioannis Havoutis

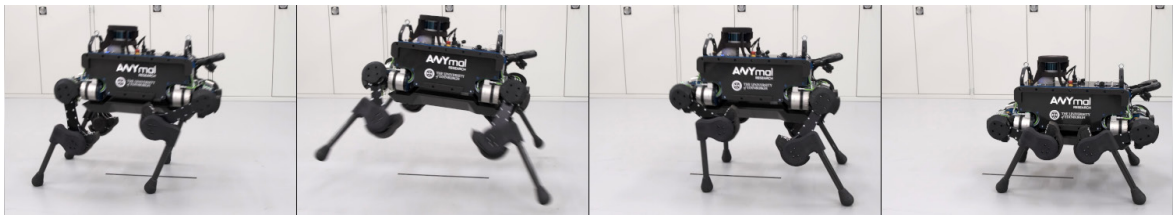


Figure 1. Snapshots of a 35 kg quadruped robot, ANYmal B, jumping forward 0.5 m.

Introduction

Direct transcription [1] is an effective approach to formulate trajectory optimization problems. It is widely used in robotics. In order to enforce the full system dynamics of robots, most implementations define constraints that require solving the forward dynamics problem. However, recent benchmarks of state-of-the-art rigid-body dynamics libraries have shown that solving inverse dynamics is faster than forward dynamics [2,3].

Objectives

Our goal was to understand whether the computational advantage of single calls to inverse dynamics would translate to direct transcription, where calculation of rigid-body dynamics and their derivatives accounts for a significant share of computation time. We also wanted to know in what ways the different approaches affect the solver and the resultant trajectories.

Contributions

The main contributions of our work are:
1. A direct transcription formulation that uses *inverse dynamics* to enforce physical consistency, for constrained trajectory optimization in domains with rigid contacts;
2. Evaluation of the performance of direct transcription formulations using either forward or inverse dynamics, for a fixed-base manipulator, a quadruped, and a humanoid;
3. Comparison of performance for different linear solvers, and across strategies to handle the barrier parameter of the interior point optimization algorithm.

Results

Our results showed that direct transcription problems formulated with inverse dynamics were faster to solve (see Table 1), more robust to coarser problem discretization, and took fewer iterations to minimize a cost function. Please refer to our paper for more details.

Inverse Dynamics vs. Forward Dynamics in Direct Transcription Formulations for Trajectory Optimization - Henrique Ferrolho

Experiments

We validated the trajectories computed with our planner in simulation and in real-world experiments, using a simple joint-level PD controller. *Figure 1* contains some snapshots of one of the experiments, where we asked a quadruped robot to leap forward 0.5 m. A video with all the clips of the real-world experiments is available at youtu.be/pV4s7hzUgjc.

Table 1. Computation time (in seconds) and number of iterations (within parenthesis) for each robot. The best computation time for each dynamics approach and each robot is highlighted in bold.

		Linear Solver	Barrier strategy (`bar_murule`) `adaptiv`	`dampmpc`	`quality`	Average time per iteration (s)
KUKA iiwa	Fwd D	MA27	**0.40** (5)	0.49 (6)	0.43 (5)	0.08 ± 0.002
		MA57	0.41 (5)	0.48 (6)	0.42 (5)	0.08 ± 0.001
		MA97	0.46 (5)	0.56 (6)	0.50 (5)	0.09 ± 0.002
	Inv D	MA27	**0.20** (4)	0.26 (5)	0.23 (4)	0.05 ± 0.002
		MA57	0.22 (4)	0.28 (5)	0.24 (4)	0.05 ± 0.001
		MA97	0.27 (4)	0.33 (5)	0.29 (4)	0.07 ± 0.002
ANYmal B	Fwd D	MA27	2.26 (7)	2.80 (9)	2.34 (7)	0.31 ± 0.021
		MA57	2.80 (10)	2.49 (9)	32.13 (99)	0.29 ± 0.020
		MA97	**2.21** (7)	2.76 (9)	2.26 (7)	0.31 ± 0.009
	Inv D	MA27	2.99 (13)	2.60 (11)	2.18 (9)	0.23 ± 0.005
		MA57	2.90 (13)	2.54 (11)	**2.10** (9)	0.22 ± 0.004
		MA97	3.21 (13)	2.81 (11)	2.37 (9)	0.25 ± 0.007
TALOS	Fwd D	MA27	—	—	14.82 (15)	0.94 ± 0.115
		MA57	—	13.47 (19)	44.23 (66)	0.68 ± 0.020
		MA97	13.42 (18)	**11.48** (15)	12.92 (16)	0.76 ± 0.026
	Inv D	MA27	8.38 (15)	8.02 (13)	38.59 (70)	0.57 ± 0.035
		MA57	7.36 (15)	**6.59** (13)	36.88 (73)	0.50 ± 0.014
		MA97	7.43 (15)	6.61 (13)	41.84 (82)	0.50 ± 0.012

Impact

This work challenges the *status quo* of trajectory optimisation using direct methods. Our results imply that problems relying on forward dynamics can—and should—be reformulated with inverse dynamics. Such reformulations enjoy the benefits of increased performance and more robustness to problem discretisation.

Future Work

As an alternative to DDP, we plan to investigate the feasibility of direct methods using inverse dynamics to control robots in an MPC fashion (i.e., fast and continuous replanning).

References

[1] J. T. Betts, *Practical Methods for Optimal Control and Estimation Using Nonlinear Programming*, 2nd ed. SIAM, 2010.
[2] T. Koolen and R. Deits, "Julia for robotics: simulation and real-time control in a high-level programming language," in *IEEE ICRA*, 2019.
[3] S. M. Neuman, T. Koolen et al., "Benchmarking and Workload Analysis of Robot Dynamics Algorithms," in *IEEE/RSJ IROS*, 2019.

Publications

H. Ferrolho, V. Ivan, W. Merkt, I. Havoutis, S. Vijayakumar, "Inverse Dynamics vs. Forward Dynamics in Direct Transcription Formulations for Trajectory Optimization," in *IEEE International Conference on Robotics and Automation (ICRA)*, Xi'an, China, 2021.

Research Area: Neurorobotics Models of Neurological Disorders

A Neurorobotics Approach to Unveil Motor Command Impairments in Parkinson's Disease

PhD candidate: Jhielson Montino Pimentel
Supervisors: Dr Patricia Vargas, Dr Michael Herrmann, Dr Renan Cipriano Moioli

Objective

The study of neurological diseases is still a big challenge to the scientific community as the dynamics of the human brain has not yet been fully understood. Animal experimentation is required to investigate brains in vivo conditions under natural behavioral scenarios, however, there are several ethical and technical limitations. As a consequence, neurorobotics models arose as an alternative to support the investigation of different neurological diseases. Based on that, and aligned with the Neuro4PD project[1], our goal is to embed in real humanoid robots new bio-inspired computational models of the brain to unveil motor command impairments in Parkinson's Disease (PD). Our model will not only contribute to the replacement and reduction of animal experimentation but, also, provide a platform on which neuroscientists may inform new therapies and diagnose approaches. In other words, we expect new insights into PD by future studies conducted using our proposed model.

[1] The Neuro4PD: Neurorobotics Model of Parkinson's Disease is a multidisciplinary project to gain further insights into the mechanisms of PD by combining neuroscience, machine learning and robotics expertise from Brazil and the UK.
The project is funded by the Newton Fund and Royal Society in the UK (https://www.macs.hw.ac.uk/neuro4pd/).

Approach

The first achievement of my research was to successfully create an initial Neurorobotics model of Parkinson's Disease by embedding a well-known biophysically plausible computational model of PD in a real humanoid robot (e.g., the NAO robot). I used different platforms (NEURON, NetPyNE and ROS) to simulate the neural network in real time and, at the same time, to control the robot during the execution of a simple behavioural task. In this way, the basal ganglia-thalamus-cortex region of the brain could be incorporated into our robot sensorimotor loop (Figure 1), thus making possible the interaction between **brain, body and environment**. Within this loop, I also introduced an oscillatory component known as the central oscillators to modulate the human body's inherent oscillatory phenomena. This work made possible the reproduction of abnormal PD motor stimulation in the neurorobotics model, e.g., the PD tremor, based on cortical dynamics via the modulation of central oscillators.

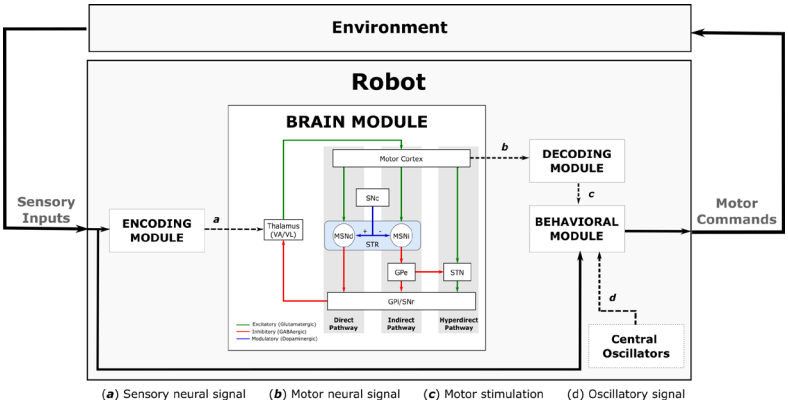


Figure 1: Full diagram showing the robot sensorimotor loop

A Neurorobotics Approach to Unveil Motor Command Impairments in Parkinson's Disease - Jhielson Montino PImentel

Results

Results show that the embedded model under both states, healthy and parkinsonian, was capable of performing a simple behavioural task (Figure 2) with different levels of motor disturbance. Under the healthy state, the motor stimulation produced by the dynamics of the cortex neurons inhibited the oscillatory patterns allowing the robot to perform the entire task with controlled movements. Meanwhile, the parkinsonian state produced a different motor stimulation, which combined with the oscillatory signal, unveiled a certain level of motor impairment that is analogous to one of the most characteristic symptoms of PD, the tremor. In this way, the tremor emerged as a combination of the oscillatory patterns generated by the brain inherent central oscillators and the dysfunction of the cortex neurons provoked by the death of dopamine receptor neurons in the basal ganglia nuclei.

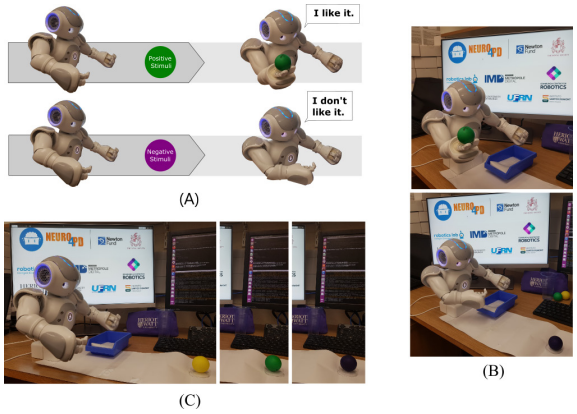


Figure 2: Illustrations of the behavioural task. In (A), the two expected behaviours after visual stimuli. (B) Shows behavioural responses based on visual information. In (C), the composed image presents the stage of the task when the robot senses the object based on its colour: yellow, green, and purple.

Impact

The proposed neurorobotics model of Parkinson's Disease represents a new platform with a strong potential for numerous future investigations. For instance, it can be used to shed light into PD research and also to support investigation on the BG-C-T circuitry within a sensorimotor loop. Other brain regions could also be incorporated to the circuitry allowing other functionalities to be studied. Moreover, a representation of the hippocampus and amygdala could be linked to the model in order to incorporate the concept of memory. As a consequence, even more complex behavioural tasks could be explored in this context and also other neural disorders.

Future Work

In this work, I used a computational model that was built using data from **rat brains** after unilateral infusions of the neurotoxin 6-hydroxydopamine (6-OHDA). Future work involves moving to a computational model of the **marmoset monkey brain**, which is closer to the human brain in terms of anatomy and features of PD. Besides, I will implement cerebellar structures and integrate them to my current model in order to make the motor control system of the robot more biologically meaningful. As a consequence, motor impairments, like tremor and bradykinesia, might be unveiled through our cerebellar structures after the activation of the parkinsonian conditions.

Publications

Pimentel, J. M., Moioli, R. C., de Araujo, M. F. P., Ranieri, C. M., Romero, R. A. F., Broz, F., & Vargas, P. A. (2021). Neuro4PD: An Initial Neurorobotics Model of Parkinson's Disease. Frontiers in eurorobotics, 15.https://doi.org/10.3389/fnbot.2021.640449

Pronin, S., Wellacott, L., Pimentel, J., Moioli, R. C., & Vargas, P. A. (2021). Neurorobotic Models of Neurological Disorders: A Mini Review. Frontiers in Neurorobotics, 15. https://doi.org/10.3389/fnbot.2021.634045

Ranieri, C. M., Moioli, R. C., Romero, R. A. F., de Araujo, M. F. P., De Santana, M. B., Pimentel, J. M., & Vargas, P. A. (2020, July). Unveiling Parkinson's Disease Features from a Primate Model with Deep Neural Networks. 2020 International Joint Conference on Neural Networks (IJCNN). https://doi.org/10.1109/ijcnn48605.2020.9207180

Research Area: Robotic Rehabilitation

Enhancing gait rehabilitation with robotic assistance and functional electrical stimulation

PhD candidate: Andreas Christou
Supervisors: Professor Sethu Vijayakumar, Dr Mustafa Suphi Erden

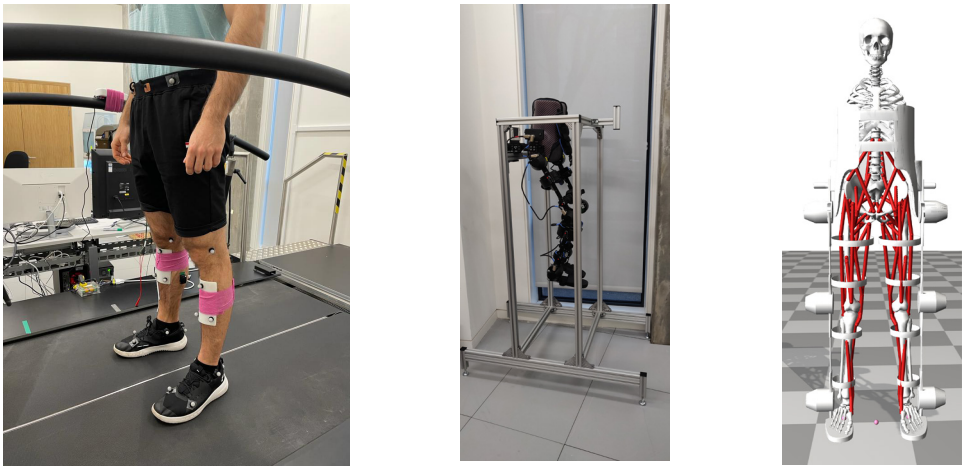


Fig 1. Healthy subject with motion capture markers (left), Suspended H3 exoskeleton (middle), Human-exoskeleton model (right)

Objective

The objective of this research project is to optimally combine robotic assistance with functional electrical stimulation (FES) in order to improve the outcomes of gait re-education in people with neurological impairments.

