University of Bristol

Faculty of Engineering

Technology and Context of Robotics and Autonomous Systems

Assignment 1: Report on Seminars

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1 WEEK 2

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1.1 ASSISTIVE ROBOTICS – HUMAN-ROBOT COLLABORATION AND LEARNING

DATE: 09-10-2019
Speaker: Praminda Caleb-Soll

Research Area: The research area focuses on supporting the elderly through assistive robotics. The goal is to make them independent and self-sufficient i.e. help them achieve physical tasks as well as understand the mental support needed. Hence, they have two aspects, socially assistive and physically assistive. They need to have the necessary controls in order to physically support them. They have to be well trained in natural language processing as well as know how to deal with non-verbal forms of communication such as body language or gestures.

Research Challenge: The robots must deal not only with the physical challenges but also with issues related to memory and cognitive decline. The physical challenges to this area mainly revolve around communication, i.e. the NLP as well as the medium of communication. As the target group may suffer from decline in vision or hearing, the challenge is to also address the multi modal interaction, contextual awareness from sensors and social intelligence.

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1.2 BIOMATHEMATICAL ROBOTICS

DATE: 10-10-2019
Speaker: Rui Ponte Costa

Research Area: This research area is inspired from nature and to bridge the gap between biology and mathematics. Simple celled organisms like cells or even sperms exhibit fascinating mathematical properties that can be used in the field of robotics. Nature has excelled in terms of optimization through evolution. This research area focuses on deriving this knowledge into optimization algorithms necessary for robotics.

Research Challenge: The main challenge of this area is to be able to understand and convert this knowledge in the application of robotics. The observation of these traits in nature are astonishing but to replicate them or even implement half of the level of sophistication is a very difficult task.

2 WEEK 3

UNIVERSITY OF WEST ENGLAND 16-10-2019

2.1 HUMAN-FRIENDLY ROBOT TELEOPERATION DESIGN AND HUMAN ROBOT SKILL TRANSFER

DATE: 16-10-2019
Speaker: Chenguang Yang

Research Area: This area focuses on bridging the gap between human and robot cognition and collaboration. It takes time to reprogram robots to do new tasks as they are not flexible. While humans have high flexibility in completing tasks, a robot is much more productive. This area focuses on bringing the best of the two worlds together by teaching robots to accomplish intricate tasks in order to have an efficient assembly line. Surface electromyography is used to collect signals that can make the robot grip an object tighter based on the operator's muscle stiffness, determined by the sensor. The robot provides feedback to the robot arm based on the stiffness. Potential collision points are detected and avoided through neural learning. Oscillations are detected and corrections are made accordingly. Knowledge gained in previous tasks is reused through tele-operation. Adapts to internal and external changes. Surface electromyography- signals from neuro motors (micro level voltage) are recorded.

Research Challenge: The major potential application of this field is in industries, but the technology used is still cannot be marketed due to cost implications and the robots itself are not autonomous enough to make a significant impact on the industry.

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2.2 TACTILE ROBOTICS: FROM ROBOT HANDS TO ROBOT BRAIN

DATE: 17-10-2019
Speaker: Nathan Lepora

Research Area: This talk focuses on bridging the gap between the physical world and the digital world, using Neuro morphic tactile sensing. To mimic natural physiology through intelligence. Optical tactile sensors are used along with deep learning to achieve this. Using image processing and deep learning to get more precise data from the sensors. 3d printed robots with sense of touch. Impart tactile intelligence to the robots. Mimic natural and physiological intelligence. Edge and surface detection, Neural morphing, contour following and Slip detection can be achieved through this.

Research Challenge: The major challenge in this area is to combine perception via contact and control of the contact efficiently, and make advancements in the field of tactile sensors to make them more precise and reliable.

3 WEEK 4

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3.1 ANTHROPOMORPHISM IN MIS ROBOTS, ROBOT EXOSKELETONS AND APPLICATION IN HAND REHABILITATION.

