TAROS LINCOLN 2021

Towards Autonomous Robotic Systems Conference (TAROS)

8 -10 September 2021

Hosted by

UNIVERSITY OF LINCOLN

L-CAS

Sponsored by

Agri FoRwArdS

EPSRC Centre for Doctoral Training in Agri-Food Robotics

Information for attendees

Thank you for joining us at TAROS 2021. We hope you enjoy the experience; we are very much looking forward to the next few days.

Please do make sure you familiarise yourself with the below information to ensure you get the most out of the conference experience.

Zoom

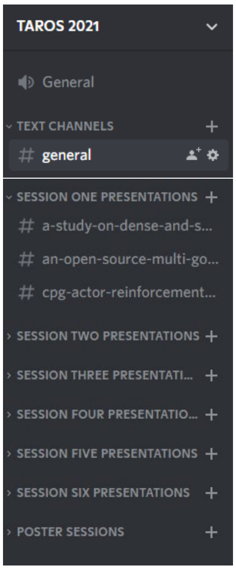
The conference will be held via Zoom. We recommend that you take a few moments to ensure that you are running the most recent version of Zoom. Detailed instructions for doing so can be found on the Zoom website.

You will be able to watch presentations and interact with fellow attendees, presenters, panellists, and hosts, via the Zoom chat function. We ask that you please remain respectful in the conference chat. Questions for our speakers are very welcome and should be posted using the Zoom Q&A function.

The link for accessing the Zoom conference is: https://eng-cam.zoom.us/j/86816663075

There is also a public lecture being held as part of the conference, this is accessed via a separate link as this lecture will be publicly broadcast on YouTube. **You can watch the lecture on Zoom, or via YouTube.**

Discord



Networking will take place via Discord. You can find out more about how to use Discord on the Discord website. We recommend familiarising yourself with Discord and joining the server before the conference starts.

There are two general channels available, one video chat (indicated by the speaker symbol) and one text chat (indicated by the #). Text chats are similar to using any other chat platform (e.g. Zoom chat or WhatsApp) and video chats are similar to using any other video meeting platform (e.g. Zoom or Microsoft Teams).

Individual channels are accessed via the menu on the left-hand side.

Using Discord for presentation questions

Each oral presentation has been allocated an individual text chat, where you can ask questions of the presenters/authors. Presentation channels are grouped according to their session. Just click on the paper title to open the chat.

Using Discord for poster sessions

Each poster presentation has been allocated an individual video chat, where you can ask questions of the presenters/authors. These channels can be found in the 'Poster Sessions' section, these are labelled by the poster numbers found on the programme.

Poster presenters will be available during the timetabled poster sessions. Just click on your poster number to open the call. There are also two text chats available (one for each session), should you wish to ask questions outside of the timetabled poster session, or don't wish to join a video chat.

The link for accessing the Discord server is: https://discord.gg/E8hKCj3jpc

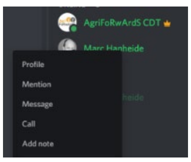
Social Media

Please do post on social media about your experiences of the conference, and don't forget to use **#TAROS2021**

Feedback

We welcome feedback so that we can improve future events. Please give your feedback by email to agriforwards.cdt@lincoln.ac.uk.

Contact information



Urgent messages during the conference should be sent directly to the conference organisers in Discord, simply @AgriFoRwArdS CDT. You can direct message @AgriFoRwArdS CDT by right clicking on the name and selecting 'message'.

Alternatively, you can contact the organisers via email on agriforwards.cdt@lincoln.ac.uk.

TAROS 2021 Programme

Please note, the TAROS 2021 Conference will be recorded

Day One Wednesday 8 September 2021

10:00 to 10:30 **Online systems and networking open**

10:30 **Simon Parsons and Charles Fox**
Welcome

10:45 **Marc Hanheide**
Introduction to TAROS technology

11:00 to 12:00 **Keynote One** **Chair: Marc Hanheide**

11:00 **Yiannis Demiris**
Towards Personal Assistive Robots

12:00 to 13:00 **Oral Session One** **Chair: Heriberto Cuayahuitl**

12:00 **Abdalkarim Mohtasib**
A Study on Dense and Sparse (Visual) Rewards in Robot Policy Learning

12:20 **Xintong Yang**
An Open-Source Multi-Goal Reinforcement Learning Environment for Robotic Manipulation with Pybullet