Introduction

Voluntary motor control of the lower limbs is commonly impaired following stroke and spinal cord injury. However, practising the correct gait sequences in physical therapy for patients who have limited control over their limbs is a labour-intensive procedure, usually requiring the assistance of more than two therapists. With the use of wearable robots, the strain on rehabilitation professionals can be alleviated as the robots can be pre-programmed to support the weight of the patient and provide assistance. Along with robotic assistance, the patient's motion can be further facilitated using short electrical impulses at selected muscles. While this can offer several physiological benefits to the patient (Gondin *et al.*, 2011), the muscles can quickly fatigue due to the specific motor unit recruitment pattern associated with FES. This hybridisation of robotic assistance with FES can allow the patients to benefit from the use of FES while it can also provide mechanical support to allow for any fatiguing muscles to recover, if needed. The aim of this project is to develop a controller that is able to optimally allocate the assistive forces to be provided from the robot and FES in order to personalise the intervention and prevent premature muscle fatigue.

Approach

Solving this actuation redundancy problem poses an optimisation challenge where a compromise needs to be made between assistance from the robot and assistance from FES. To solve this problem and test our controller, prior to adding a human in the loop, we use a simulation environment in OpenSim, a widely used open-source software for neuromusculoskeletal modelling (Seth *et al.*, 2018). Based on inverse dynamics analyses of the kinematic data recorded from healthy subjects on a treadmill (see Fig. 1 left), a reference

Enhancing gait rehabilitation with robotic assistance and functional electrical stimulation - Andreas Christou

kinematic pattern is obtained. By providing to the model the human motion intention, which can be extracted from the recorded motion, we test the ability of our controller to provide robotic assistance and FES in order to adjust the trajectory of the model to a trajectory that may be considered healthier.

Results

We developed the combined human-exoskeleton model (see Fig. 1 right) with the robotic exoskeleton H3 (see Fig. 1 middle), which will be used for this project. In a simulation environment, forward dynamics analyses are carried out to predict the effect of a hybrid robot-FES intervention on the kinematics of the human-exoskeleton model. The simulated results show that with the assistance of a robot and FES, the kinematic trajectory of the model can better follow the reference kinematic trajectory (see Fig. 2).

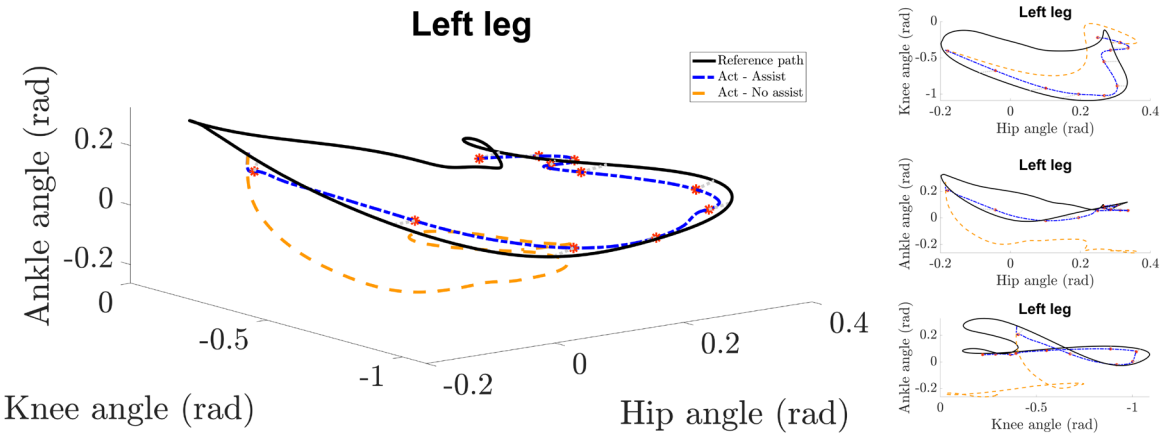


Fig 2. Simulation results of the kinematic trajectory of the human-exoskeleton model with (blue line) and without assistance (orange line) compared to the reference (black line)

Impact

The ability of the hybrid controller to find the optimum distribution of assistive forces will ensure that the training is not interrupted due to muscle fatigue and that physical therapy is personalised. This can lead to enhanced functional outcomes in a shorter period of time. The improved outcomes from physical therapy can prevent potential injuries and significantly improve the quality of life.

Future Work

The next milestones for this project involve the optimisation of the hybrid controller and its verification with healthy subjects wearing the H3 exoskeleton.

References

Gondin, J. *et al.* (2011) 'Neuromuscular electrical stimulation training induces atypical adaptations of the human skeletal muscle phenotype: A functional and proteomic analysis', *Journal of Applied Physiology*, 110(2), pp. 433–450. doi: 10.1152/japplphysiol.00914.2010.

Seth, A. *et al.* (2018) 'OpenSim: Simulating musculoskeletal dynamics and neuromuscular control to study human and animal movement', *PLOS Computational Biology*. Edited by D. Schneidman, 14(7), p. e1006223. doi: 10.1371/journal.pcbi.1006223.

Research Area: Human-Computer Interaction

How Well Am I Doing?: Measuring Human Performance in Teleoperation – The Introduction of a Novel Approach

PhD candidate: Eleftherios Triantafyllidis
Supervisor: Dr Zhibin Li
Contributors: Wenbin Hu, Christopher McGreavy

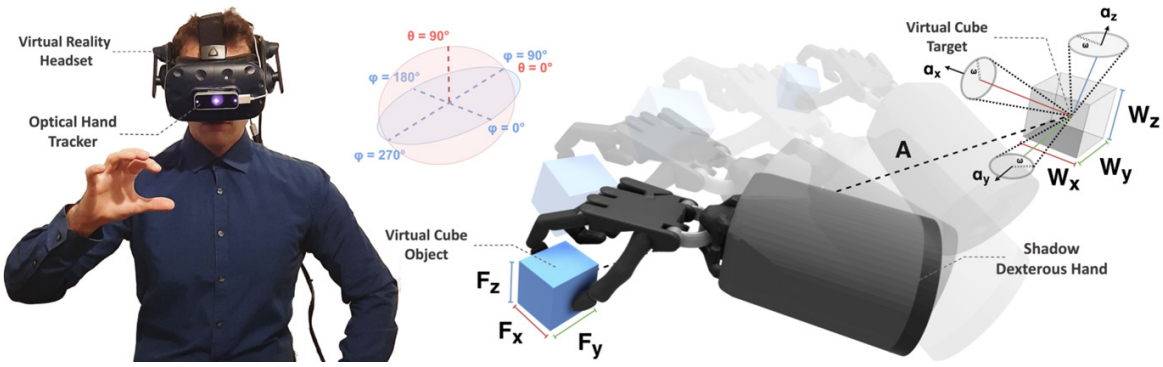


Figure 1. An operator interacts with objects in full 3D virtual reality with all task-related spatial variables.

Objective

Assessing the performance of human movements during teleoperation is challenging, due to complex spatial settings. A promising human performance model is Fitts' law; one of the most widely used models in HCI history. While a promising basis for measuring performance, the law suffers in terms of simplicity when full 3D space is considered. Nevertheless, the ability of the law to combine both time and spatial based metrics renders the pursuit of extending it to 3D of importance. Even though there has been a collective effort in extending the law to 3D, a compelling standardized metric in 3D is still missing, aggravating inter-study comparability.

Approach

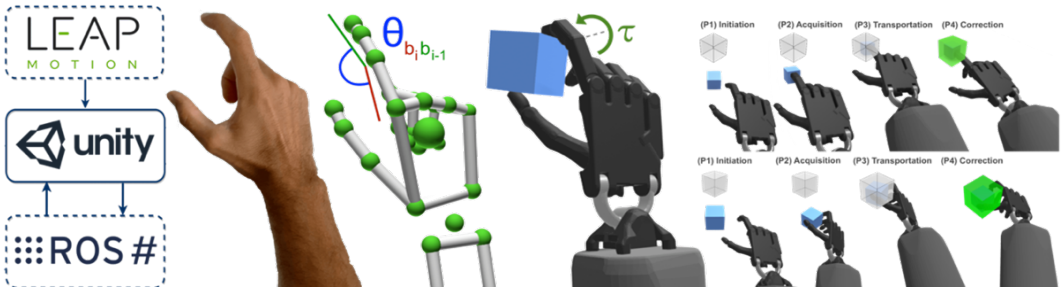


Figure 2. The system setup and depiction of the hand retargeting approach of the user's hand in the simulation.

To account for this limitation, four experiments (E1 to E4) were designed and conducted with progressively higher spatial complexity to study and compare existing metrics thoroughly. Figure 1 and Figure 2 represent the study setup and apparatus respectively. Our research goal was to quantify the difficulty of these 3D tasks and model human performance sufficiently. Consequently, we evaluated the most popular 2D and 3D extensions of Fitts' original 1D law in full 3D as seen in teleoperation tasks. To achieve this, we conducted a user study (N=20), in the virtual simulation environment Unity3D. To evaluate each model on the experimental results, including ours, we used linear regression analysis (R^2) to determine the model fitting.

How Well Am I Doing?: Measuring Human Performance in Teleoperation – The Introduction of a Novel Approach - Eleftherios Triantafyllidis

Results

In the most basic form of 3D translation (E1), we observed that existing approaches can be used to adequately model human performance but were insufficient when spatial angles were introduced (E2). Moreover, the majority of these approaches did not model rotation well (E3) and were insufficient in full 3D when combining translation and rotation (E4). Hence, a new model has been proposed, with our model outperforming existing formulations in full 3D space.

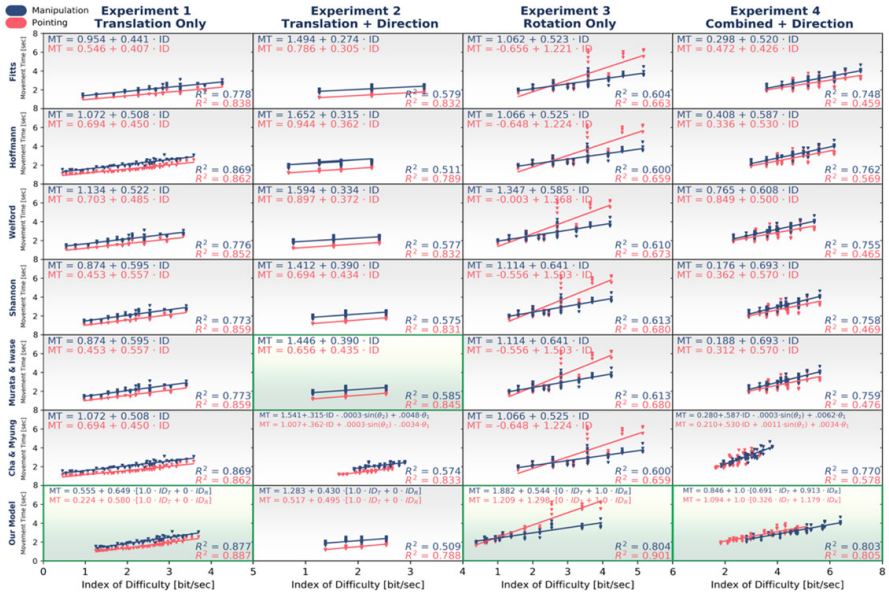


Figure 3. Regression plots of all models across E1 to E4 with R^2 values. Green boxes represent best model.

Impact

To the best of our knowledge, this work extensively compared the most widely used performance metrics based on Fitts' law. Our proposed metric modelled human performance better than existing models, especially in increasing spatial complexities as seen in full 3D.

Future work

As for all human performance models deriving from Fitts' law, the main limitations are stationary pointing or manipulation tasks. All current model extensions, including ours, did not take into account upper-body movements, such as movements from torsos and/or shoulders.

Publications

E. Triantafyllidis, W. HU, C. McGreavy and Z. Li, Metrics for 3D Object Pointing and Manipulation in Virtual Reality: The Introduction and Validation of a Novel Approach in Measuring Human Performance, *in IEEE Robotics & Automation Magazine*, doi: 10.1109/MRA.2021.3090070. Online: https://ieeexplore.ieee.org/document/9492850

E. Triantafyllidis and Z. Li, The Challenges in Modeling Human Performance in 3D Space with Fitts' Law, *in CHI Conference on Human Factors in Computing Systems (CHI '21).* Association for Computing Machinery, May 8–13, 2021, Yokohama, Japan. ACM, New York, NY, USA. DOI: 10.1145/3411763.3443442. Online: https://dl.acm.org/doi/10.1145/3411763.3443442

E. Triantafyllidis and Z. Li, Considerations and Challenges of Measuring Operator Performance in Telepresence and Teleoperation Entailing Mixed Reality Technologies, *in CHI Conference on Human Factors in Computing Systems Workshop CHI '21 (Evaluating User Experiences in Mixed Reality).* Association for Computing Machinery, May 7, 2021, Yokohama, Japan. ACM, New York, NY, USA. Online: https://arxiv.org/abs/2103.12702

Research Area: Soft Body Dynamics Learning

Data-Driven Modelling and Simulation of Deformable Materials

PhD candidate: Georgios Kamaras
Supervisors: Professor Subramanian Ramamoorthy, Dr Kartic Subr

Objective

This work is aimed at improving the state of the art in dynamic simulation of soft materials. The long term objective is to design neural network based models that emulate the dynamics exhibited in corresponding simulators. In work done so far, we address whether current data-driven methods can effectively capture such dynamic phenomena.

Introduction

Data-driven robotic manipulation methods often learn physics models directly from sequences of raw state observations. *Particle-based* representations of dynamics are popular for modelling rigid and deformable bodies. Object dynamics are encoded as a connected lattice of particles (e.g. Graph Networks), using message passing updates as the learning process. Cutting presents a unique challenge to this simulation paradigm, as it corresponds to making specific, localised *structural* changes to the particle interaction graph *during execution*. In our work, we focus especially on such phenomena involving *structural discontinuities*, which occur in numerous robotics domains.

Figure 1: Cutting scenarios in CutBench - (**top**) the knife only pushes the body, (**middle**) the knife partly cuts the body and (**bottom**) the knife completely separates the original body and pushes one body part to the side

Technical Contributions

We present CutBench (Fig. 1) - a suite of soft object manipulation benchmarks for the cutting domain. It allows users to simulate cutting deformable objects with a rigid knife under various adjustable parameters such as knife bluntness, and cut body stiffness. We also propose a corresponding set of evaluation metrics; Mean Squared Error (MSE), Number of Connected Components (NCC) and Intersection-Over-Union (IoU), to assess how successful a learned model of the cutting simulation is. We conduct a case study on DPI-Net [1] - a prominent Graph Neural Network model capable of learning soft body dynamics. Our experiments first evaluate the learning of only cutting dynamics, and then evaluate the learning of post-cutting dynamics when a cutting action is followed by pushing one body part to the side.

Results

In our experiments, we show that particle-based neural dynamical models like DPI-Net do not accurately represent scenarios where the topology of the manipulated object can change,

Data-Driven Modelling and Simulation of Deformable Materials - Georgios Kamaras

especially in cases where a clear, isolated discontinuity is introduced to the structure of the body, but the resultant components are sturdy and have to preserve their shape post-cutting. This is reflected in Fig. 2, where we see the predicted body falling apart following a pushing action, after it has been cut. Further, we quantitatively characterise specific metrics according to which the models fall short (Fig. 3), so that new models can be developed to address these shortcomings.