DATE: 24-10-2019
Speaker: Antonia Tzemanaki

Research Area: This area seeks to understand the way humans operate and seek to mimic their actions through a robot using soft robotic exoskeletons. In areas like medicine and nuclear power plants, where precision is key, robots have a significant advantage over human hands. So, the goal is to find a way to use experience and knowledge of a human to the accuracy and skills of a robot and apply it to environments like these. For example, the Da Vinci uses the precision of robots and the experienced handling of a surgeon. This is done through linear actuators attached to fingers and haptic feedback. Use of Hall sensors and soft robotics can ensure flexibility in size for human hands. Surgeon movements are studied by hand tracking during actual surgery. Kinematic mapping is done for rigid body guidance.

Research Challenge: The main challenge in this area is the sophistication of the exoskeletons used by surgeons, they not only need to be precise but also need to be light and have a free flow of motion without any frictional opposition from the robot joints itself as to not slow or deter the movement of the surgeon. As the sensors and the technology are expensive, the main challenge is to use a substitute to reduce the investment and make it feasible for hospitals etc. The sensors use Hall effect to measure small changes in hand movements, so in a magnetic environment, for example in a CAT scan room the sensor may give out false information.

4 WEEK 5

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4.1 EVOLUTIONARY SWARM ROBOTICS

DATE: 30-10-2019
Speaker: Matthew Studley

Research Area: This area seeks to understand how animals in swarms have evolved over the generations and can display intricate behaviours and interact with each other as a whole. If this can be implemented using robots, by using mass numbers we can cover a lot more ground as compared to using single controlled autonomous systems. If this can be handled in such a way that there is no central controller then we can overcome the problem of robots not being able to co-ordinate with each other, in the same way in which birds in a swarm co-ordinate their movements without any central or global system overruling them. A key advantage here is that if one fails the others can cover it up, whereas in case of a central guided system if one goes wrong everything fails. Similarly, each robot will act on the local information gathered by its sensors and not globally. ML is used to generate different sets of behaviours, like generator algorithms with reinforcement learning.

Research Challenge: A major challenge in this field is control. How to come up with a method to control the entire swarm. Even if the system is completely autonomous human interaction is still needed in some instances.

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4.2 BIO-INSPIRED SWARM ROBOTICS

DATE: 31-10-2019
Speaker: Edmund Hunt

Research Area: This area seeks to understand how animals interact with each other in the real world. Flocking, that is, self-organizing coherent movement, is a very complex behaviour adapted by animals in swarms. The flocks are flexible, versatile and also robust, which means if one animal sheds away from the group, the group does not lose functionality. In one of the research projects, the researchers tried to understand how ants interact to find suitable habitats (name of how they interact). They created social networks based on how the ants interact with each other. The ants had no centralized control, no access to global information, and no knowledge if group size. The key here is local information, that is, interaction with

neighbours. It is a vital part of forming swarms in the biological world. The main goal of the flock/swarm is to minimize risk but communicate mostly with neighbours.

Research Challenge: The major challenge in this field of robotics is to be able to create cost effective systems. As it is swarm robotics the number of robots will be large, so to make reliable end to end systems while keeping in mind the number of robots to be built could be tricky.

5 WEEK 6

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5.1 MACHINE VISION

DATE: 06-11-2019
Speaker: Wenhao Zhang

Research Area: This area focuses on solving real world problems using machine vision. This is very useful in areas where there is a time constraint or requires high computation. Using machine vision complex tasks can be solved with ease and efficiency. One of the projects for **FastTrack** requires face rendering or mapping to make the ticketing system a bit faster. Use of machines can make it a lot quicker as compared to using conventional manual checks. Another application is plant phenotyping wherein the species and also the characteristics of the plant can be determined using patterns on the leaf with the help of machine learning, which would otherwise be tough for the naked eye. Instead of using cameras with greater specifications, using depth resolution can be a lot cheaper and fruitful. Eye movement is linked to many symptoms of brain functions. Another identified challenge is the very costly and slow task of detecting Alzheimer's in patients. As eye movement is linked to many symptoms of brain functions, the movement of the eye can be studied with the help of machine learning and linked to various functions of the brain, which would allow doctors to pin point the disease faster. Eye health monitoring is another application which can be efficiently carried out using machine vision.