12:40 **Luigi Campanaro**
CPG-Actor: Reinforcement Learning for Central Pattern Generators

13:00 to 14:00 **Lunch**

14:00 to 15:00 **Oral Session Two** **Chair: Sergi Molina**

14:00 **Karoline Heiwolt**
Deep semantic segmentation of 3D plant point clouds

14:20 **Muhammad Sami Siddiqui**
Discovering stable robot grasps for unknown objects in presence of uncertainty using Bayesian models

14:40 **R. Zhang**
Improving SLAM in Pipe Networks by Leveraging Cylindrical Regularity

15:00 to 16:00 **Poster Session One** **Chair: Marc Hanheide**

16:00 to 17:00 **Oral Session Three** **Chair: Taeyeong Choi**

16:00 **James R Heselden**
CRH: A Deadlock Free Framework for Scalable Prioritised Path Planning in Multi-Robot Systems*

16:20 **Elnaz Shafipour**
Task-based ad-hoc teamwork with Adversary

16:40 **Gizem Ateş**
Human-Robot Cooperative Lifting using IMUs and Human Gestures

17:00 **Day One Close**

18:00 Public Lecture

18:00 to 19:00 Keynote Two — Chair: Simon Parsons

18:00 **Nick Hawes**
An Uncertain Mission: Decision Making for Autonomous Robots

Day Two Thursday 9 September 2021

09:30 to 10:00 Online systems and networking open

10:00 to 11:00 Keynote Three — Chair: Charles Fox

10:00 **Barbara Webb**
Ant-inspired Robots

11:00 to 11:45 Award Presentations — Chair: Lorenzo Jamone

11:00 **UKRAS Best Paper Presentation**
Chip Jansen and Elizabeth Sklar – *Predicting Artist Drawing Activity via Multi-Camera Inputs for Co-Creative Drawing*

11:20 **QMUL Best Thesis Presentation**
Shortlist; Katie Winkle, Fan Zhang, Pierre Berthet-Rayne

11:45 to 12:00 Break

12:00 to 13:00 Oral Session Four — Chair: Fanta Camara

12:00 **Alfred Wilmot**
3D printed mechanically modular two-degree-of-freedom robotic segment utilizing variable-stiffness actuators

12:20 **Oliver Shorthose**
Design of a Multimaterial 3D-printed Soft Actuator with Bi-directional Variable Stiffness

12:40 **Jack M. Frampton**
Designing a Multi-Locomotion Modular Snake Robot

13:00 to 14:00 Lunch

14:00 to 15:00 Oral Session Five — Chair: Athanasios Polydoros

14:00 **Marta Crivellari**
Deep robot path planning from demonstrations for breast cancer examination

14:20 **Daniel Schäle**
Priors inspired by Speed-Accuracy Trade-Offs for Incremental Learning of Probabilistic Movement Primitives

14:40 **Kiyanoush Nazari**
Tactile Dynamic Behaviour Prediction Based on Robot Action

15:00 to 16:00 Poster Session Two — Chair: Marc Hanheide

16:00 to 17:00 Oral Session Six — Chair: Grzegorz Ceilniak

16:00 **Ian S. Howard**
State space analysis of variable-stiffness tendon drive with non-back-drivable worm-gear motor actuation

16:20 **Hatem Fakhruldeen**
Development of a ROS Driver and Support Stack for the KMR iiwa Mobile Manipulator

16:40 **Vibhakar Mohta**
Collision Avoidance with Optimal Path Replanning for Mobile Robots