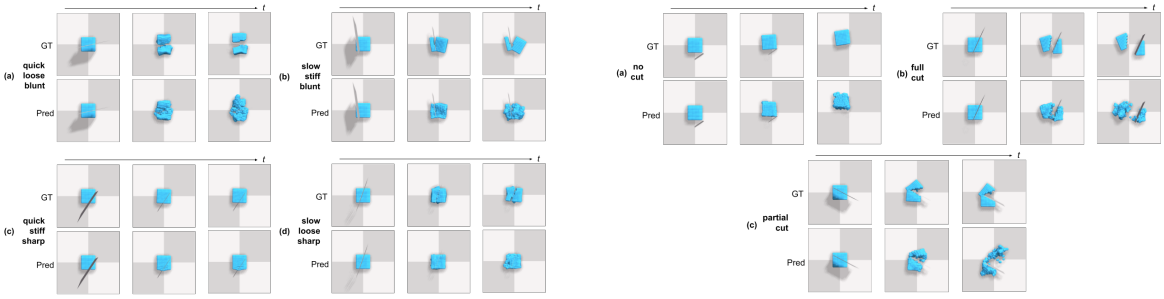


Figure 2: Qualitative results from simulating only cutting dynamics for bodies with different properties (**left**) and from simulating cutting & pushing dynamics for bodies with different properties (**right**)

	quick stiff blunt	quick loose blunt	slow stiff blunt	slow loose blunt
NCC GT	2.00 (.45)	1.85 (.85)	1.65 (.48)	1.65 (.57)
NCC Pred	9.30 (4.82)	1.25 (.53)	6.25 (3.35)	1.35 (.57)
IoU	0.30 (.06)	0.54 (.06)	0.31 (.07)	0.46 (.05)

	no cuts	partial cuts	full cuts
NCC GT	1.00 (0.0)	1.10 (0.30)	2.05 (.22)
NCC Pred	3.65 (4.56)	4.10 (1.30)	11.25 (3.08)
IoU	0.39 (.09)	0.34 (.07)	0.28 (.08)

Figure 3: Metric statistics (mean and standard deviation) for a set of 4 experiments, focusing on cutting dynamics of deformable bodies, cut with a blunt knife (**left**), and for a set of 3 experiments, focusing on the postcutting dynamics of the deformable bodies (**right**).

Impact

This work is related to the Turing sponsored project on Safe AI for Surgical Assistance, and fits within a programme of work aimed at better characterising soft material properties for improved manipulation, e.g., of tissue in a surgical setting. The core methodology is also applicable in domains ranging from food preparation and agriculture, to domestic robots.

Future Work

There are two major directions for future work. We are developing improved models for learning to simulate continuum dynamics, and for model calibration to data from real world objects. Also, we are working to expand CutBench, by introducing heterogeneous soft objects, extending the supported types of tool geometries, and considering different tool motions, potentially using approaches from the area of Learning from Demonstration.

Publications

G. Kamaras, Y. Hristov, C.A. Innes, J.K. Gupta, and S. Ramamoorthy. "CutBench: Evaluating Soft Body Dynamics Learning Methods in Cutting Actions". (*Manuscript under review*) Website: https://sites.google.com/view/cutbench.

References

[1] Y. Li, J. Wu, R. Tedrake, J. B. Tenenbaum, and A. Torralba. "Learning particle dynamics for manipulating rigid bodies, deformable objects, and fluids". In International Conference on Learning Representations (ICLR), 2019. Website: http://dpi.csail.mit.edu/.

Research Area: Computational Co-Design

Co-Designing Robots by Differentiating Motion Solvers

PhD candidate: Traiko Dinev
Supervisors: Professor Sethu Vijayakumar, Dr Steve Tonneau
Contributors: Carlos Mastalli, Vladimir Ivan

Introduction

Figure 1. Solo robot. Left – 3D printed parts and motors, right – the assembled robot (source Open Dynamic Robot Initiative)

Mechanical design is a time-consuming process that requires many iterations. Robot design is even more difficult, as designers need to also take into consideration the motions the robot will execute. Figure 1) shows the Solo robot and some of the many parts required to build it. My project aims to develop algorithms to automate parts of the design process, also known as computational co-design, by optimizing the design of the robot for the tasks it will execute. The optimization takes into account motion planning and finds the optimal design for the given task.

Objectives

Our objective is to have realistic and fast co-design algorithms that allow us to transfer our results to the real world. We aim to develop a modular co-design solution that leverages recent advances in motion planning.

Approach

To use existing advanced motion planning algorithms, we propose a bi-level scheme (shown in Figure 2)). We use a motion planning algorithm in the lower level and take its derivative to optimize the design in the upper layer. We additionally verify our approach in a physics simulator by fitting the best proportional-derivative controller and computing the improvements in the co-design metrics.

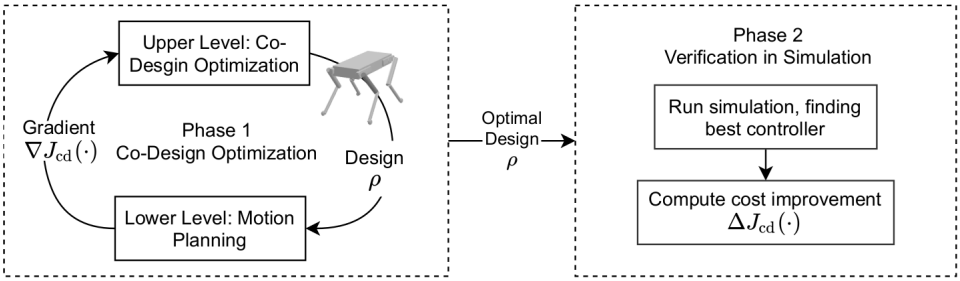


Figure 2. Co-design optimization pipeline

Co-Designing Robots by Differentiating Motion Solvers - Traiko Dinev

Results

We optimized robot designs for two tasks -- trotting and jumping. In Figure 3 we show the different energy-optimal designs. For trotting we see a larger robot than for jumping, as jumping with a heavier body requires more energy, whereas for trotting longer legs lead to the robot using less force while moving.

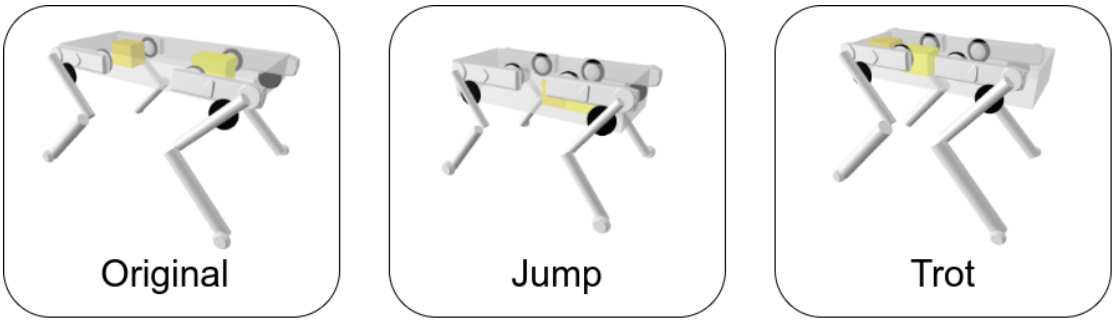


Figure 3. Results. For different tasks, different robot designs are optimal.

We also compared our approach to a similar, two-level optimization, namely Covariance Matrix Adaptation (CMA), for three different co-design costs. We demonstrate clearly that our method is more scalable, while achieving a similar final cost to CMA.

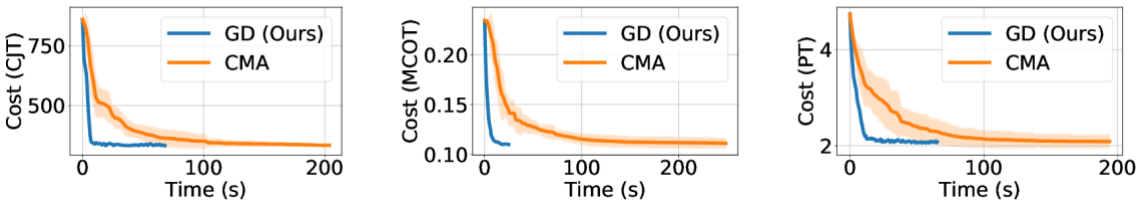


Figure 4. Scalability. Our approach is more scalable than commonly used genetic algorithms (here Covariance Matrix Adaptation (CMA))

Impact

Our work focuses on developing a modular approach to co-design using gradient-based optimization. With our work, it is now possible to use fast local gradient optimizations with complex state-of-the-art motion planners.

References

[1] Dinev, Traiko, Carlos Mastalli, Vladimir Ivan, Steve Tonneau, and Sethu Vijayakumar. "Co-Designing Robots by Differentiating Motion Solvers." *arXiv preprint arXiv:2103.04660* (2021).

Research Area: Explainable Autonomy

Plan Verbalisation for Robots Acting in Dynamic Environments

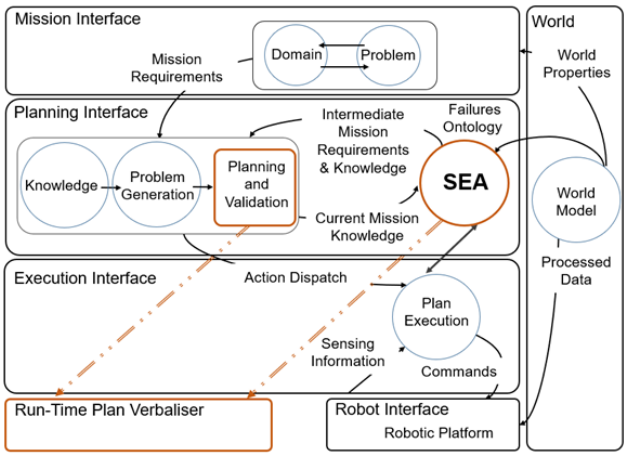
PhD candidate: Konstantinos Gavriilidis
Supervisor: Professor Helen Hastie

Introduction

Autonomous systems are designed to perform optimally in multiple scenarios while adapting to unexpected disruptions or environment behaviours. At the same time with automated planning, a plan can be devised in a manner of seconds if the capabilities of a robot and the problem at hand are known. However, their behaviour and reasoning cannot always be easily comprehended and that in turn leads to limited situation awareness. In order for operators to sufficiently oversee robotic operations, understandable representations that disambiguate mission outcomes are needed. An effective way of making robotic behaviours more transparent is by providing natural language explanations. To develop such an explanation model, aspects such as the content of verbalisations and the amount of information that is conveyed have to be considered to make the interaction optimal. This is a necessary element for human-in-the-loop applications to establish trust towards automated systems and to notify users when their assistance is needed for the completion of a task. This work presents a system that retrieves data during plan validation and execution and carefully explains concepts such as the expected mission outcomes, action updates, detected faults and replanning.

Approach

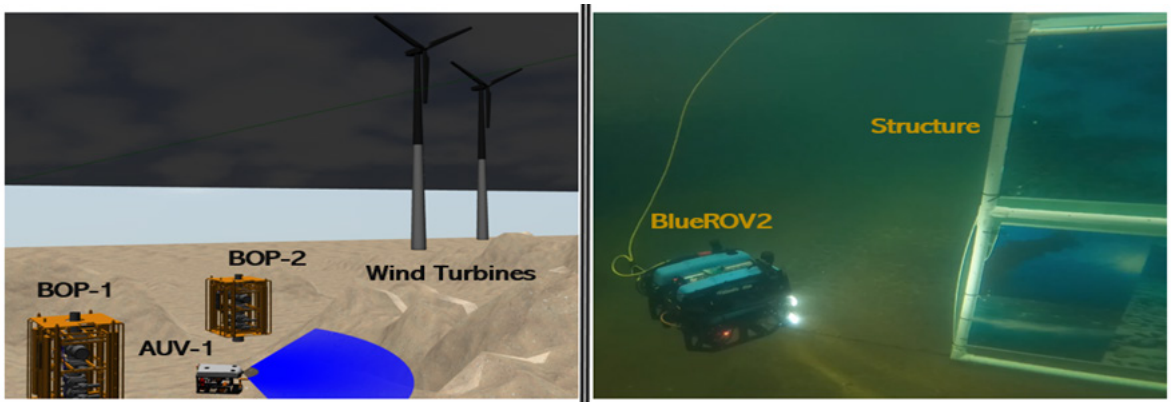
The objective of this work is to combine planning elements with external knowledge, to provide additional meaning to plan execution outputs and thus aid operator understanding. To represent an autonomous system, a Planning Domain Definition Language domain that focuses on underwater robots has been designed. Additionally, with the use of the OPTIC temporal planner, it was possible to derive plans and execute them with the ROSPlan interface, which generates information about actions and sensor readings. Concurrently, a verbaliser receives this information and passes it to a knowledge base that can make sense of the data and recognise multiple events or state inconsistencies. Making use of the reasoner outputs, we funnel that information to a template-based surface realiser, which generates a natural language explanation that is aimed for users with minimum planning expertise.



Plan Verbalisation for Robots Acting in Dynamic Environments - Konstantinos Gavriilidis

Outcome

Verbalisation of planning during plan validation and execution has been successfully established both in simulation and also in the wave tank at Heriot-Watt University (see image below).



0.000: navigation (auv wp0 wp10) [10.000]
Action Initialisation: **Components To Extract:** *action id*: 1 *name*: navigation *parameters*: (auv wp0 wp10) *dispatch time*: 0.000 *duration*: 10.000 **Verbalisation**: auv *has started moving from* wp0 *to* wp10. *The action started at* 0.000 *sec. with duration* 10.000 *sec.*
Action Feedback: **Components to Extract:** *action id*: 1 *action status*: i.e., enabled or achieved **Verbalisation**: Auv *is now located at* wp10.
Action Updates: **Components to Extract:** *action interface*: i.e., ***Navigation A-Int.***, ***Map A-Int.***, etc. **Verbalisation**: *Latest update received from* ***Navigation A-Int.***

Table 1: Verbalisation for navigation action.

In Table 1, you can see the data used for input to the online explanations. The system was able to initially provide information about the commencing of an action ('Action Initialisation'). Upon action execution ('Action Feedback/Updates''), the explanation model made clear to the user various task outcomes and in case of an error, the affected hardware and causality were described in natural language. Additionally, with the use of a knowledge base it was possible to add more context to mission data and derive the desirable content for explanations. This work highlights the use of knowledge-enhanced systems for situation awareness and indicates that grounded interaction has the potential to inform the user about mission outcomes in a responsible manner.

Future Work

To extend this work, the inclusion of more vehicle types is needed for the generalisation of this approach across multiple domains. This would require a modification of both the domain and knowledge base. Our approach is scalable so this seems feasible. Secondly, full automation of content selection would be preferred with the use of a data-driven natural language generation model. Personalisation of explanations based on user expertise is going to be pursued in order for our system to intuitively reduce the mental load of the user. Finally, results for our approach will be validated by conducting human evaluations in realistic scenarios.

Publications

Gavriilidis, K., Carreno, Y., Munafo, A., Pang, W., Petrick, R.P. and Hastie, H., 2021. Plan Verbalisation for Robots Acting in Dynamic Environments. In Proceedings of ICAPS Workshop in Knowledge Engineering for Planning and Scheduling (KEPS).