Research Challenge: A major challenge in the field of machine vision is flexibly. The experiments in the lab seem great but out in the real world the camera is not always able to capture the right images due to contrast or lighting. Any small changes in the exposure to light so something shiny can cause the accuracy of the predictions to drop drastically. So we need a robust systems that can accommodate these drawbacks.

5.2 MORPHOLOGICAL COMPUTATION – NATURE'S SECRET TO RESILIENCE AND ADAPTIVITY

DATE: 07-11-2019
Speaker: Helmut Hauser

Research Area: "offloading computation from the brain to the body". "the contribution of the body to the cognition and control". Many lower celled organisms make use of morphological computation to carry out complex tasks, such as the rhodium seed. This property with the help of soft robotics can have significant applications in the field of robotics. Movement of single celled organisms like amoeba can carry out multiple tasks with no centre of cognition or control governing the movement. The movement of a fish is incorporated in the design of the body. Morphological computation proposes that some part of the task such as walking can be offloaded to the body, in other words body can be used to compute these motions.

Research Challenge: A major challenge in this area is to programming the morphological computational model. It is a very challenging task to be able to fully formulate a language to communicate with the computational model.

6 WEEK 7

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6.1 HUMAN-ROBOT INTERACTION + SOCIAL ROBOTICS

DATE: 13-11-2019
Speaker: Séverin Lemaignan

Research Area: This area focuses on answering the million-dollar question if robots can be social. A social robot are autonomous agents that interacts with humans and the environment based on how it is programmed to react to certain situations. General tasks such as opening a book or fetching an object can be done through this. This research area could help in many areas including household work to assistive robots for elderly or in hospitals.

Research Challenge: The real challenge in this filed revolves around the mind of social robots, i.e. artificial intelligence and NLP. And the current level of NLP is not sophisticated enough for these social robots to understand colloquial terms and achieve complete tasks, so

there still is are many limitations to be solved in AI/NLP before these robots can be brought into society.

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6.2 BIO-ROBOTICS WITH EMBODIED INTELLIGENCE

DATE: 14-11-2019
Speaker: Andrew Conn

Research Area: Reactions to move. Tendons can release energy faster than muscles. Using fluidic elastomer networks (fluidic chambers). Mechanical response with no use of electronics. Dielectric elastomers are used to fabricate structures. Taking inspiration from nature, rather than having to deform or adapt to environment, to do it passively. This area is a promising field as it answers the challenges faced in soft robotics, where control is one of the major issues, embodied intelligence can be used to increase flexibility and adaptability.

Research Challenge: Lack of artificial muscles remains a bottle neck in this field. Also by avoiding electrical actuators, other methods are still not up to the same level of sophistication. Ex air chambers are used in arms to actuate the arm may not generate as much as force and precision needed.

7 WEEK 9

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7.1 ROBOTIC ENHANCEMENT FOR AMPUTEES THROUGH BIO-INSPIRED REHABILITATION DEVICES

DATE: 27-11-2019
Speaker: Appolinaire Etoundi

Research Area: This area focuses on extracting solutions from nature, by not only mimicking and understanding the evolution of various features in biological structures, but also extracting beneficial features depending on the problem. It uses engineering solutions to help amputees, based on bio-inspired structures. An example is the speaker Appolinaire Etoundi's work with a Paralympic athlete which revolves around building state-of-the-art knee joints to make it easier for him to switch legs for different activities in the Paralympics, be it swimming or biking or running. It took around 12 seconds for the athlete to switch legs but after working with Appolinaire, the time was reduced to 5 seconds, which is quite a significant change in

athletics. He talked about helping amputees who cannot afford high-end exoskeletons and making an impact on society using bio-inspired rehabilitation devices.

Research Challenge: The exoskeletons currently in the market are very costly. And reducing the price even slightly can go a long way in helping people. They are also very bulky and have very rigid motion, which means making a free-flowing joint will be considered as a big challenge in this field. Currently researchers in this field do not use a lot of simulation testing and virtual prototype design.