17:00 **Day Two Close**

Day Three Friday 10 September 2021

09:25 to 09:30 **Welcome**

09:30 **Performance Projects**
Christopher Horton

10:00 **GMV NSL and Sundance Ltd**
Aron Kisdi and Flemming Christensen

10:30 **University of Oxford**
Maurice Fallon

11:00 **RAR UK Automation**
Jonathan Raine

11:30 **RAR UK Automation**
Ross Lacey

12:00 **Imperial College London**
Ashutosh Choubey

12:30 **MathWorks**
Francesco Ciriello

13:00 to 13:30 **Lunch**

13:30 **Touchlab Limited**
Locky Wright

14:00 **Synergy Logistics**
Anish Mackan

14:30 **University of Surry**
Simon Hadfield

15:00 **Offshore Renewable Energy Catapult**
Ben George

15:30 **University of Lincoln**
TBC

16:00 **Day Three Close**

TAROS 2021 Keynote Speakers

Towards Personal Assistive Robots

Yiannis Demiris, Imperial College London

How can robots assist people in achieving their tasks in a way that adapts to the individual? From physical assistance with activities of daily living to educational support, personalisation mechanisms share perceptual, representational, and learning challenges in determining the nature and timing of the optimal assistance by the robot: robots need to understand the current state and intention of their users through multimodal perception and action understanding algorithms, and adapt the assistance to the users' particular (and evolving) needs. In this talk, I will present our research towards designing and implementing cognitive architectures that enable robots to build multiscale models of their users and adapt their behaviour to maximise assistance effectiveness over extended periods of interaction. I will argue that such personalisation, and the explainability of the learned user models, can help in developing effective and trustworthy robot assistants. I will illustrate our approach with examples from robots assisting people with activities of daily living, for example, dressing and mobility, as well as educational support tasks.

Yiannis Demiris is a Professor of Human-Centred Robotics at Imperial College London, where he holds the Royal Academy of Engineering Chair in Emerging Technologies. He directs the Personal Robotics Lab, which investigates multimodal perception, multiscale user modelling, and cognitive architectures, for developing effective and trustworthy robot assistants, with a particular interest in healthcare and assisted living. He has published more than 200 peer-reviewed journal and conference papers on these topics while maintaining multidisciplinary national and international collaborations with academic and commercial organisations in human-robot interaction projects, including most recently the UKRI TAS Node on Trust. He maintains a strong interest in robotics education, having received multiple teaching awards at Imperial including the Rector's Award on Teaching Excellence. He is a Fellow of BCS, IET and RSS.

An Uncertain Mission: Decision Making for Autonomous Robots (IET Public Lecture)

Nick Hawes, University of Oxford

Autonomous systems, including robots and voice assistants, are becoming increasingly capable of performing useful actions such as moving between two locations or looking up information from a website. To go beyond single actions, an autonomous system needs the ability to produce sequences of actions to allow it to achieve a user-specified goal (such as collecting then delivering a package or booking a holiday). Within the field of AI, the capability of creating these goal-directed action sequences is known as mission planning. Creating mission planning algorithms to control robots is particularly challenging because the outcomes of robot actions are often unpredictable, and may only achieve the desired outcome with some probability. In this talk, I'll motivate the need for mission planning algorithms for robots that model uncertainty, present our approach to this problem, and talk about how we've used our algorithms to control robots in a range of domains from greeting people in a hospital, to inspecting a nuclear waste store.

Nick Hawes is an Associate Professor of Engineering Science in the Oxford Robotics Institute at the University of Oxford. He is also a Tutorial Fellow at Pembroke College and a Group Leader for AI/Robotics at the Turing Institute. His research is focused on developing Artificial Intelligence techniques that allow robots to perform useful tasks in everyday environments, with a particular interest in long-term autonomy, mobile service robots, and logistics. His work tackles the two connected problems of how robots can model the world around them (e.g. where objects usually appear, how people move through buildings etc.), and how they can exploit these models to perform tasks efficiently, safely, and intelligently.

Ant-inspired Robotics

Barbara Webb, University of Edinburgh

Ants are highly capable of many behaviours relevant to robotics. Their navigational abilities have been the focus of behavioural and ethological study for many years, and a range of algorithmic models of their behaviour have been proposed, often tested in robot implementations. Our recent work has focussed on bridging the gap to understanding the neural circuits that underly capacities such as visual orientation, path integration, and the combination of multiple cues. In each case, there is an important interplay between exploiting critical sensory cues in the natural environment, and the efficient and robust computation that supports behavioural control. A new direction for this research is to investigate the manipulation capabilities of ants, which allow them to handle a wide diversity of arbitrary, unknown objects with a skill that goes well beyond current robotics.

Barbara Webb completed a BSc in Psychology at the University of Sydney then a PhD in Artificial Intelligence at the University of Edinburgh. Her PhD research on building a robot model of cricket sound localization was featured in Scientific American and established her as a pioneer in the field of bio-robotics – using embodied models to evaluate biological hypotheses of behavioural control. She held lectureships at the University of Nottingham and University of Stirling before returning to a faculty position in the School of Informatics at Edinburgh in 2003. She was appointed to a personal chair as Professor of Biorobotics in 2010 and awarded an EPSRC Established Career Fellowship in 2021.