Research Area: Robotic manipulation of soft objects

Towards autonomous soft tissue surgery: Understanding the skill of surgical excision from force measurements

PhD candidate: Artūras Straižys
Supervisors: Professor Subramanian Ramamoorthy, Dr Suphi Erden, Dr Michael Burke

Introduction

The autonomous cutting of soft tissues is a challenging problem due to complexity of the deformation and separation processes in soft tissues [1]. The human surgeons demonstrate a remarkable robustness in this task, without access to a detailed model of biological tissues. In this study we attempt to improve our understanding what underlies this psychomotor skill and to provide an insight to control mechanisms that shape this complex behaviour. In contrast to most of the literature on surgical skills that focuses on motion-based analysis, in this study we investigate the force modality and its role in defining the surgical proficiency.

Approach

First, we developed the sensorized cutting instrument capable of measuring forces acting on the blade (Fig. 1), and constructed a multi-layered tissue phantom that mimic mechanical properties of biological skin (Fig. 2).

Next, we conducted the experiment involving 15 medical students performing the series of elliptical excisions on the phantom. The analysis of collected force data showed that incision task can be effectively modelled with switching linear dynamical system under a Maxwell material model (Fig. 3).

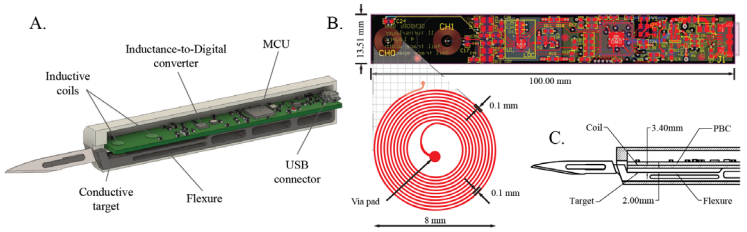


Figure 1. (A) Concept design (cross section) of the cutting tool with an integrated flexure- based uniaxial force sensor. (B) PCB and planar coil dimensions. (C) Cross-sectional schematic of the instrument.

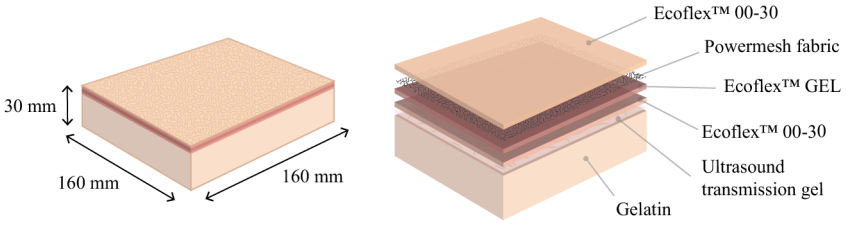


Figure 2. Design and material composition of the skin-mimicking phantom.

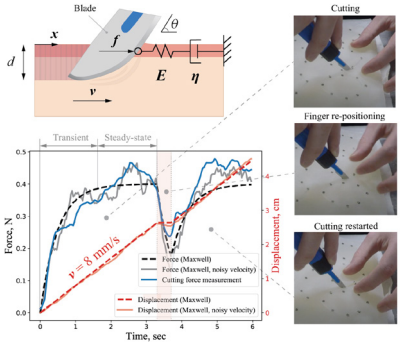


Figure 3. Maxwell model of cutting forces at different phases of the task. **E** and **η** are spring and damping coefficients, respectively.

The main contributions of our study:

- The design of minituarized force sensor
- Investigation of cutting forces in the task of surgical excision
- The generative model of incision forces based on the latent dynamical system with viscoelastic tissue dynamics

Towards autonomous soft tissue surgery: Understanding the skill of surgical excision from force measurements - Artūras Straižys

Results

We model a cutting process as a virtual hybrid system with a set of linear regimes, in which the blade velocity is feedback-regulated in the presence of disturbance. Our proposed generative model (Fig. 4) captures three key components of the observed behaviour: 1) the step-like profile of the incision force, with distinct transient and steady-state task phases, 2) the variation of the force magnitude in both task phases, and 3) the smoothness of task execution flow characterised by a frequency of interruptions due to tissue re-tension or finger re-positioning events.

We show that these components can compactly describe the manner at which the surgical excision is executed (Fig. 5) and offer greater insight compared to the traditional statistical description approach.

In contrast to the traditional summary statistics, that regard the force measurements as i.i.d. random variable and rely on stationarity assumption, our model effectively captures and quantifies each of the distinct phases of the task execution.

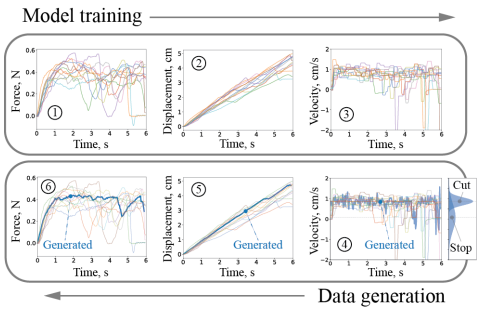
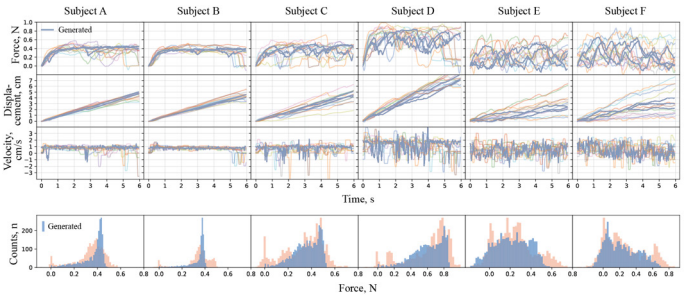


Figure 4. An overview of model training and data generation processes. (1) Actual measurements of cutting forces collected during the trials. (2) The profiles of virtual displacement of the blade, derived from the force measurements using the Maxwell model. (3) The profiles of virtual velocity of the blade obtained by regularized differentiation of the displacement series (used to train the model). (4) The velocity profile (blue line) sampled from the trained model (on the right is the observation model). (5 and 6) The generated displacement and force profiles (blue lines).

Figure 5. The virtual displacement and velocity profiles (middle rows) derived from the actual cutting force measurements (top row). Bottom row shows the histograms of actual cutting force measurements (peach bars) versus force samples generated by the model (blue bars).



Impact

Better understanding of what underlies the skill of surgical incisions is critical, as it may improve the surgical training and assessment, as well as to provide key insights to robotic surgery challenges. In this preliminary study, we propose a generative model of incision forces that can be used in analysis of surgeon-specific force signatures and skill identification.

Future work

The next step in this study is to investigate the efficacy of our model in the objective evaluation of surgical proficiency. The ability to discriminate the skill from parameters of a hybrid system can offer great insights for safe and robust autonomous surgical excision.

References

[1] A. Straižys, M. Burke and S. Ramamoorthy, "Surfing on an uncertain edge: Precision cutting of soft tissue using torque-based medium classification," 2020 IEEE International Conference on Robotics and Automation (ICRA), 2020, pp. 4623-4629, doi: 10.1109/ICRA40945.2020.9196623.

New Research Programmes

Harmony: Enhancing Healthcare with Assistive Robotic Mobile Manipulation

Harmony
Assistive robots for healthcare

The vision of this project, which received £759k of funding, is to enable robust, flexible and safe autonomous mobile manipulation technology for use in human-centred environments. This project is a collaboration with ETH Zurich (coordinator), TU Delft, University of Bonn, University of Twente, CREATE, ABB and healthcare partners including Karolinska University Hospital and University Hospital Zurich. Edinburgh's role in the consortium will be to develop robust, flexible and adaptive dual arm manipulation on mobile loco-manipulation platforms such as the Kawada Nextage, addressing both dynamic motion planning under challenging environments as well as compliant, real-time control.

Digital Circular Electrochemical Economy (DCEE)

This project focuses on a radical change to chemical manufacturing with a view to effective step changes in environmental sustainability and in circularity of materials. It will focus on the emerging electrochemical sector which is expected to grow strongly and within which there are many opportunities for the deployment of digital technologies to underpin system design and operation. The project, led by Imperial College London in collaboration with Loughborough and Heriot-Watt Universities, has received £965k of funding and will run for three years from June 2021.

UKRI Research Node on Trustworthy Autonomous Systems (TAS) Governance & Regulation

Professor Subramanian Ramamoorthy at the School of Informatics, University of Edinburgh will be leading this research node which aims to develop a novel framework for the certification, assurance and legality of TAS. This requires consideration of a range of issues from safety certification of autonomous robots to incorporating values such as fairness, accountability and responsibility in AI-driven diagnostic decisions.

UKRI Trustworthy Autonomous Systems Node in Trust

Professor Helen Hastie from the School of Mathematical and Computer Sciences at Heriot-Watt University is leading this project which will explore solutions to manage trust in autonomous systems, covering scenarios that require interaction with humans. Examples include self-driving cars, autonomous wheelchairs or 'cobots' in the workforce. The group's work will help design the autonomous systems of the future, ensuring they are widely used and accepted in a variety of industry relevant applications. This project received approximately £3m in funding.

Prosperity

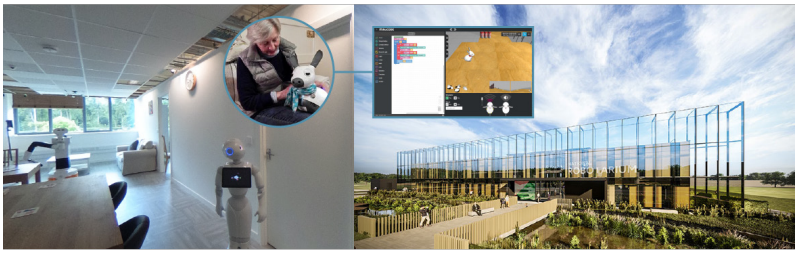
During summer 2021 it was announced that EPSRC would invest £19m in projects through its long-running Prosperity Partnerships initiative, with industry and university partners investing a further £40m. Prosperity Partnerships build on existing UK strengths in industry and academia to develop new technologies, processes and skills that will deliver economic growth and create jobs across the UK.

Heriot-Watt University and SeeByte have received £2.2m to work together to develop the robust methods needed for humans to collaborate with autonomous systems to have them operate effectively and safely in hazardous and unpredictable environments. These methods include manned-unmanned teaming; explainable AI; robot scene understanding; and joint decision-making.

New Research Programmes

Open AAL

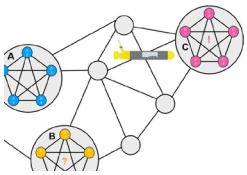
The Open Ambient Assisted Living (OpenAAL) project targets the fast co-creation of scalable and affordable solutions to support the care of vulnerable people whose urgent need has been exemplified by the COVID-19 pandemic. The project which ran from July 2020 to April 2021 received £50k for funding from EPSRC under the Impact Acceleration Accounts scheme. Part of the National Robotarium, based at Heriot-Watt University, the OpenAAL lab will use digital twin, Internet of Things (IoT) and cloud technologies to provide a platform where researchers, industry and care providers alongside end users of assisted living services can co-create technology, where time and distance is no longer a barrier – any time, any place access.



EMERGENCE: Tackling Frailty - Facilitating the Emergence of Healthcare Robots from Labs

The EMERGENCE network will explore how robots can be used to support people to better self-manage the conditions that result from frailty and, by providing information and data to healthcare practitioners, enable more timely interventions. This project is supported through a three-year £700k EPSRC NetworkPlus grant and includes partners from Sheffield, Sheffield Hallam and Hertfordshire Universities.

HUDSON - Harvesting of Underwater Data from SensOr Networks



HUDSON will develop models and systems to enable an AUV to harvest measurements from stationary smart sensor nodes within a sparse underwater sensor network via acoustic modems. This one-year project led by the National Oceanography Centre is a collaboration with ORCA Hub, University of Oxford and Newcastle University, which has received £79k of funding from EPSRC.

Digital Facility

Digital Facility will create a digital ecosystem of the state-of-the-art FASTBLADE facility to demonstrate the advantages of holistic modelling of systems through digital twinning to improve asset management, structural health monitoring and industrial processes to deliver environmental and economic benefit. This project is supported through a £25k DataLab grant, a £10k Housing Construction and Infrastructure (HCI) Skills Gateway Scholarship and £100k contribution (cash and in-kind) from Babcock. The partners are Babcock and the University of Edinburgh.

Leverhulme Trust Senior Research Fellowship

The overall aim of this project is to adapt existing Visual Dialogue research to the use-case of the Blind and Partially Sighted (BPS). Visual Dialog requires an AI agent to hold a meaningful conversation with humans, in our case BPS, in natural language about visual content, e.g. a picture. This use case scenario opens up new research challenges, which we address by extending current datasets and algorithms to this more challenging task, building on our own work in multimodal dialogue. In particular, the project has two main objectives:

1. Develop visual Question-Answering technology for the BPS
2. Exploit models of linguistic "communicative grounding" by developing multimodal technology to collaborate with BPS people on a task

Industrial studentships

Statistical Methods for AUV Underwater Pipeline Tracking in Multi Sensor Data

Kawasaki Heavy Industries, Kobe, Japan

Pipeline tracking is a challenging task for Autonomous Underwater Vehicles because sections of the pipe may be deliberately buried and not visible from the surface. This project investigates multi-sensor solutions to tracking pipelines in and out of burial from an AUV flying low over the pipe using multi-sensor data, to be selected from sub bottom sonar, wideband biosonar, magnetometer, laser and video. The PhD work focuses on statistical methods for tracking, starting with the Probability Hypothesis Density filter.

Cooperative Control of Drilling Equipment

Schlumberger, UK

As automation of drilling processes is developed, operation will be split between completely automated tasks and tasks that are carried out by humans. The project looks at how teams comprising human and robotic actors can collaborate to achieve complex and uncertain tasks in drilling operations.

Interactive Robotic Inspection Strategies Using Unstructured Data

Renishaw, UK

Document based 2D technical drawings rather than a digital 3D model are still the main format in a production-inspection workflow. This research is focused on using unstructured data such as the symbolic representations of geometric dimensioning and tolerance (GD&T) as input to conduct a teach-execute regime for coordinate measuring robots.

Shared Autonomy for Kinesthetic Tools

Costain, UK

Many repetitive industrial tasks require significant cognitive load which results in operator fatigue and in turn can become dangerous. The development of robotic sensing technology and compliant feedback technology will allow semi-autonomous robotics systems to improve this type of workflow. This project aims to explore methods in which a robotic system with shared autonomy can contribute to the operation of a Kinesthetic tool (such as a piece of machinery) and in doing so reduce the cognitive load and fatigue of the human operator.

Towards Full Autonomy: Deep Learning Enhanced Scene Understanding for Underwater Robots

SeeByte Limited

This project will investigate state-of-the-art driven machine learning techniques, e.g. Convolutional and Recurrent Neural Networks, as well as Deep Reinforcement Learning techniques, extending these novel approaches to be applicable to the underwater robotics domain.

Bridge Inspection - Inspection of Brickwork and Masonry Assets

RSSB, UK

This project aims to inspect the brickwork and masonry assets of railway bridges, particularly the intrados of arches where access is limited. The project will use drones to collect images autonomously under the arches and then analyse the images to automatically detect the defects in the structure.

Intention-aware Motion Planning

Thales, UK

The goal of this industrially sponsored project is to research and extend previous techniques to give a new approach to categorising motion and inferring possible future system states to support robust maritime autonomy decision making processes.

Industrial studentships

Long Term Autonomy for Multi Agent Systems in the Maritime Domain
BAE Systems

The main aim of this project is to develop algorithms that can devise, execute and monitor plans suitable for long-term missions of marine 'systems of systems' where overall goals are well defined but their effective implementation is dependent on external parameters that cannot be pre-determined.

