

Workshop on « Connected robotics for industry 4.0»

Monday May 17 2021

CentraleSupélec, L2S, virtual meeting

The connected robotics is one of the pillars of industry 4.0, jointly with IoT, AI and big data. This workshop aims at presenting state of the art results from industry and academia on the topic of connected robotics for industry 4.0.

Program:

9h00 – 9h15 Introduction : Didier Dumur, CentraleSupélec, L2S

9h15 – 9h45 Fabrice Robert (Capgemini) : “Robotics As A Service”

9h45 – 10h15 Vineeth Varma (CRAN) : “Trajectory planning for robots with communication objectives”

10h15 – 10h30 break

10h30 – 11h00 Meriem Mhedhbi (Orange) : “Predictive QoS for industry 4.0”

11h00 – 11h30 L2S Michel Kieffer (L2S) : “Estimation of the localisation of partially hidden targets using drones”

11h30 – 12h00 Vincent Fortineau (L2S) : “Human impedance estimation during physical interaction with a robot”

12h00 – 13h30 Lunch break

13h30 – 14h15 Frank Fitzek (TU Dresden) : “Tactile Internet with Human-In-The-Loop”

14h15 – 15h00 Angelo Corsaro (ADLINK) : “Connected Robotics: The Zenoh Way”

15h00 – 15h15 Pause

15h15 – 15h45 Sébastien Tixeuil (LIP6) : “Mitigating faults in Mobile Robotic Swarms”

15h45 – 16h00 Conclusion – Salah El Ayoubi, CentraleSupélec, L2S

Summary of talks

1. **Title** : " Robotics As A Service " – **Fabrice Robert**

Abstract: Industrial world is changing as fast as the digital technologies are evolving. Based on its deep knowledge of clients’ needs from Engineering to manufacturing and its expertise in robotics, Capgemini developed a platform to provide “Robotics as a Service” for new domains of industries processes. Robots are not only assembling, they can collaborate, react, move, touch, repeat to more than tasks but deliver « Service ». This presentation is about TRY (Teach Robot Yourself) platform and how Capgemini customers use it.

2. **Title** : "Trajectory planning for robots with communication objectives" – **Vineeth Varma**

Abstract: In tasks such as surveying or monitoring remote regions, an autonomous robot must move while transmitting data over a wireless network with position-dependent transmission rates. For such a robot, we consider the problem of transmitting a data buffer in minimum time and energy, while possibly also navigating towards a goal position. While several existing results have looked at the problem of trajectory planning with continuous communication requirements like maintaining a certain SNR, the objective in this work is to empty a certain amount of data before reaching the goal. The map is also such that no signal or only a very weak signal

may be found in certain zones. We explore several cases of interest such as a i) simple communication topology and a simple robot model ii) noisy communication map and a high fidelity robot model and finally iii) unknown rates with a generic robot model. While theoretical results are found for i), we provide an algorithm using some control theoretic results for ii), and a learning based solution for iii).

3. **Title :** "5G for industrial automation: use cases and requirements" – **Meriem Mhedhbi**

Abstract: The development of the 5G was not only to expand the broadband capabilities of mobile networks, but also to provide advanced wireless connectivity for a wide variety of vertical industries, such as the manufacturing, automotive and agricultural sectors. By supporting ultra reliable low latency communications URLLC, 5G system can deliver the strict latency and reliability demands. Thus, 5G technologies, adopted by industrials, is enabling use cases in industrial environment. In this presentation, we will present the main use cases for 5G industrial automation and the associated requirements. The use cases are identified by the 5G Alliance for Connected Industries and Automation (5G- ACIA) partners and considered of high priority among the use cases standardized in 3GPP

4. **Title :** " Estimation of the localisation of partially hidden targets using drones" – **Michel Kieffer** en collaboration avec Julius Ibenthal, Luc Meyer, H el ene Piet-Lahanier (ONERA)

<https://drive.google.com/drive/folders/1djK7qQJCGBYPKVwD8nAey7C9f4bbQ65I?usp=sharing>

5. **Title :** "Human impedance estimation during physical interaction with a robot " – **Vincent Fortineau**, Isabelle Siegler, Maria Makarov, Pedro Rodriguez-Ayerbe

Abstract: Understanding and reproducing the properties of human physical interactions with various environments is an active research topic for security, efficiency and adaptability, notably because of the emergence of interactive robotics – we can cite *exoskeletons*, *medical robots*, *industrial cobots*...

For decades, human motor control has been studied through the lens of control theory and neural sciences to deal with these subjects. The study of human, mechanical impedance and biomechanics allows modelling the relationships between forces and kinematics during physical interactions. Identifying the parameters of such models is still a relevant subject. On the one hand, to observe changes during interactions (fatigue, new operator ...) to improve the control strategies and adapt them to the manipulator, and on the other hand to draw inspiration from human strategies and increase the robustness of robot interactions.

As a continuation of previous work dealing with a benchmark rhythmic task, dynamic considerations were added, with an estimation methodology for human arm impedance during the task using a poly-articulated robot. The aspiration is to measure the human biomechanical behavior seamlessly, then study both the robustness of the task and the interaction with the robot to propose a bio-inspired control strategy.

6. **Title :** "Tactile Internet with Human-In-The-Loop" – **Frank Fitzek**

Abstract: The talk will address the technology needed to build up the tactile Internet. Main focus is on low latency and ultra-reliable communication and how it can be realized in softwarized networks. Current technologies such as 5G are discussed to enable the tactile Internet. Furthermore, the talk will highlight inter disciplinary research on tactile Internet with focus on psychology and medicine building the required human to machine interfaces to have mutual learning between humans and machines

7. **Title :** "Connected Robotics: The Zenoh Way" – **Angelo Corsaro**

Abstract: Robotic applications are increasingly requiring support for efficient and scalable communication to support use cases such as Internet-scale telemetry and tele-operation, swarm coordination/collaboration, and edge offloading. Yet, mainstream robotic platforms were designed for single robot operation and did not necessarily consider these use cases – or at least did not have the full picture of the actual problem space. In this presentation, we will distill the challenges posed by robots connectivity, explain why mainstream platforms such as ROS2 have limited support for these scenarios and show how the combination of **ROS2** and **Zenoh** can be used to address these emerging connectivity needs. We will also show case how these combination provides an entirely open solution used today for extremely high performance telemetry and tele-operation, in the context of autonomous race cars, and in general for swarm robotics.

8. **Title :** "Mitigating faults in Mobile Robotic Swarms" – **S ebastien Tixeuil**

Abstract: This talk will review recent results related to the various kinds of faults that can occur in the context of mobile robotic swarms, be they of hardware, software, or human origin, and what techniques can be used to mitigate them.