TAROS 2021 Presentations

A Study on Dense and Sparse (Visual) Rewards in Robot Policy Learning

Abdalkarim Mohtasib, Gerhard Neumann, and Heriberto Cuayáhuitl

Deep Reinforcement Learning (DRL) is a promising approach for teaching robots new behaviour. However, one of its main limitations is the need for carefully hand-coded reward signals by an expert. We argue that it is crucial to automate the reward learning process so that new skills can be taught to robots by their users. To address such automation, we consider task success classifiers using visual observations to estimate the rewards in terms of task success. In this work, we study the performance of multiple state-of-the-art deep reinforcement learning algorithms under different types of reward: Dense, Sparse, Visual Dense, and Visual Sparse rewards. Our experiments in various simulation tasks (Pendulum, Reacher, Pusher, and Fetch Reach) show that while DRL agents can learn successful behaviours using visual rewards when the goal targets are distinguishable, their performance may decrease if the task goal is not clearly visible. Our results also show that visual dense rewards are more successful than visual sparse rewards and that there is no single best algorithm for all tasks.

An Open-Source Multi-Goal Reinforcement Learning Environment for Robotic Manipulation with Pybullet

Xintong Yang, Ze Ji, Jing Wu, and Yu-Kun Lai

This work re-implements the OpenAI Gym multi-goal robotic manipulation environment, originally based on the commercial Mujoco engine, onto the open-source Pybullet engine. By comparing the performances of the Hindsight Experience Replay-aided Deep Deterministic Policy Gradient agent on both environments, we demonstrate our successful re-implementation of the original environment. Besides, we provide users with new APIs to access a joint control mode, image observations and goals with customisable camera and a built-in on-hand camera. We further design a set of multi-step, multi-goal, long-horizon and sparse reward robotic manipulation tasks, aiming to inspire new goal-conditioned reinforcement learning algorithms for such challenges. We use a simple, human-prior-based curriculum learning method to benchmark the multi-step manipulation tasks. Discussions about future research opportunities regarding this kind of tasks are also provided.

CPG-Actor: Reinforcement Learning for Central Pattern Generators

Luigi Campanaro, Siddhant Gangapurwala, Daniele De Martini, Wolfgang Merkt, and Ioannis Havoutis

Central Pattern Generators (CPGs) have several properties desirable for locomotion: they generate smooth trajectories, are robust to perturbations and are simple to implement. However, they are notoriously difficult to tune and commonly operate in an open-loop manner. This paper proposes a new methodology that allows tuning CPG controllers through gradient-based optimisation in a Reinforcement Learning (RL) setting. In particular, we show how CPGs can directly be integrated as the Actor in an Actor-Critic formulation. Additionally, we demonstrate how this change permits us to integrate highly non-linear feedback directly from sensory perception to reshape the oscillators' dynamics. Our results on a locomotion task using a single-leg hopper demonstrate that explicitly using the CPG as the Actor rather than as part of the environment results in a significant increase in the reward gained over time (20x more) compared with previous approaches. Finally, we demonstrate how our closed-loop CPG progressively improves the hopping behaviour for longer training epochs relying only on basic reward functions.

Deep semantic segmentation of 3D plant point clouds

Karoline Heiwolt, Tom Duckett, and Grzegorz Cielniak

Plant phenotyping is an essential step in the plant breeding cycle, necessary to ensure food safety for a growing world population. Standard procedures for evaluating three-dimensional plant morphology and extracting relevant phenotypic characteristics are slow, costly, and in need of automation. Previous work towards automatic semantic segmentation of plants relies on explicit prior knowledge about the species and sensor set-up, as well as manually tuned parameters. In this work, we propose to use a supervised machine learning algorithm to predict per-point semantic annotations directly from point cloud data of whole plants and minimise the necessary user input. We train a PointNet++ variant on a fully annotated procedurally generated data set of partial point clouds of tomato plants, and show that the network is capable of distinguishing between the semantic classes of leaves, stems, and soil based on structural data only. We present both quantitative and qualitative evaluation results, and establish a proof of concept, indicating that deep learning is a promising approach towards replacing the current complex, laborious, species-specific, state-of-the-art plant segmentation procedures.