Intention Aware Human-Robot Collaborative Manipulation of Large Objects
Honda Research Institute Europe

Until the past few years, robots were typically temporally or spatially separated from human co-workers to ensure humans' safety. In the case of today's cobots that's not the case anymore. However, the unpredictability and the variability of humans' actions generate scenarios with frequent plan alterations and considerable uncertainty, to the extent that robots fail to successfully complete the collaborative tasks in hand. This project aims to develop the required theory to overcome these limitations and demonstrate collaborative human-robot manipulation scenarios.

Explainable AI and Autonomy for the Maritime Domain
SeeByte Limited & SRPe

The principal goal for this project is to enable effective text-based interaction between an operator and an AUV to unlock situation awareness in the underwater domain and explain behaviours. This will be achieved by investigating Data2Text methods to derive verbal explanations from a mix of structured and unstructured data, including a world model and its dynamic environment, status from the vehicle, as well as a representation of the autonomy model logic.

Mobile Inspection Units on the Train
RSSB, UK

This project aims to develop robotized inspection units that can navigate and manipulate in the confined workspaces, typical of in-between and under the seats of a train cab. The typical application for an on-train mobile robot platform is inspection of the compartments for cleaning and hazard identification purposes. The platform is also intended to have manipulation capability to perform some cleaning tasks.

Lifelong Learning for Vision based AUV Control
Rovco & SRPe

Precise robot control for underwater inspection is of paramount importance to generate high quality survey data. This is a challenging problem as the environment these robots operate in is dynamic, uncertain and very difficult to model a priori. Moreover, the robot configuration changes from mission to mission and tuning the controllers for each configuration is time consuming. The main objective of this project is to design adaptive low-level controllers for autonomous underwater vehicles using sensor feedback and machine learning frameworks. The algorithms will take input from real time sensors and actuators and adapt in real time to changes in vehicle performances (change of payload, actuator fatigue, tether drag) and environmental conditions (waves, currents, wind). Ideally, they should be portable across multiple robots.

Miscommunication and Repair in Visual Conversational AI
Alana AI Ltd

This project will investigate and develop visually grounded NLP models that allow grounded representations to be systematically edited, repaired or recomputed, paving the way for VAI systems that are able to both understand user repairs as well as engage in repair when needed. The said models will be evaluated against appropriate 'visual repair' datasets collected as part of the project. The resulting VAI systems will be developed using the existing Alana framework and evaluated with Alana's partially sighted users.

Edinburgh Centre for Robotics Industrial Partners

ABB

ALANA

BAKER HUGHES a GE company

Balfour Beatty

BAE SYSTEMS INSPIRED WORK

bp

CHITENDAI

codeplay

CONSTRUCTION SCOTLAND INNOVATION CENTRE

COSTAIN

THE DATA LAB value from data

DIGITAL HEALTH & CARE INSTITUTE

DI4D PERFORMANCE CAPTURE

dyson

FIVE AI

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

HITACHI

HRI

HYDRASON solutions

industrial systems and control

L3HARRIS | ASV

Kawasaki Powering your potential

KINOVA ROBOTICS

KUKA

LEONARDO

MACTAGGART SCOTT Innovators since 1898

MARZA ANIMATION PLANET

NII 大学共同利用機関法人 情報・システム研究機構 国立情報学研究所 National Institute of Informatics

Edinburgh Centre for Robotics Industrial Partners

Engaging with the Centre

Robots will revolutionise the world's economy and society over the next twenty years, working for us, beside us and interacting with us.
The UK Engineering and Physical Sciences Research Council (EPSRC) has invested nearly £500m in new Centres for Doctoral Training (CDTs) to develop industrially relevant, cutting-edge technologies and the research leaders of the future.
The Edinburgh Centre for Robotics, a £120M joint venture between Heriot-Watt University and the University of Edinburgh, has been running an EPSRC CDT in Robotics and Autonomous Systems since 2014, training around 70 highly-skilled graduates. As a result of a successful follow-on bid, we received an additional eight years of funding, allowing us to train a further five cohorts of between 10-15 innovation-ready PhD students annually from September 2019.

In order to maximise the number of students who can benefit from this programme, we invite proposals for new research projects from companies with a research activity in the UK.

The theme of the CDT RAS 2.0 is **Safe Interaction**, which includes the following topics:

Physical Interactions:
Control, actuation, compliance, sensing, mapping, planning, embodiments, swarming

People Interactions:
Human-robot interaction, affective robotics, smart spaces, teaming, collaborative decision-making, cobots, multimodal interfaces

Self-Interactions:
Condition monitoring, prognosis, explainable AI, certification, verification, safety, security

Interaction Enablers:
Vision, embedded and parallel computing, novel fabrication methods, machine learning algorithms and other AI techniques including NLP

How to engage with the Centre

A company can choose to support a relevant PhD research project in a university laboratory, in return gaining early access to results, the potential to exclusively license foreground IP and the right to host the student at their site for 3 months of the project. Companies generally provide financial support for stipend, UK/EU fees and project costs.

Entry to the programme is in September, with students completing two semesters of taught courses whilst starting to explore their PhD research direction.

Project proposals from companies are accepted throughout the year but are particularly encouraged by the end of March to allow recruitment to the programme in the new academic year.

In addition to funding a studentship, companies can also provide support by:
- Providing access to equipment/software at their premises
- Co-supervision of students and projects
- Student placements and internships
- Contribution to MSc taught programmes
- Support for student robot competitions

If you are interested in engaging with the Centre, please contact:
Professor Helen Hastie h.hastie@hw.ac.uk
Professor Michael Mistry michael.mistry@ed.ac.uk

Highlights 2020-21

Annual Conference, October 6th 2020

Due to Covid-19 restrictions, our annual conference took place online this year and we found it to be just as engaging and diverse as our usual face to face event.

We were joined on Zoom by four keynote speakers and about 100 students, staff and industry representatives.

Proceedings were opened by keynote speaker Professor Metin Sitti from the Max Planck Institute who presented on soft bodied small scale robotics that featured memorable robots modelled on baby jellyfish.

Rich Walker from Shadow Robots gave an informative talk about the evolution of his robotic hand company, while giving students lots of practical advice for their own business ventures.

Professor Sara Bernardini from Royal Holloway University demonstrated some of their projects, focusing on Robotics in Extreme Environments. We viewed robots that perform maintenance on wind turbines, drones that can travel down boreholes and self-building platforms.

Our final keynote speaker was Professor Maja Mataric from The University of Southern California who gave a very interesting talk titled "Socially Assistive Robotics Right Now", which discussed the need for personalised embodied systems for in-home support of health, wellness, education and training.

Students had created padlets to showcase their research activities online, and time was allocated in the programme to allow the delegates to view these and to interact with the students either via a Zoom call or by leaving comments and questions for students on their individual padlets.

Our industry representatives judged the student padlets and awarded the prize for best padlet to Nathan Western from the 2018 cohort.

Our keynote speakers kindly reviewed the case studies submitted by our students for inclusion in our Annual Review, and awarded the prize for best case study to Emily Rolley-Parnell, a student in the 2019 cohort. Both students received gift vouchers to the value of £200.

As we were unable to have our usual post-conference dinner together, we had a virtual robot themed cocktail/mocktail making party and contest. Cocktails created during the event included "We Love Python," "Reinforcement Blending," and "Dear Supervisor, the hydraulic oil has a strange colour". The winner was "An Robot Air Leth-Mhisg" which translates to "The Tipsy Robot", created by student Helmi Fraser.

Highlights 2020-21

Professors Helen Hastie and Yvan Petillot appointed to lead the National Robotarium

Professor Helen Hastie and Professor Yvan Petillot have been appointed as joint academic leads of the National Robotarium.

The National Robotarium, a partnership between Heriot-Watt University and the University of Edinburgh, is a world-leading centre for Robotics and Artificial Intelligence based at Heriot-Watt's Edinburgh campus. Taking a responsible and collaborative approach, its pioneering research develops new prototypes, supports early stage product development and drives forward productivity. Key areas of research applications include power systems, manufacturing, healthcare, human-robot interaction, assisted living and hazardous environments.

Speaking on her vision for the National Robotarium, Professor Hastie said: "The National Robotarium will forge a centre of excellence for fundamental research, as well as its translation into the marketplace, leveraging the world leading talent of the staff at the Edinburgh Centre for Robotics and the students at the Centre for Doctoral Training in Robotics and Autonomous Systems.

"There are a whole range of sectors, from healthcare to agriculture, where autonomous systems could provide valuable assistance and the research and industry-related activities of the National Robotarium will enable this."

Commenting on why the National Robotarium will accelerate the commercial development of autonomous systems, Professor Petillot explained: "Working at the interface between academia and industry, the National Robotarium will translate world-class research into new products and markets for the benefit of the UK.

"It will become a major innovation hub, working across multiple sectors and offering our staff and students the opportunity to co-create new products and businesses to support the net-zero and circular economy of the future."

Professor David Lane, the inaugural academic director, will continue his association with the National Robotarium through an ongoing position on its Scientific Advisory Board.

The National Robotarium building will open on Heriot-Watt's Edinburgh campus in 2022.

Source: https://www.hw.ac.uk/news/articles/2020/national-robotarium-leaders.htm

Highlights 2020-21

UKRI Trustworthy Autonomous Systems Programme - ECR Staff to lead Research Nodes

The UK Research and Innovation (UKRI) has launched six new research projects or, "nodes", aimed at tackling challenges in the development of autonomous systems. These are part of the Trustworthy Autonomous Systems (TAS) programme which will undertake fundamental, creative and multidisciplinary research in various areas key to ensuring autonomous systems can be built in a way society can trust and use.

Professor Subramanian Ramamoorthy at the School of Informatics, University of Edinburgh will be leading the UKRI Research Node on Trustworthy Autonomous Systems (TAS) Governance & Regulation.

This research node aims to develop a novel framework for the certification, assurance and legality of TAS. This requires consideration of a range of issues from safety certification of autonomous robots to incorporating values such as fairness, accountability and responsibility in AI-driven diagnostic decisions.

The project will establish a new software engineering framework to support TAS governance and trial them with external stakeholders in the domains of mobile autonomous systems, AI-driven diagnostics and social care. Newly developed computational tools for regulators and developers will complement the new methods of governance. In particular, this will include a deeper understanding, from multiple disciplinary perspectives, of how and why autonomous systems fail. The team also aims to improve understanding of the iterative nature of design processes associated with such technologies and to recommend ways to better govern such processes.

The Node will take a deeply inter-disciplinary approach to its work, bringing together researchers with backgrounds in Computer Science and AI, Law, AI ethics, Social Studies of Information Technology and Design Ethnography. The diverse team offers a uniquely holistic perspective that combines technical, social science and humanities research to guarantee that autonomous systems can be trusted and integrated into society with confidence.

Sources:
https://www.ukri.org/news/new-trustworthy-autonomous-systems-projects-launched/
https://www.ed.ac.uk/informatics/news-events/stories/2020/3-2-million-project-governance-regulation-machines
https://www.hw.ac.uk/news/articles/2020/national-robotarium-unveils-3m-research.htm

Highlights 2020-21

UKRI Trustworthy Autonomous Systems Programme - ECR Staff to lead Research Nodes

Professor Helen Hastie from the School of Mathematical and Computer Sciences at Heriot-Watt University is leading the UKRI Trustworthy Autonomous Systems Node in Trust.

This project will explore solutions to manage trust in autonomous systems, covering scenarios that require interaction with humans. Examples include self-driving cars, autonomous wheelchairs or 'cobots' in the workforce. The group's work will help design the autonomous systems of the future, ensuring they are widely used and accepted in a variety of industry relevant applications.

Professor Hastie explains: "The challenge of managing trust between the human and the system is particularly difficult because there can be a lack of mutual understanding of the task and the environment. The new consortium will perform foundational research on how humans, robots and autonomous systems can work together by building a shared reality through human-robot interaction.

"By adopting a multidisciplinary approach, grounded in psychology and cognitive science, systems will learn situations where trust is typically lost unnecessarily, adapting this prediction for specific people and contexts. We will explore how to best establish, maintain and repair trust by incorporating the subjective view of humans towards autonomous systems, with the goal being to increase adoption and maximise their positive societal and economic benefits.

"Trust will be managed through transparent interaction, increasing the confidence of those using autonomous systems, allowing them to be adopted in scenarios never before thought possible. This might include jobs that currently endanger humans, such as pandemic-related tasks or those in hazardous environments."

Sources:
https://www.ukri.org/news/new-trustworthy-autonomous-systems-projects-launched/
https://www.ed.ac.uk/informatics/news-events/stories/2020/3-2-million-project-governance-regulation-machines
https://www.hw.ac.uk/news/articles/2020/national-robotarium-unveils-3m-research.htm

More information:
https://trust.tas.ac.uk/

@tas_trust

Highlights 2020-21

Amanda Solloway MP visits The Bayes Centre

Amanda Solloway, Minister for Science, Research and Innovation, visited the Bayes Centre on 25th June, where she met with Professors Helen Hastie, Barbara Webb and Sethu Vijayakumar. Researchers from the Statistical Machine Learning and Motor Control Group provided a demo of some of the cutting edge research in humanoids, assistive devices and telepresence. After the visit, the Minister tweeted "Thrilled to visit the Centre for Robotics. New tech, like robotics, is integral in our #UnleashingInnovation ambitions and rebuilding our economy".

Dr Adam Stokes wins inaugural Academic Entrepreneurship Award

Dr Adam Stokes, CDT Deputy Director, has been awarded the University of Edinburgh's first Data Driven Entrepreneurship Academic Entrepreneurship Award. This is presented to a member of academic staff who has demonstrated exceptional leadership in encouraging entrepreneurship among students and fellow researchers.

Reacting to the award, Dr Stokes said: "This award recognises the role of knowledge exchange as an essential feature of the research landscape. Entrepreneurship requires a complementary set of skills and knowledge to those employed in my role as a research academic.

"I am passionate about science and engineering, and I feel a sense of responsibility that publicly funded research should, where appropriate, deliver economic and societal impact outside of the laboratory.

"The students who have nominated me for this award are outstanding engineers and entrepreneurs who share a common vision: creating the world in which we want to live."

Credit: University of Edinburgh

The original version of this can be found here.

Spot robot arrives at Heriot-Watt University

Credit: ORCA Hub and Chris Watt Photography

A robot from the "Spot" range, created by Boston Dynamics, has recently arrived on Heriot-Watt University's Edinburgh campus. The four-legged robot will be used to conduct research into how humans working in hazardous environments such as oil platforms can be supported by robots. Researchers are fitting Spot with "telexistance" technology which allows humans to experience an environment without actually being there through the use of microphones and cameras to relay sounds and videos.

Spot has already been earmarked for its first project for the ORCA Hub, where it will be deployed on construction sites, collecting data and measurements in real time. This will allow multiple parties, regardless of location, to access and review the data, building greater understanding of the construction process and allowing companies to identify potential hazards and quality control measures.

Highlights 2020-21

ARI robot arrives at Heriot-Watt University

Academics and students at Heriot-Watt University were delighted to take delivery of three ARI robots in late July.

ARI is the newest robot developed by PAL robotics. This 1.65m tall humanoid robot has 14 Degrees of Freedom: 2 for the head, 5 in each arm and hands, and 2 in the mobile base. This robot uses a wheeled differential drive for movement and can use its arms for gestures. The Head features two LCD screens as the eyes and a tablet is mounted in the robot's chest. All of this makes ARI the ideal platform for Human-Robot Interaction. ARI also has several cameras in the head, chest, and back, a microphone array in the torso and speakers in the base. Together with the state of the art PC with an i7 processor and an NVIDIA Jetson TX2, this robot provides all the capabilities required for autonomous interaction.