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7.2 COMPUTER VISION

DATE: 28-11-2019
Speaker: Dima Damen

Research Area: This research area revolves around egocentric vision, a sub-field of video analytics captured from wearable cameras. As cooking is considered one of the most difficult of human actions, and has the most complex environment, the data set contains people carrying out tasks in the kitchen. The videos are first rated over skill determination using I3D to abstract special and motion information, and then broken into segments to identify the segments with the most skilled parts. The videos are then classified using best segments and worst segments. Using disparity and rank awareness loss. Retro actions and fine-grained object interactions- audio visual temporal binding using audio and video data to align them and egocentric actions.

Research Challenge: Data still remains a major challenge for computer vision or ai in general. Even though thousands of data points, millions in some cases, are used to train the model, it is still not at the level researchers would want it to be. And to obtain large data sets is a big challenge.

8 WEEK 10

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8.1 DEEP LEARNING AND COMPUTER VISION

DATE: 04-12-2019
Speaker: Mark Hansen

Research Area: Prof Mark Hansen's area of research is around 3D acquisition of images with the help of Computer vision and deep learning. With the use of computer vision and techniques like depth detection 3D surfaces are configured based on 2D images. Projects like 3D deep face recognition are promising areas of research as they are relatively new, they are much more efficient and precise than the conventional face recognition algorithms. This can be used to predict the motions of pedestrians in from cctv footages and can be used to avoid accidents. This also takes the pose and predicts the movement which gives advantage over the conventional object detection and tracking algorithms, which may prove to be very useful in the real world.

Research Challenge: The main challenge of this field is the general problem faced by deep learning, i.e. data. The data used for training deep learning models is not high resolution and it might be very difficult to generate 3d contours out of poor resolution images.

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8.2 CONTROLLING ROBOTS WITHOUT ELECTRONICS

DATE: 05-12-2019
Speaker: Martin Garrad

Research Area: This area, a subtopic of soft robotics, deals with the control part of soft robotics. The goal is to develop a computer based on soft robotics that doesn't need computation. Instead of using electrons (electricity), the microchips involved use pneumatic pressure or fluid. It is inspired from biological DFAD, like the Cornish mallow which converts starch to sugar and sugar to starch to position itself to receive more sunlight. It revolves around vascular computing and embodied intelligence.

Research Challenge: The main challenge is that these methods are the challenges that are faced in soft robotics, i.e. they have low adaptability. These methods still cannot generate the level of force or the precision desired by the operators, so much research has to be done in this area in order to solve the problem.

9 WEEK 11

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9.1 DESIGN EXPERIENCE & CONSEQUENTIAL ROBOTICS

DATE: 11-12-2019
Speaker: Sebastian Conran

Research Area: The main focus of this area of research is to build more engaging and interactive robots based on the design rather than making them smarter or more sophisticated in terms of AI. This is a very simple yet novel approach to the challenge of making robots a more social agent. Interesting Research is being done around robots that are hybrid of domestic animals to make the users feel more comfortable around them.

Research Challenge: The topic of the filed is the main challenge. The apart from the engineering perspective of the design the emotional perspective is very subjective. The gola of this research is to make the robots more social and friendly, but by doing this sometimes the engineering aspects of the desing must be alterted too. So there gas to be a right balance between these two aspects which can be tricky.

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9.2 ON ROBOT VISION AND NOVEL HUMAN ROBOT INTERACTION

DATE: 12-12-2019
Speaker: Walterio Mayol-Cuevas

Research Area: This research area focuses on finding new computer vision methods, especially for robotic devices. A project of the speaker was to develop a camera designed in such a way that each pixel had its own CPU. The process of decoding the data from the images, then processing it in a GPU and various processing pipelines, all outdated methods in the field of robotics, were omitted to increase the efficiency. This is primarily being developed for MAVs (Miniature Arial Vehicles). Handheld robotics, balance between the ideal robots with decision making and exoskeleton robots. Using visual odometry.

Research Challenge: As the steadiness of the camera cannot be determined motion bias and shutter speed will always remain a tricky problem to completely eradicate.