Discovering stable robot grasps for unknown objects in presence of uncertainty using Bayesian models

Muhammad Sami Siddiqui, Claudio Coppola, Gokhan Solak, and Lorenzo Jamone

Autonomous grasping of unknown objects is challenging due to the uncertainty in robotic sensing and action generation. This paper presents a pipeline for predicting a safe grasp in unknown objects using depth and tactile sensing. The main objective of the work is to explore haptically to maximise a given grasp metric, such that the probability of dropping the object after lifting from the surface is minimal. The performance of the uniform grid search method is compared with probabilistic methods (i.e. standard and unscented Bayesian Optimisation) to discover safe points. The results show that unscented Bayesian Optimisation provides better confidence in finding a safe grasp. This is demonstrated by observing optimum points being far from the edges and the exploration converging sooner than other methods in a limited number of exploratory observations.

Improving SLAM in Pipe Networks by Leveraging Cylindrical Regularity

R. Zhang, M. H. Evans, R. Worley, S. R. Anderson, and L. Mihaylova

Monocular visual Simultaneous Localisation and Mapping algorithms estimate map points and frame poses simultaneously based on video data. The estimated map point locations do not contain any structural information. Due to the measurement noise, the estimated trajectory is slightly different from the ground truth. This paper improves the estimation accuracy of trajectory in a pipe network by leveraging structural regularity. An optimisation-based method is used to detect a cylinder among map points in the SLAM back-end. When the cylinder is detected, the system enforces cylindrical regularity to the points from the cylindrical pipe surface, which is named cylindrical points. The estimated trajectory and map points will benefit from this structural information. This method is verified and evaluated on both synthetic data and realworld pipe video datasets.

CRH*: A Deadlock Free Framework for Scalable Prioritised Path Planning in Multi-Robot Systems

James R Heselden and Gautham P Das

Multi-robot system is an ever growing tool which is able to be applied to a wide range of industries to improve productivity and robustness, especially when tasks are distributed in space, time and functionality. Recent works have shown the benefits of multi-robot systems in fields such as warehouse automation, entertainment and agriculture. The work presented in this paper tackles the deadlock problem in multi-robot navigation, in which robots within a common work-space, are caught in situations where they are unable to navigate to their targets, being blocked by one another. This problem can be mitigated by efficient multi-robot path planning. Our work focused around the development of a scalable rescheduling algorithm named Conflict Resolution Heuristic A* (CRH*) 1 for decoupled prioritised planning. Extensive experimental evaluation of CRH* was carried out in discrete event simulations of a fleet of autonomous agricultural robots. The results from these experiments proved that the algorithm was both scalable and deadlock-free. Additionally, novel customisation options were included to test further optimisations in system performance. Continuous Assignment and Dynamic Scoring showed to reduce the make-span of the routing whilst Combinatorial Heuristics showed to reduce the impact of outliers on priority orderings.

Task-based ad-hoc teamwork with Adversary

Elnaz Shafipour and Saber Fallah

Many real-world applications require agents to cooperate and collaborate to accomplish shared missions; though, there are many instances where the agents should work together without communication or prior coordination. In the meantime, agents often coordinate in a decentralised manner to complete tasks that are displaced in an environment (e.g., foraging, demining, rescue or firefighting). Each agent in the team is responsible for selecting their own task and completing it autonomously. However, there is a possibility of an adversary in the team, who tries to prevent other agents from achieving their goals. In this study, we assume there is an agent who estimates the model of other agents in the team to boost the team's performance regardless of the enemy's attacks. Hence, we present On-line Estimators for Ad-hoc Task Allocation with Adversary (OEATA-A), a novel algorithm to have better estimations of the teammates' future behaviour, which includes identifying enemies among friends.

Human-Robot Cooperative Lifting using IMUs and Human Gestures

Gizem Ateş and Erik Kyrkjebø

In physical Human-Robot Cooperation (pHRC), humans and robots interact frequently or continuously to manipulate the same object or workpiece. One of the tasks within pHRC that has the highest potential for increased value in the industry is the cooperative lifting (co-lift) task where humans and robots lift long, flexible or heavy objects together. For such tasks, it is important for both safety and control that the human and robot can access motion information of the other to safely and accurately execute tasks together. In this paper, we propose to use Inertial Measurement Units (IMUs) to estimate human motions for pHRC, and also to use the IMU motion data to identify two-arm gestures that can aid in controlling the human-robot cooperation. We show how to use pHRC leaderfollower roles to exploit the human cognitive skills to easily locate the object to lift, and robot skills to accurately place the object on a predefined target location. The experimental results presented show how to divide the co-lifting operation into stages: approaching the object while clutching in and out of controlling the robot motions, cooperatively lift and move the object towards a new location, and place the object accurately on a predefined target location. We believe that the results presented in this paper have the potential to further increase the uptake of pHRC in the industry since the proposed approach do not require any preinstallation of a positioning system or features of the object to enable pHRC.