Initially, the robots will be used by members of the Interaction Lab and the Trustworthy Technologies Lab. First project ideas include work on the EU SPRING project to advance research on verbal multi-party human-robot interaction and as a fitness coach to investigate the use of humanoid robots for healthcare and physiotherapy.

Highlights 2020-21

The ORCA Hub secures £2.5m of further funding

The ORCA Hub, led by Heriot-Watt University and the University of Edinburgh, has secured £2.5 million of further funding from UK Research & Innovation (UKRI), supporting its work developing robots to make offshore infrastructure inspection and repair safer.

£600k of the new funding will be used to help deliver six demonstration projects with industrial partners, including the inspection of wind turbine foundations and the deployment of Industrial Internet of Things (IIoT) sensors.

The remaining £1.9m will fund an extension of ORCA Hub's activities to investigate if technologies and processes developed by the Hub can be used in other sectors, ranging from construction and urban infrastructure through to decommissioning and waste management.

Professor Yvan Petillot has been appointed as the ORCA Hub's new director, taking over from Professor David Lane who continues as an advisor to its independent steering committee.

Professor Petillot said: "The international offshore energy industry is undergoing a revolution, adopting aggressive net-zero objectives and shifting rapidly towards large scale offshore wind energy production.

"The long-term industry vision is for a digitised offshore energy field, operated, inspected and maintained from the shore using robots, digital architectures and cloud-based processes to realise this vision. However, the recent pandemic has highlighted a widespread need for remote operations in many other industrial sectors.

"The ORCA Hub has built a community of roboticists and expertise during its initial phase. This funding extension aims to accelerate the translation of the research into our existing industry network, working with companies including Wood, EDF and Ross Robotics, while expanding into new sectors by adapting the current research and tackling the novel challenges these sectors bring."

Professor David Lane added: "Since the ORCA Hub was launched, its successes have been wide ranging from launching tech that can help humans and robots to speak the same language to autonomous drones that can inspect offshore turbines.

"Significant industry engagement has been achieved with 68 individual research projects, PhD sponsorships, user engagements and supply of equipment, hardware, software, data and asset samples taking place with a further 16 projects currently in discussion or pending approval with an estimated value of over £6m. We've spun-out a company and two more are in the process of spin-out, alongside two patent applications enabling developments to be licensed to companies."

ORCA HUB
Offshore Robotics for Certification of Assets

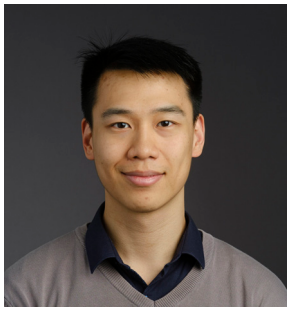
Achievements

Summer School win for CDT student Robin Trute

Robin Trute, PhD student in the 2019 cohort, participated in the Connected Everything Summer School focused on digital manufacturing. Connected Everything is supported by an EPSRC funded NetworkPlus grant co-hosted by the Smart Products Beacon at the University of Nottingham.

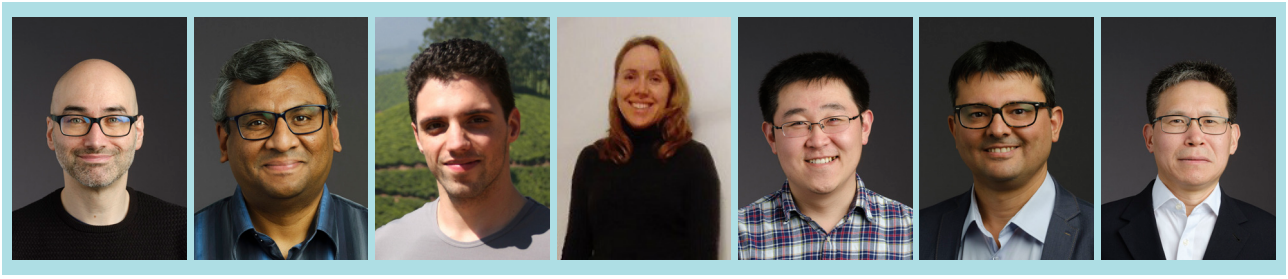
The event considered the use of collaborative robots (COBOTs) in a COVID-19 world, focusing on applications in food production, healthcare and help around the home. Students were put into teams and Robin's team came up with the winning design which was a pneumatic robot that uses pressurized air and soft tissue to protect against bruising of patients when lifting them up. You can see some clips from the summer school including Robin presenting at 7:27 here.

CDT Student Kai Yuan receives Rising Star Award



Kai Yuan, PhD student in the 2017 cohort, has received a Rising Star Award from the UK-RAS network. This award was one of four made, and it recognises excellence and achievement by the UK robotics and autonomous systems community during the past challenging year.

Following an open nomination process, the winners were selected by an expert panel from the UK-RAS network's Executive Committee. After receiving their awards, the winners gave an overview presentation to the UK-RAS Robotics Summer Showcase attendees.



Academic Promotions

Congratulations to the following academic staff on their promotions during the 2020/21 Academic Year:

Dr Michael Mistry, CDT Director, the University of Edinburgh, has been promoted to Professor.

Dr Ramamoorthy, the University of Edinburgh, has been promoted to Professor and has been awarded the position of Personal Chair of Robot Learning and Autonomy within the School of Informatics at the University of Edinburgh.

Dr Timothy Hospedales, the University of Edinburgh, has been promoted to Professor.

Dr Katya Komendantskaya, Heriot-Watt University has been promoted to Professor.

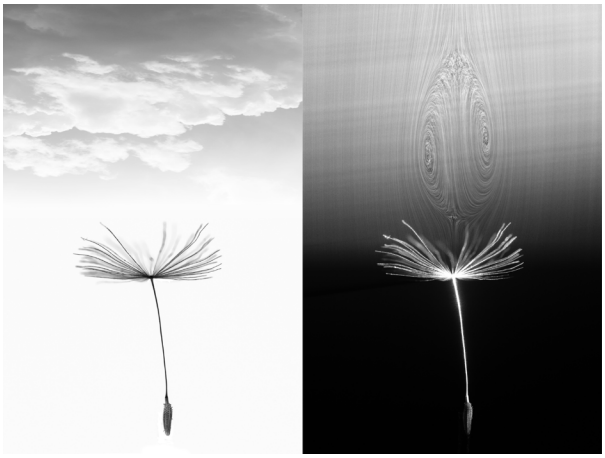
Dr Sen Wang, Dr Suphi Erden and Dr Xianwen Kong, academics at Heriot-Watt University, have been promoted to Associate Professors.

Achievements

Ignazio Maria Viola awarded a European Research Council Consolidator Grant

Dr Ignazio Maria Viola, an academic at the School of Engineering, the University of Edinburgh, has been awarded a £2m grant over 5 years. The project, which started in June 2021, will study the fluid dynamics of dandelion-inspired drones that are transported by the wind.

What is the Dandidrone project?
Imagine we could fly small drones that remain airborne for days: monitoring the environment, searching for pollutants, tracking airborne coronaviruses.
Unfortunately, this is not yet possible, because insect-scale drones can remain airborne for only a few minutes before the power runs out.



But some natural flyers, by contrast, remain airborne for days without using any power.
One of the most extraordinary examples is the dandelion seed: it takes off from just 30 cm away from the ground, and travels for hundreds of kilometres powered only by the wind.

In a recent study led by Viola and Naomi Nakayama (School of Biology), of which some findings were published in the leading journal Nature [1], the researchers revealed that the flight of the dandelion is enhanced by a new flow feature that had never been observed before: the separated vortex ring.

In this ERC-funded five-year project, Viola will next investigate how the amazing flight capabilities of the dandelion can be replicated by manmade flyers. The project seeks to understand and establish proof of principle of a completely new fluid mechanics mechanism that might enable small flyers to passively hover in turbulent wind.

The funding will enable the recruitment of three postdoctoral research associates, two PhD students, the construction of a one-of-its-kind wind tunnel to study small flyers in gusts and a period of study at the California Institute of Technology (Caltech) in Pasadena, USA.

About ERC Consolidator Grants
The ERC Consolidator Grants are awarded to outstanding researchers with seven to twelve years of postdoctoral experience and a scientific track record showing great promise.

The ERC received 2,453 research proposals in this particular round and approximately 12% were funded, across 24 countries in Europe, covering a wide range of academic disciplines.

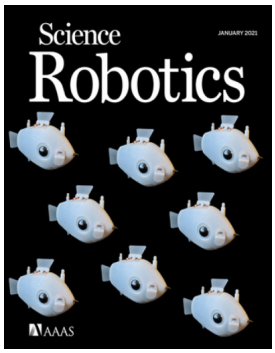
References
[1] Cummins, C., Seale, M., Macente, A., Certini, D., Mastropaolo, E., Viola, I. M. & Nakayama, N. A separated vortex ring underlies the flight of the dandelion. Nature 562, 414–418 (2018).

Ignazio's research group: https://voilab.eng.ed.ac.uk

Achievements

New publication from Dr Francesco Giorgio-Serchi

Dr Francesco Giorgio-Serchi, the University of Edinburgh, has a new publication out on Science Robotics. You can read it here



Abstract

Elasticity has been linked to the remarkable propulsive efficiency of pulse-jet animals such as the squid and jellyfish, but reports that quantify the underlying dynamics or demonstrate its application in robotic systems are rare. This work identifies the pulse-jet propulsion mode used by these animals as a coupled mass-spring-mass oscillator, enabling the design of a flexible self-propelled robot. We use this system to experimentally demonstrate that resonance greatly benefits pulse-jet swimming speed and efficiency, and the robot's optimal cost of transport is found to match that of the most efficient biological swimmers in nature, such as the jellyfish Aurelia aurita. The robot also exhibits a preferred Strouhal number for efficient swimming, thereby bridging the gap between pulse-jet propulsion and established findings in efficient fish swimming. Extensions of the current robotic framework to larger amplitude oscillations could combine resonance effects with optimal vortex formation to further increase propulsive performance and potentially outperform biological swimmers altogether.

Professor Barbara Webb awarded Fellowship

Professor Barbara Webb from the University of Edinburgh has been awarded a five year EPSRC Established Career Fellowship to start in October 2021. The topic is "An Insect-Inspired Approach to Robotic Grasping" and Professor Webb will examine how ants are able to reliably grasp arbitrary unknown objects in clutter and how these skills can be transferred to robot applications such as e-commerce and environmental clean-up.

Professor Yvan Petillot elected Fellow of the Royal Society

Congratulations to Professor Yvan Petillot, who has been elected Fellow of the Royal Society of Edinburgh. This recognises Professor Petillot's pioneering work in marine robotics, his role in turning research into industrial innovation and his involvement in training new generations of roboticists through robotics competitions.

Congratulations to Professor Subramanian Ramamoorthy, who has been selected as one of the Top 100 Asian Stars in UK Tech 2021 for his work at FiveAI.

THE UNIVERSITY of EDINBURGH informatics

Achievements

Papers Accepted at Conferences

Emanuele De Pellegrin, 2020 cohort, presented a paper on his masters project at ICAPS 2020 titled "PDSim: Planning Domain Simulation with the Unity Game Engine". Both the paper and the project were presented during the KEPS (Knowledge Engineering for Planning and Scheduling) workshop.

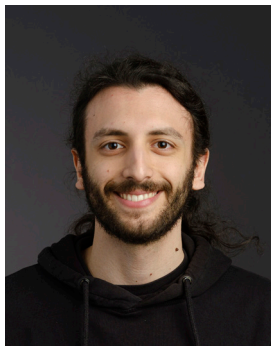
The following is an abstract of the work:
PDSim is an extension for the Unity game engine that adds support for simulating a classical plan through the visualisation of 3D animations of user-defined models and objects. With PDSim it is possible to define models for PDDL types and animations for actions and predicates in a 3D environment. This paper will present the main features of the PDSim system as well as its long-term goals.

ICAPS is one of the main conferences for automated planning and the KEPS workshop is the only one responsible for knowledge engineering for AI planning and scheduling.

A video of the presentation can be seen here.

Hugo Sardinha, 2016 cohort, had his paper titled "Towards an Adaptive Lévy Walk Using Artificial Endocrine Systems" accepted at the twelfth International Conference on Adaptive and Self-Adaptive Systems and Applications which took place in October 2020.

This paper proposes an adaptation mechanism, that draws inspiration from the regulatory function of hormones, allowing artificial agents to modulate their behaviour between local and global searches in cluster-based foraging scenarios.
http://www.iaria.org/conferences2020/ADAPTIVE20.html



Filippos Christianos, 2018 cohort, had a paper accepted at Neural Information Processing Systems (NeurIPS) 2020 which took place in December 2020.

The paper, co-authored with Lukas Schäfer and Stefano Albrecht from the Autonomous Agents Research Group at the University of Edinburgh, is titled "Shared Experience Actor-Critic for Multi-Agent Reinforcement Learning".

The paper proposes a new algorithm for efficient multiagent learning in a sparse-reward environment, showing that the group's algorithm learns faster and converges to higher returns than several baselines and other state-of-the-art algorithms, in a series of tested environments. The full text can be found here.

Achievements

EACL 2021

Alessandro Suglia, 2017 cohort, had his long paper presented at the International Conference on Computational Linguistics. His paper is titled "Imagining Grounded Conceptual Representations from Perceptual Information in Situated Guessing Games". You can read the paper here.

Alessandro also presented a paper at EACL 2021 titled "An Empirical Study on the Generalization Power of Neural Representations Learned via Visual Guessing Games", which is part of a collaboration between Heriot-Watt University, Carnegie Mellon University and the University of California, Los Angeles. In this paper, he studies the power of visual guessing games as a holistic procedure for grounded language learning tasks. Guessing games are a prototypical instance of the "learning by interacting" paradigm. This work investigates how well an artificial agent can benefit from playing guessing games when later asked to perform on novel NLP downstream tasks such as Visual Question Answering (VQA). He proposes two ways to exploit playing guessing games:

1) a supervised learning scenario in which the agent learns to mimic successful guessing games and
2) a novel way for an agent to play by itself, called Self-play via Iterated Experience Learning (SPIEL).

This work formalises a self-play learning framework that allows artificial agents to learn more effective representations that are useful for other multi-modal downstream tasks. The learning procedure is generic and versatile because it does not require any human supervision and can be applied to any vision-language downstream tasks.

NeurIPS 2021

CDT students Georgios Papoudakis and Filippos Christianos have had a paper titled "Benchmarking Multi-Agent Deep Reinforcement Learning Algorithms in Cooperative Tasks" accepted for NeurIPS 2021. The paper, code, appendix and reviews can be found here

ACL-IJCNLP 2021

Two students from the CDT have had papers accepted at a premier NLP Conference.
Karin Sevegnani (2018 cohort) submitted a long paper titled "OTTers: One-turn Topic Transitions for Open-Domain Dialogue", The paper presents a one-turn topic transition task, which explores how a system connects two topics in a cooperative and coherent manner.
Xinnuo Xu, 2016 cohort, submitted a short paper titled "AggGen: Ordering and Aggregating While Generating".