3D printed mechanically modular two-degree-of-freedom robotic segment utilizing variable-stiffness actuators

Alfred Wilmot and Ian S. Howard

Here we describe the initial development of a 3D printed modular robotic segment that is driven by variable stiffness actuators (VSAs). The novelty of the presented work is the combination of cost-effective antagonist VSAs with mechanical modularity: this enables multiple segments to be used either as a stand-alone serpentine robot or as compliant joints that can easily be integrated into other robotic systems. The VSAs are comprised of antagonist DC motor pairs that separately actuate two orthogonal revolute joints via a viscoelastic tendon-based transmission system. The simplistic nature of the design also aims to minimize the effects of joint coupling. Joint-level control is performed on a microcontroller which transmits motor current and joint position information over USB to a computer. ROS packages, including those needed for Gazebo and MoveIt! were created to enable physics simulations and motion-planning of either a single isolated segment, multiple chained segments, or some combination of segments and other robotic devices. We present results of a preliminary physical prototype of one such robotic segment whose joint positions and co-contractions were manually controlled using a gamepad and subsequently visualized using the developed ROS packages. The dynamics of the VSA were analyzed and the joint-torque equations were derived as functions of tendon parameters, joint angles, and motor electrical characteristics.

Design of a Multimaterial 3D-printed Soft Actuator with Bi-directional Variable Stiffness

Oliver Shorthose, Liang He, Alessandro Albini, and Perla Maiolino

A multi-material 3D printed soft actuator is presented that uses symmetrical, parallel chambers to achieve bi-directional variable stiffness. Many recent soft robotic solutions involve multi-stage fabrication, provide variable stiffness in only one direction or lack a means of reliably controlling the actuator stiffness. The use of multi-material 3D printing means complex monolithic designs can be produced without the need for further fabrication steps. We demonstrate that this allows for a high degree of repeatability between actuators and the ability to introduce different control behaviours into a single body. By independently varying the pressure in two parallel chambers, two control modes are proposed: complementary and antagonistic. We show that the actuator is able to tune its force output.

The differential control significantly increases force output with controllable stiffness enabled within a safe, low-pressure range (_ 20 kPa). Experimental characterisations in angular range, repeatability between printed models, hysteresis, absolute maximum force, and beam stiffness are presented. The proposed design demonstrated a maximum bending angle of 102.6_, maximum output force 2.17N, and maximum beam stiness 0.96mN m2.

Designing a Multi-Locomotion Modular Snake Robot

Jack M. Frampton, Sara Djoudi, Angelina Murphy, Thomas Scammell, Toby Wright, and Ze Ji

Snakes possess multi-locomotion abilities to best suit different environments. This work explores the design of a robot to replicate three types of snake motions: rectilinear, serpentine and sidewinding. The design featured identical modular housing units containing all the components for movement, a biomimetic skin to replicate the anisotropic friction created by the scales of the snakeskin and smart servos motors that produce adjacent housing rotation to imitate the body motion of a snake. Two prototypes are manufactured using rapid prototyping. Prototype 1 is designed to replicate rectilinear motion produced by the biomimetic snakeskin and collinear movement of each housing. Prototype 2 is powered by the smart servos and the rotation of adjacent housings to produce serpentine and sidewinding motions. From initial tests, prototype 1 is shown to be able to replicate rectilinear motion at low speeds, and prototype 2 is shown to be able to undertake 6 different movement options utilising both sidewinding and serpentine motions.

Deep robot path planning from demonstrations for breast cancer examination

Marta Crivellari, Oluwatoyin Sanni, Andrea Zanchettin, and Amir Ghalamzan Esfahani

In 2020, breast cancer affected around two million people worldwide. Early cancer detection is, therefore, needed to save many lives and reduce treatment costs. Nowadays, mammography and self- palpation are the most popular monitoring methods. The high number of cases and the difficulty of correct self-diagnosis has prompted this research work to design a fully autonomous robot to perform breast palpation. Specifically, this study focuses on learning the path for a successful breast examination of a silicone model. Learning from demonstrations proved to be the most suitable approach to reproduce the desired path. We implemented a teleoperation control between two Franka Emika Panda robots with tactile and force feedback to perform palpation on both simple and complex shapes. Moreover, we created a dataset of simple palpation strategy. Finally, we developed and tested different sequential neural networks such as Recurrent Neural Network (RNN), Long short-term memory (LSTM), Gated recurrent unit (GRU) and Temporal Convolutional Network (TCN) to learn the stochastic behaviour of the acquired palpation trajectories. The results showed that TCN is capable of reproducing the desired behaviour with more accuracy and stability than the other models.

Priors inspired by Speed-Accuracy Trade-Offs for Incremental Learning of Probabilistic Movement Primitives

Daniel Schäle, Martin F. Stoelen, and Erik Kyrkjebø

Probabilistic Movement Primitives (ProMPs) model robot motor skills by capturing the mean and variance of a set of demonstrations provided by a human teacher. Such a probabilistic representation of motor skills is beneficial in physical human-robot cooperation (pHRC) where robots have to respond to the inherent variance in human motion. However, learning ProMPs incrementally and from scratch, as it is desirable in pHRC, is difficult due to the large number of parameters required to model the distribution of a motor skill compared to the few demonstrations available at the beginning of training. In this paper we propose to predict the variance structure of a motor skill based on the speed found in the individual demonstrations and to incorporate this prediction into the prior parameter distribution of the ProMP. Our basic approach is taking inspiration from the speed-accuracy trade-off found in human motion. Experimental evaluation suggests that with the proposed prior parameter distributions, the true distribution is approached faster in incremental learning of a motor skill than with the priors previously proposed for batch learning.

Tactile Dynamic Behaviour Prediction Based on Robot Action

Kiyanoush Nazari, Willow Mandill, Marc Hanheide, and Amir Ghalamzan Esfahani

Tactile sensing provides essential information about the state of the world for the robotic system to perform a successful and robust manipulation task. Integrating and exploiting tactile sensation enables the robotic systems to perform wider variety of manipulation tasks in unstructured environments relative to pure vision based systems. While slip detection and grip force control have been the focus of many research works, investigation of tactile dynamic behaviour based on robot actions is not yet sufficiently explored. This analysis can provide a tactile plant which can be used for both control methods and slip prediction using tactile signals. In this letter, we present a data driven approach to and an efficient tactile dynamic model with different tactile data representations. Having evaluated the performance of the trained models, it is shown that the tactile action conditional behaviour can be predicted in a sufficiently long time horizon in future for doing robot motion control.

State space analysis of variable-stiffness tendon drive with non-back-driveable worm-gear motor actuation

Ian S. Howard and Martin F. Stoelen

Here we investigate variable-stiffness tendon drive for a robot arm. The novel aspect of our design is that it makes use of non-back-drivable wormgear motor actuation, so static arm configurations can be maintained at a desired stiffness level without requiring motor power. We first analyze a link that is driven via uni-directional agonistic-antagonistic non-linear elastic tendons and construct the state space model of the system. We then design an observer-based state feedback controller. This ensures the output link can track a reference input vector consisting of a desired joint angle as well as tendon extension realized by tendon co-contraction. We simulated the controller and plant in MATLAB and show examples of typical movement trajectories for angular control of the link.

Development of a ROS Driver and Support Stack for the KMR iiwa Mobile Manipulator

Hatem Fakhruldeen, David Marquez-Gamez, and Andrew I Cooper

Mobile manipulators are expected to revolutionise robotics applications because they combine mobility and dexterity. Robotics middlewares such as ROS (Robot Operating System) is a key component to develop the capability of these platforms and to research their novel applications. In this paper, we present a complete ROS stack for the KMR iiwa mobile manipulator. This stack comprises of a ROS driver, with a novel architecture, running natively on the platform controller and the essential support packages that allow motion planning, navigation, visualisation and simulation using ROS standard tools and frameworks. To our knowledge, this work is the _rst ROS 1 1 package for the KMR iiwa. To demonstrate the capabilities of our work, we present example applications both in simulation and using the real robot. Finally, the proposed stack is used in a heterogeneous multi-robot system in the context of an autonomous chemistry laboratory.