Paola Ardon wins Best Workshop Presentation Award

Paola Ardon, 2017 cohort, has won the Best Workshop Presentation Award at the ICRA 2021 Workshop on Learning for Caregiving Robots for her paper on "Affordance-Aware Handovers With Human Arm Mobility Constraints."

Achievements

Papers accepted at ICRA 2021 Conference

The following Statistical Machine Learning and Motor Control Group (SLMC) papers co-authored by current and former CDT RAS students were accepted at the International Conference on Robotics and Automation (ICRA 2021) held in Xi'an, China.

Ran Long, **Christian Rauch**, Tianwei Zhang, Vladimir Ivan and Sethu Vijayakumar,
RigidFusion: Robot Localisation and Mapping in Environments with Large Dynamic Rigid Objects, IEEE Robotics and Automation Letters (RAL), 2021
RigidFusion is a state-of-the-art dense SLAM method that is robust to large dynamic occlusion (over 65%) in the scene, without requiring prior shape or appearance of the dynamic objects. It also contributes a pipeline to simultaneously segment, track and reconstruct the static background and one dynamic rigid body from RGB-D sequences.

Henrique Ferrolho, Vladimir Ivan, **Wolfgang Xaver Merkt**, Ioannis Havoutis, Sethu Vijayakumar,
Inverse Dynamics vs. Forward Dynamics in Direct Transcription Formulations for Trajectory Optimization, Proc. IEEE International Conference on Robotics and Automation (ICRA 2021), Xian, China, 2021.
Direct transcription is a powerful technique that uses numerical optimisation to solve motion planning problems. Such numerical formulations use mathematical constraints to enforce motion requirements; in robotics, those constraints are used for e.g., body placement, contact positions, system dynamics. Two possible approaches to enforce nonlinear whole body dynamics of robots in direct transcription are discussed: forward dynamics vs. inverse dynamics. Results show that using inverse dynamics is faster, requires less iterations, and is more robust to coarse problem discretisations.

Traiko Dinev, Wolfgang Xaver Merkt, Vladimir Ivan, Ioannis Havoutis and Sethu Vijayakumar, Sparsity-Inducing Optimal Control via Differential Dynamic Programming , Proc. IEEE International Conference on Robotics and Automation (ICRA 2021), Xian, China, 2021.
The paper describes how to use sparse controls in dynamic motion planning. The group applied sparsity inducing costs to plan satellite manoeuvres, where thrusters using liquid propellants can only be switched on and off and cannot provide variable thrust. They also applied sparsity in controls to a humanoid reaching task, which allowed them to select the required number of joints for this lower dimensional motion. They analyzed the properties of a family of soft sparse costs and gave insight into how to tune their free parameters.

Carlo Tiseo, Vladimir Ivan, **Wolfgang Xaver Merkt**, Ioannis Havoutis, Michael Mistry, Sethu Vijayakumar,
A Passive Navigation Planning Algorithm for Collision-free Control of Mobile Robots, Proc. IEEE International Conference on Robotics and Automation (ICRA 2021), Xian, China, 2021.
A passive planning algorithm capable of autonomous obstacle avoidance in a domain with small concavity is presented. This novel method uses a passive controller that enables the navigation of complex dynamic maps without relying on numerical optimisation. Simulation and experimental results show that the technique can generate smooth, stable trajectories in drones and wheeled robots. The small computational cost enables scalability to swarm applications where the agents' movements are synchronised by issuing coordinated targets.

Further Information: ICRA 2021

Centre Activities

Dr Mustafa Suphi Erden presents at BioRob2020

Dr Mustafa Suphi Erden, an Associate Professor and supervisor at Heriot-Watt University presented a conference paper alongside William McColl, Djouzar Abassebay and Shaun Haldane at the IEEE International Conference on Biomedical Robotics and Biomechatronics 2020. BioRob2020 was due to take place in New York City but was held virtually from November 29 to December 1, 2020.

In this paper, a prototype exoskeleton is proposed to perform active finger movements to mimic a therapist for assessment of hand spasticity. Current methods for assessing spasticity are based on the subjective appreciation of physiotherapists as there is no quantifiably standardised method of evaluation and no rigorous method to record data for monitoring. For the purpose of imitating the therapist's movements and recording data pertaining to spasticity, servos are used to manipulate each joint in an index finger in a programmable and controlled way. Film type force sensors are used at fingertip to judge the maximum opening and closing capability of the patient's hand in relation to the force which would be felt by a therapist due to the patient's resistance to passive movement. Using potentiometers and positional data from the servo motors, the trajectory of the finger joints is recorded in parallel to the fingertip force applied during the movement. The exoskeleton is a three degrees of freedom system which can move the index finger through an entire range of motion. The physical prototype and the software control module have been tested to validate the functionality of the mechanical structure, measuring and recording capabilities. A GUI software tool is designed to be user friendly for the medical therapists and to produce a report document in a style familiar to them. Positive feedback was obtained from medical therapists about this initial prototype.

The eighth IEEE International Conference on Biomedical Robotics and Biomechatronics – BioRob2020 – is a joint effort of the two IEEE Societies of Robotics and Automation – RAS – and Engineering in Medicine and Biology - EMBS. BioRob covers both theoretical and experimental challenges posed by the application of robotics and mechatronics in medicine and biology. The primary focus of Biorobotics is to analyze biological systems from a "biomechatronic" point of view, trying to understand the scientific and engineering principles underlying their extraordinary performance. This profound understanding of how biological systems work, behave and interact can be used for two main objectives: to guide the design and fabrication of novel, high performance bio-inspired machines and systems for many different applications; and to develop novel nano-, micro-, and macro- devices that can act upon, substitute parts of, and assist human beings in prevention, diagnosis, surgery, prosthetics, rehabilitation, and personal assistance.

BIOROB 2020 NYC

Centre Activities

Bite Size News

Dr Alex Li, an academic at the University of Edinburgh was featured in an article on BBC News about his work with robotic dogs. Read the article here.

Prof Sethu Vijayakumar, co-director of CDT RAS was interviewed by Ruth Davidson for the Podcast An Inconvenient Ruth. Listen here.

On 18th May, Professor Verena Rieser gave a talk as part of the CS Lectures at IT University of Copenhagen. The talk was titled "A Short History of Data-driven Dialogue Systems in 5 Acts: Where Do We Go from Here?. Professor Rieser provided a short review of the last 20 years of data-driven development of conversational AI through the lens of 5 major systems and initiatives in which she was involved. Listen here.

Professor Lynne Baillie wrote an article for AT Today which explored how robotics can support independent living and create significant final savings for local authorities. Read the article here.

Professors Helen Hastie and Michael Rovatsos were two of the panel members at the May 2021 Data Driven Innovation (DDI) discussion on the role of Scottish Universities in the development of AI. DDI are an innovation network helping organisations tackle challenges for industry and society by doing data right to support Edinburgh to become the data capital of Europe.

THE UNIVERSITY of EDINBURGH | HERIOT WATT UNIVERSITY

DDI Data-Driven Innovation

Part of the Edinburgh & South East Scotland City Region Deal

STEM for BRITAIN

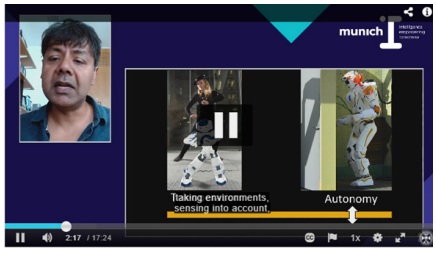
Professor Helen Hastie was on the judging panel for the Parliamentary and Scientific Committee's STEM for BRITAIN 2021, an exhibition of posters by early-career research scientists, engineers and mathematicians. This took place online on Monday 8th March during British Science Week.

Professor Sethu Vijayakumar chaired an online talk by Professor Masashi Sugiyama, Director of the RIKEN Center for Advanced Intelligence Project (RIKEN-AIP), hosted at Japan House in collaboration with the Embassy of Japan in the UK and the Alan Turing Institute. A recording of the talk titled "AI Research in Japan: Challenges at the RIKEN Center for Advanced Intelligence Project " can be heard here.

Professor Helen Hastie was one of the keynote speakers at the IEEE RO-MAN Workshop on Trust, Acceptance and Social Cues in Robot Interaction (SCRITA) on August 12th, 2021.

Centre Activities

Professor Sethu Vijayakumar participated in the Automatica Sprint 2021 which took place virtually on 22nd June 2021. International experts from the field of AI and robotics were invited to discuss their visions, insights and theories. Professor Vijayakumar's keynote "Shared Autonomy: The Future of Interactive Robotics" is available to watch as a recording here.



CDT Director Professor Helen Hastie spoke with Naga Munchetty on BBC5 Live on 22nd June. Professor Hastie discussed her research into trust of robotics, human-robot interaction, and the wider work being carried out in the National Robotarium to develop robotics and AI solutions for industry needs.

Professor Hastie also gave a talk on "Trustworthy Social Robots" at the Furhat Conference on Social Robots in Research. Prof. Hastie explained why trust is important in social robotics and presented the findings of two studies on this topic. Watch here.

Professor Oliver Lemon was a keynote speaker at Lifelong Learning and Personalization in Long-Term Human-Robot Interaction (LEAP-HRI) which took place virtually on 8th March 2021. His presentation was titled "Conversational LEAPs in Human-Robot Interaction".

Professor Yvan Petillot gave a talk "From Research to Innovation - How Can Academia Support the Commercial Sector in Adopting Robotics Solutions?" at the 2021 Robotics and Innovation Conference which took place on 23rd and 24th June 2021.

ROBOTICS & INNOVATION
CONFERENCE 23rd & 24th JUNE 2021

Professor Petillot drew on past and current research projects in the marine environment to support his arguments and also presented the National Robotarium which will play a leading role in driving collaboration between academia and industry in the UK.

Professor Subramanian Ramamoorthy, Personal Chair of Robot Learning and Autonomy at The University of Edinburgh, spoke to Computerphile about how self-driving cars learn. Watch here.

Professor Lynne Baillie and Dr Mauro Dragone spoke on The Scotsman's Data Capital podcast, which looks at a range of projects that aim to make the dream of Edinburgh becoming the Data Capital of Europe a reality.
Their talk "Can Robots Help us to Live Longer in our Own Homes?" discussed how robots can already do basic tasks such as vacuuming and mowing the lawn but there is great potential for them to do much more. Professor Baillie advised that their research is looking at how a robot might remind people of the different steps to make a cup of tea rather than making it for them, thus helping to slow cognitive decline. The Assisted Living Lab allows researchers to test different scenarios in a realistic way, something that Dr Dragone explains is vital as users need to feel that they are actually stepping into their own home, or a future version of it. Listen here.

Professor Hastie took part in a Scotsman podcast as part of their Future Work series, where she talked about robots and their impact on jobs https://www.scotsman.com/business/futurework-podcast-will-robots-take-my-job-3233400.

She also took part in a podcast with Prof Yvan Petillot on DDI for the Scotsman. https://www.scotsman.com/business/scotsman-launches-new-data-capital-podcast-series-3071800

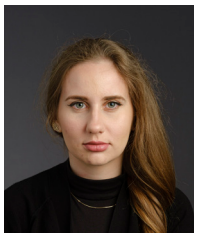
Student Activities

Internships

The following CDT students are currently undertaking prestigious internships which give them experience of carrying out research in a large organisation and help them develop skills that will be beneficial when they return to their PhD studies.

Alessandro Suglia (2017 cohort)
spent 3 months working virtually with Amazon Alexa AI in Manhattan Beach, California on Deep Learning models for Embodied AI. He is currently undertaking a second 3-month virtual internship on large-scale multi-modal deep learning models with Facebook AI in Seattle.

Karin Sevegnani (2018 cohort)
is currently spending six months interning with Amazon where she is working on a recommender system for a physical store opening in the US in 2022.



Miruna Clinciu (2018 cohort)
is currently undertaking a six month internship with Schlumberger where she is working on Explainable Bayesian Networks for creating effective Human-AI interaction via Natural Language Explanations and visualisation techniques.

Joshua Smith (2016 cohort)
is currently undertaking a four month internship with Amazon where he is working on robot arm manipulation and control in an industrial setting with Amazon Robotics Berlin.

Student Activities - Year Two Group Project

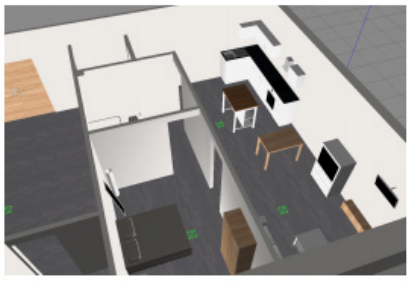
Over the course of the spring semester, the 2019 cohort worked together on their group project. This important part of their PhD journey provided valuable multi-disciplinary team working experience, relevant for both academic and industry careers.
They were tasked with producing a prototype robotic system that was demonstrated at an industry showcase event in March, where a cash prize was presented to the top group(s). In addition, they wrote a short report and provided a reflective piece on their experience.
The groups were supervised by an academic and helped by earlier cohort PhD students or PDRAs. All three groups were highly successful in their group project, with industry commenting on how much the students managed to achieve in a short amount of time by working together. The three topics are as follows:

Group1
Granny Annie's Android Nanny, an entry for the European Robotic League for Consumer Service Robots competition

Students: Alexandre Colle, Shreyank Gowda, Emilyann Nault, Pierre Nicolay, Emily Rolley-Parnell, John Skottis, Liam Wellacott
Academic supervisor: Dr Mauro Dragone
Group Advisors: Scott MacLeod & Meriam Moujahid

Description: The group presented their entry to the European Robotics League Consumer Service Robotics (ERLCSR) competition. The competition challenges the state-of-the-art in home service robotics by presenting realistic household tasks for robots to complete.

The system: Granny Annie's Android Nanny (GAAN) implements navigation, manipulation, natural language processing, object recognition and face recognition strategies. In their report, they discuss their system and the underlying libraries used, followed by the resources they have made available to help new competition teams to get started with their own implementation. These resources are (i) extensive project documentation including visualisation of the competition handbook and (ii) an executable test scenario in a virtual version of the Robotic Assisted Living Testbed (RALT) environment at Heriot-Watt University.



The virtual RALT Gazebo world

Impact: they wrote up their work as an extended abstract that was published at the 2021 UK-RAS conference: Robotics at Home

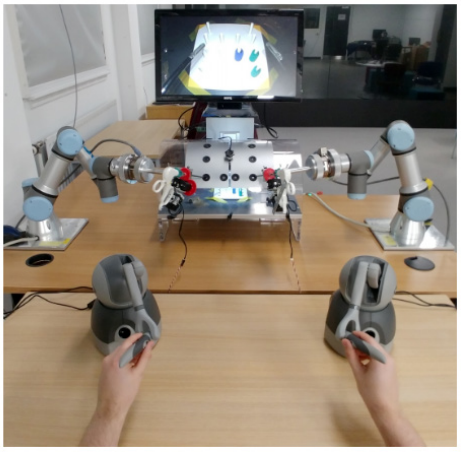
Wellacott, L., Nault, E., Skottis, I., Colle, A., Gowda, S. N., Nicolay, P., Rolley-Parnell, E., (2021). Test Framework for a Virtual Competition Testbed. UKRAS21 Conference: Robotics at Home Proceedings, 11-12. doi: 10.31256/Iq9Ki4X preprint

Student Activities - Year Two Group Project

Group 2
Development of a Robotic Surgery Dry Lab Training System

Students: Robin J. Trute, Andreas Christou, Carlos Suarez Zapico and Daniel Layeghi
Academic supervisor: Dr Mustafa Erden
Group Advisor: Harun Tuga

Description: Minimally-invasive training setups have become more popular as new technologies such as virtual reality, haptics or simulations have evolved and become more available as well as the increasing number of surgical procedures that have changed from traditional open surgeries to minimally-invasive surgeries (laparoscopic or robotic).
Despite the benefits of minimally invasive procedures, the challenges for the surgeon are increased in addition to the required training. The lack of observations and their quality (endoscopic vision or contact sense through laparoscopic instrument) in addition to the fulcrum effect are some of the aspects new surgeons have to adapt to. In their report, the group presents a new robotic surgery training system. The group aimed for wider accessibility by making it available to any professional with an internet connection and a computer, or alternatively, working alongside the robot platform at a small fraction of the cost when compared to training on a real surgical robotic system such as the Da Vinci.

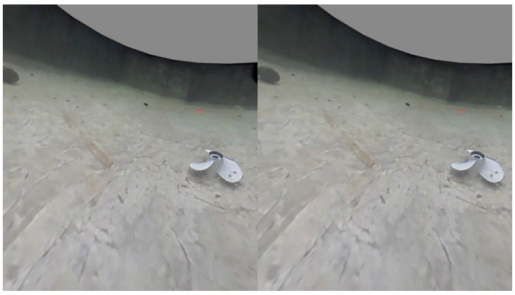


Setup of the robotic training system with all components in on-site control mode

Impact: A paper is currently being written up for submission for publication.

Group 3
Remote Telepresence Through Virtual Reality for Subsea Vehicles

Students: Elliot Fosong, Konstantinos Gavriilidis, and Wei Yu
Academic Supervisor: Prof. Yvan Petillot
Group Advisors: Joshua Roe, Jonatan Willners, Sean Katagiri



Description: Remotely operating or supervising underwater robotic vehicles can be challenging, even for experienced operators. A major source of this difficulty may be attributed to difficulties in mentally modelling the robot's state when interacting via a fixed 2D video stream. In this work, the group developed a system for creating an immersive live telepresence experience for operators of subsea vehicles using readily-available camera and virtual reality equipment. This solution allows operators to 'be' the vehicle, facilitating operators' abilities to carry out complex underwater tasks remotely.

Impact: This project has been continued by the Ocean Systems Lab in collaboration with Cyberselves, adding remote manipulation in the functionality. Kostas and Wei assisted in the continuation of this project as PDRAs, developing robotic models describing the movement of the robot and the arm.

Public Outreach

Verena Rieser Presents on Chatbots

Professor Verena Rieser has been involved in a number of outreach activities including:

Speaking at the Royal Society of Edinburgh (RSE) Curious online event. The talk was titled " Designing a Feminist Alexa – An Exercise in Empathic Design" and looked at the potential societal impact of anthropomorphising of chatbots and Personal Intelligence Assistants.

She was involved in an RSE online discussion as part of "RSE Investigates...AI" called "How Machines Learn to Talk. Challenges and Opportunities of Machine Learning for Conversational AI."

In October 2020, she was interviewed by MIT Technology Review in an article called "How to Make a Chatbot that isn't Racist or Sexist" which can be found here.

During November 2020, Professor Rieser was interviewed by Venture Beat on metrics in conversational AI for an article called "Pandorabots' Bot Battle Highlights Lack of Industrywide Metrics for Open Domain AI." The article can be read here.

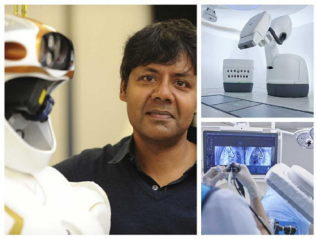
Professor Subramanian Ramamoorthy speaks at the ESSS 12th National Undergraduate Surgery & Trauma Conference

On March 13 Professor Ramamoorthy gave a talk entitled "Robotics in Surgery: What's Under the Hood?"
This talk was aimed at introducing key ideas about robotics and AI and how they are rapidly changing the landscape of surgical systems.

Drawing on work done within the Turing Institute sponsored project on Safe AI for Surgical Assistance, this talk covered topics including dexterous manipulation of soft tissue and models learned from detailed observation of human performance in surgical tasks, machine learning methods for interpreting imaging and other sensory information and approaches to closing the loop towards tasks such as autonomous excision. This talk was aimed at the audience of medical students specialising in surgery and trauma.

Scotsman Inside Science

In an article published in The Scotsman at the start of 2021, Centre Director Professor Sethu Vijayakumar looked at the potential of robotics in healthcare and explained how the latest advancements could be used in the fight against cancers or lung damage caused by Covid-19. A modified version of the article can be found here.



Collaboration

COLLABORATION
EDINBURGH CENTRE FOR ROBOTICS

Professor Vijayakumar secures two new Joint Industry Projects

In two new projects working alongside Honda Research Institute and Kawada Robotics Corporation, Professor Sethu Vijayakumar and his team will be focusing on enhancing and improving human-robot interaction, while also looking at the issues faced by an ageing society, addressing the question of how robots can assist healthcare professionals in their day to day work.

Honda: Co-bots and Exoskeletons for Assisted Living with Ergonomic Measures

In a world where increased ageing presents a significant challenge to society in preserving people's mobility and independence, this project joins forces with HONDA Research Institute to look at how robotics can aid the growing problem. The team will be looking at how exoskeletons can aid in restoring or maintaining mobility and the use of robots in providing assistance to a subject while relieving the physical strain felt by healthcare professionals.

Research will be undertaken to investigate and implement a framework for optimising the behaviour of robotic agents in collaborative assistance tasks, produce behaviours which promote ergonomic movements that maximise the comfort and safety of both the patient and the care provider and minimise the physical requirements of external human agents, instead increasing the supervisory nature of their role.

Kawada: Interactive Collision-Free Bi-Manual Manipulation

The collaboration with Kawada Robotics Corporation and associated externally funded projects (e.g. Horizon 2020 project HARMONY: Enhancing Healthcare with Assistive Robotic Mobile Manipulation) aims to develop enhanced, robust capabilities on Kawada's NextageA Research Platform. Focusing on realising an obstacle-aware, safe bimanual robot system that can react to dynamic, unseen environments and accurately and robustly perform tasks with compliant real-time control, the aim is to test capabilities in interactive environments like exhibitions, science festivals and ultimately, in healthcare and hospital settings.

Professor Vijayakumar stated "I am delighted to collaborate with one of the leading robotics companies in Japan to advance cutting edge, yet extremely practical capabilities on the Nextage platform. We will leverage the world leading research at the Edinburgh Centre for Robotics in dynamic motion planning and real-time control to realise real-world translation. I expect this work to expand the domain of application of such bimanual platforms beyond restrictive, machine only environments to allow human-centric applications in complex social environments such as shopping malls, hospital and healthcare settings and for in-home assistive technologies."

Further details on the project can be found here: Kawada Interactive Collision-Free Bi-Manual Manipulation | InfWeb (ed.ac.uk)

Source: https://web.inf.ed.ac.uk/slmc/news-and-events

Collaboration

Connect-R project

Dr Adam Stokes, CDT Deputy Director, is a member of a consortium of leading UK businesses and academics that has launched the Connect-R project, a self-building robotic structure that can work in the world's most hazardous environments.

Connect-R can withstand radioactivity, intense heat and cold, high pressure, high levels of acidity or alkalinity and is able to operate in a vacuum. As a result, it offers huge potential to undertake missions and build emergency structures in environments that pose risks to humans.

The project received £6m from Innovate UK from the £93m 'Robots for a Safer World' challenge launched in 2017 as part of the UK's Industrial Strategy Challenge Fund (ISCF).

The project brought together academics and technologists across the UK to push robotics into ground breaking terrain. This included experts from Barrnon, Royal Holloway, ROSS Robotics, The National Robotarium, Edinburgh Centre for Robotics, Tharsus, Jigsaw Structures and RACE.

This article originally appeared in the National Robotarium July 2021 newsletter.

Robotics and Social Care Mashup Event

A collaborative robotics and social care event has brought together innovators and end-users in a week-long burst of creativity around assistive technology, supported by the world's first example of an open assisted living laboratory. Highlights included connecting multiple home appliances with a single in-ear switch and new concepts for using technology to help support social isolation and existing care packages.

The event was organised by The National Robotarium, in partnership with Product Forge, the Usher Institute and Design Informatics at the University of Edinburgh and Scottish Health Innovations Ltd (SHIL).

Attended by health and care professionals, academics and assistive technology providers, it aimed to prototype new solutions and accelerate technical designs to tackle multiple care and assisted living challenges.

Participants were mentored by representatives from the Discovery Stage sponsor Scottish Health Innovations Ltd (SHIL), and the Scottish Social Service Council (SSSC), Scotland's Innovation Centre for Sensing, Imaging and Internet of Things (IoT) Technologies (CENSIS), the Institute of Design Informatics at University of Edinburgh, and the Digital Health & Care Innovation Centre.

Successes from the week's event included demonstrating how the 'Earswitch' can be used to operate multiple devices using an ear muscle alone. The 'Earswitch' was created by primary care practitioner, Dr Nick Gompertz, from Somerset and is supported by funding from NIHR. Dr Gompertz previously proved voluntary movements of the eardrum could be filmed and then used to trigger a virtual keyboard for MND and complex stroke sufferers.

Dr Gompertz worked with Thomas Gillett, a PhD student at Heriot-Watt University, to improve the accuracy of the switch and to connect it to existing assistive devices and automation frameworks. This simplifies the use of the Earswitch with a diverse range of assistive devices, including emerging examples of assistive robotic technology.

This article first appeard on https://www.hw.ac.uk/news/articles/2021/robotics-and-care-event-demonstrates-world.htm

Collaboration

Do Healthcare Workers Want Robots Deployed in Hospitals

Professor Subramanian Ramamoorthy has collaborated with an international team of researchers to look at the expectations and perceptions of healthcare professionals for robot deployment in hospital environments during the COVID-19 pandemic.

The study, a collaboration with several South American universities, was funded by The Royal Academy of Engineering's Engineering X Pandemic Preparedness Programme and was published in Frontiers in Robotics and AI.

It highlighted the numerous challenges that have arisen for healthcare professionals during the pandemic including the vulnerability and overloading of services, the need for decongestion and reduction of the risk of contagion in intra-hospital environments, the availability of biomedical technology and the sustainability of patient care. Multiple strategies have been proposed to address such challenges including robotics as a promising solution to help control and mitigate the effects of the virus.

Although the literature has shown some robotics applications to overcome the potential hazards and risks in hospital environments, implementing those developments is limited. Few studies measure the perception and the acceptance of clinicians. This work presents the design and implementation of several perception questionnaires to assess healthcare providers' level of acceptance and education towards robotics for COVID-19 control in clinic scenarios. 82.9 % of participants indicated a positive perception concerning the development and implementation of robotics in clinic environments. In the research, clinicians had a positive perception of the robot as a tool to manage rehabilitation procedures.

Read more here

UKRI Prosperity Partnerships

UKRI recently announced eight Prosperity Partnerships in support of the government's Innovation Strategy, which will be funded with almost £60m from the Engineering and Physical Sciences Research Council, businesses and universities.

SeeByte and Heriot-Watt University have received funding to help develop the robust methods required for humans to collaborate with autonomous systems. This research will allow a variety of sectors to transition to the use of teams of smart robots to carry out roles in harsh and extreme environments, working closely with human operators and experts onshore.

This article originally appeared in the National Robotarium July 2021 newsletter.

Collaborative work gains media attention

Dr Morteza Amjadi from Heriot-Watt University and Professor Jeong Young Park from Korea Advanced Institute of Science and Technology (KAIST) secured the front cover of Advanced Healthcare Materials for their collaborative work Ultra-Wide Range Pressure Sensor Based on a Microstructured Conductive Nanocomposite for Wearable Workout Monitoring.

Collaboration with Apple on Natural Language Generation

Dr Ioannis Konstas and Professor Verena Rieser from Heriot-Watt University have started a collaboration with Apple to work on low resource Natural Language Generation.

Collaboration

COLLABORATION
EDINBURGH CENTRE FOR ROBOTICS

Health Robotics Workshop

The first health robotics workshop, organised by Professor Lynne Baillie, took place on the 9th June 2021. There were five speakers who focused on a wide range of topics applicable to health robotics from social robotics to assist with cognitive rehabilitation to data drive modelling for surgical robots. Around 30 delegates participated in the workshop and there were some excellent questions and answers which generated interesting discussions.

It is intended that there will be a 2nd Health Robotics PhD Workshop in early 2022 at which the team will be joined by robotics research groups from Tampere University (Finland) and Monash University (Australia).

Speakers and titles from the first workshop:

Speaker: George Kamaras (CDT student)
Title: Data-Driven Modelling and Control of Deformable Materials

Speaker: Emilyann Nault (CDT student)
Title: Socially Assistive Robots and Sensory Feedback for MCI/Dementia Cognitive Rehabilitation

Speaker: Isobel Voysey (CDT student)
Title: Developing a Minimal Animate Companion Animal Robot

Speaker: Martin Ross (Affiliated student)
Title: An Adaptive Robot Coach for Sports and Rehabilitation Coach-ing: Design and Implementation

Speaker: Arturas Straizys (CDT student)
Title: Understanding and Reproducing Wide Local Surgical Excision

THE NATIONAL
ROBOTARIUM
PEOPLE CENTRED :: INTELLIGENCE DRIVEN

The National Robotarium is a world-leading centre for Robotics and Artificial Intelligence. Its responsible and collaborative approach creates innovative solutions to global challenges. Its pioneering research moves rapidly from laboratory to market, developing highly skilled visionaries and delivering substantial benefits for society. Its ethos is People centred; Intelligence driven. This world-leading research and development facility translates cutting-edge research into technologies to create disruptive innovation in an expanding global market in robotics and autonomous systems, delivering sustainable economic benefit to the Edinburgh City Region, Scotland, and the UK.

The £22.4m purpose-built centre, opening in early 2022, will have unrivalled facilities adding to our existing laboratories in Ocean Systems, Human Robotic Interaction and Assisted Living and will also include smart manufacturing. The design of the new building and its unrivalled facilities will encourage the collaborative approach that is at the heart of the National Robotarium's ethos. Facilities include a partner suite: an area dedicated to fostering collaboration between industry partners, academics and government. With a strong focus on entrepreneurship and job creation, the National Robotarium will offer an ecosystem for industry collaboration where humans and robots work in partnership.

As building work enters the final stages, the National Robotarium's first CEO has been appointed. Stewart Millar's ambition is to build the National Robotarium into a globally recognised centre of excellence for AI and Robotics, working directly with business to accelerate innovation and drive value from world class research, create talent of the future through a flexible skills programme and support entrepreneurs capable of creating exciting new businesses to fuel our economy.

https://www.hw.ac.uk/uk/research/the-national-robotarium.htm

@EDINRobotics
@EDINRobotics
Edinburgh Centre for Robotics
Edinburgh Centre for Robotics

enquiries@edinburgh-robotics.org

This publication is available online at:

www.edinburgh-robotics.org/reports

This publication can also be made available in alternative formats on request.

Published by:
EPSRC Centre for Doctoral Trainining in
Robotics and Autonomous Systems
Heriot-Watt University
University of Edinburgh

Thank you to all students and staff who contributed to the production of this publication.

www.edinburgh-robotics.org