Collision Avoidance with Optimal Path Replanning for Mobile Robots

Vibhakar Mohta, Sagar Dimri, Hariharan Ravichandran, and Sikha Hota

This paper generates a collision-free trajectory for wheeled mobile robots in presence of dynamic obstacles. The existing literature solves the collision avoidance problem by changing the velocity vector instantaneously, which is not feasible due to the non-holonomic constraints of robots. So in this work, a smooth change in the velocity vector along with constraints in turn radius has been considered for any required manoeuvres. This work also re-plans the path evading re-collision to reach the goal ensuring minimum deviation from the initial path, which was also not addressed in the literature. The low computational requirement of the proposed algorithm allows for online applications on wheeled mobile robots with limited computational resources. The approach is validated through simulations on multiple randomized configurations.

TAROS 2021 Posters

Poster Session One

1.01 Reinforcement Learning-based Mapless Navigation with Fail-safe Localisation
Feiqiang Lin, Ze Ji, Changyun Wei, and Hanlin Niu

1.02 Collaborative Coverage for a Network of Vacuum Cleaner Robots
Junyan Hu, Barry Lennox, and Farshad Arvin

1.03 Network-Aware Genetic Algorithms for the Coordination of MALE UAV Networks
Alexandros Giagkos, Myra S. Wilson, and Ben Bancroft

1.04 Self-organised Flocking of Robotic Swarm in Cluttered Environments
Zheyu Liu, Ali Emre Turgut, Barry Lennox, and Farshad Arvin

1.05 Deep Learning Traversability Estimator for Mobile Robots in Unstructured Environments
Marco Visca, Sampo Kuutti, Roger Powell, Yang Gao, and Saber Fallah

1.06 Evaluating Feedback Modalities in a Mobile Robot for Telecare

Noa Markfeld, Samuel Olatunji, and Yael Edan

1.07 Demonstrating the Differential Impact of Flock Heterogeneity on Multi-Agent Herding
Chris Bennett, Seth Bullock, and Jonathan Lawry

1.08 Evaluation of an OpenCV Implementation of Structure from Motion on Open Source Data
Ali Alouache and Qinghe Wu

1.09 Benchmark of visual and 3D lidar SLAM systems in simulation environment for vineyards
Ibrahim Hroob, Riccardo Polvara, Sergi Molina, Grzegorz Ceilniak, and Marc Hanheide

1.10 Lidar-only localization in 3D Pose-Feature Map
Chaokun Zhang, Taotao Shan, Bolin Zhou, and Yu Guo

1.11 Toward robust visual odometry using prior 2D map information and multiple hypothesis particle filtering
S. Edwards, L. Mihaylova, J. M. Aikten, and S. Anderson

1.12 Comparison of Concentrated and Distributed Compliant Elements in a 3D Printed Gripper
Jordan Cormack, Mohammad Fotouhi, Guy Adams and Tony Pipe

1.13 Perception of a humanoid robot as an interface for auditory testing
Luke Meyer, Gloria Araiza-Illan, Laura Rachman, Etienne Gaudrain, and Deniz Başkent

Session Two

2.01 An Autonomous Mapping Approach for Confined Spaces using Flying Robots
Ahmad Alsayed, Mostafa R. A. Nabawy, Akilu Yunusa-Kaltungo, Mark K Quinn, and Farshad Arvin

2.02 Maximising availability of transportation robots through intelligent allocation of parking spaces
Roopika Ravikanna, Marc Hanheide, Gautham Das, and Zuyuan Zhu

2.03 A Minimalist Solution to the Multi-Robot Barrier Coverage Problem
Thomas Green, Kevin Kamel, Siyuan Li, Christopher Shinn, Paolo Toscano, Xintong Wang, Yuchen Ye, and Roderich Gross

2.04 Scheduling Multi-robot Missions with Joint Tasks and Heterogenous Robot Teams
Gricel Vázquez, Radu Calinescu, and Javier Cámara

2.05 Area Coverage in Two-Dimensional Grid Worlds Using Computation-Free Agents
Arjan Dhesi and Roderich Gross

2.06 Online Scene Visibility Estimation as a Complement to SLAM and UAVs
Rory Haggart and Jonathan Aitken

2.07 Statics Optimization of a Hexapedal Robot Modelled as a Stewart Platform
Enrico Donato, Giacomo Picardi, and Marcello Calisti

2.08 EtherCAT implementation of a variable-stiffness tendon drive with non-back-drivable worm-gear motor actuation
Ian S. Howard and Martin F. Stoelen

2.09 Growing Robotic Endoscope for early Breast Cancer Detection: Robot Motion Control
Carmen Larrea, Pierre Berthet-Rayne, S. M. Hadi Sadati, Daniel Richard Leff, Christos Bergeles, and Ioannis Georgilas

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