Factory-in-a-day at European Robotics Forum 2017

The eighth edition of the European Robotics Forum will take place in Edinburgh, Scotland, UK from the 22nd till the 24th of March 2017 (http://www.erf2017.eu). Within this context the 4th Workshop on Hybrid Production Systems will take place on March 23rd. The EU-funded project Factory-in-a-day will present two presentations.

This workshop is dedicated to presenting the latest technologies, research results facilitating Human Robot Collaboration (HRC) in an industrial setting, e.g. Applications of augmented reality and wearables, Safety, Interaction, Planning, Simulation, Tele-Operation, etc.

In the first quarter of the workshop early results from ongoing research projects are introduced. Early results are characterized as being developed within the first year of the project and as having been validated as a simple proof of concept in the lab (TRL3). The purpose is to give the researcher/inventor feedback w.r.t. to her/his results, e.g. potential enablers, multiplicators, restrictions, etc.

The second and third quarter of the workshop are dedicated respectively to elaborating developed technologies (TRL 5/6) for intuitive and safe human robot interaction, with a short interlope of actual industrial applications of HRC in between. The purpose is to inform the community of emerging technologies that may soon be available on the market.

Finally, the last quarter will be spent on discussing a joint technology report about the technologies to be submitted to the EC, as part of the joint dissemination effort of the Factories-of-the-Future Cluster on Human-Robot-Collaboration.

Agenda of workshop:

- 10:45 – 10:55 Introduction of Workshop and recap of HPS booth at AUTOMATICA 2016
- 10:55 – 11:15 Early Results (moderated by Inaki Martua)
- 11:15 – 12:15 Interaction Technologies (moderated by Sotiris Makris)
- 12:15 – 14:00 Lunch Break
- 14:00 – 14:15 Applications (moderated by Ramez Awad)
- 14:15 – 15:15 Safety Technologies (moderated by George Michalos)
- 15:15 – 15:30 Discussion of next Steps

Find in the following the list of speakers and brief synopsis of their presentations

<u>Section I: Early Results</u>

Loris Roveda (ITIA-CNR): Empowering humans in cooperative heavy parts installation industrial applications

> *Nowadays, improving/empowering the human capabilities is increasingly required in many industrial contexts. Robotics solutions are pursuing such research direction in order to properly conceive, design and interface robotic devices to achieve this ambitious goal. The presentation will propose novel control methodologies to empower human operators in executing onerous industrial applications improving ergonomy and increasing human-robot cooperation performance (e.g., allowing force-tracking capabilities).*

Amedeo Cesta (ISTC-CNR): A new framework for human-aware planning: integration of robot motion planning, task planning and scheduling

During the last decade, the robot has entered industrial environments and, specifically, production systems with the aim to support humans in their activities. This has led to the definition of new production paradigms to which answer through the development of human-aware techniques. In this context, this presentation describes innovative outcomes from the FourByThree project consisting in new techniques for integrating robot motion planning, task planning & scheduling and their deployment in the project's human-robot collaboration framework. A movie and a discussion of open issues will be part of the presentation.

Stefano Michieletto (University of Padova): People tracking in Industrial Environments

Safety is the main issue when human and robot are working together is the same cell. The presentation will describe a method for enhancing the safety of a workcell with a camera network system covering the environment from multiple view points to minimize occlusions. The proposed algorithm tracks people in the robot working area in order to detect when a person enters a danger zone around the robot. The system is able to enhance the safety granted by collaborative lightweight robots by avoiding possible collisions.

Section II: Interaction Technologies

Nils Andersson (EON Reality Inc.): Using holographic and Augmented Reality techniques for Human/Computer collaboration – with a LIVE DEMO using the Microsoft HoloLens

Within the LIAA project we developed two tools. One is a service for uploading simulation data and exporting them as a smartphone app, which enables system-integrators to discuss robot cell designs with end-users on site at the production line. The other is an editing tool for creating and displaying Assembly Instructions using Augmented Reality. Those instructions re packaged in a ROS node, which can be triggered through its ROS Interfaces. A live demo of the tools using the Microsoft HoloLens will be part of the presentation.

Dr. George Michalos (LMS, University of Patras): ROBO-PARTNER hybrid assembly cell – novel communication & interaction mechanisms - LIVE DEMO using a Smart Watch and HMD on a simulated Robot Cell

The presentation will discuss the implementation of a service based hybrid station controller, responsible for orchestrating and monitoring the execution of human robot cooperative scenarios. The deployed system uses novel hardware and software technologies in order to include the human operator in the execution loop while at the same time increase his safety awareness when working close to the robot. An Augmented Reality application coupled with a smartwatch application as well as the robot's controller have been integrated in the station controller under a ROS based framework. The developed system has been deployed in the automotive and the white goods pilots of the project and it will be demonstrated and discussed during the presentation.

Dr. Fei Chen (IIT): Human and Robot Tele-operated Collaboration in Industrial Assembly and Maintenance Scenario

In industrial environment, there exists a situation that the human worker may not be able to present on-site. The main motivation using a remotely controlled mobile robot is that the human worker can teleoperate the robot to do some simple assembly or maintenance work. A second motivation is that the robot will be able to autonomously carry out the same tasks after it learns from human worker's remote demonstration.

Arne Rönnau (FZI Forschungszentrum Informatik): CAD-2-Path: EuRoC - Intuitive Programming of Surface Trajectories for Complex Objects

We will present our result of the EuRoC Freestyle task showing an simple solution to teach robots complex surface trajectories. The user draws the desired trajectory in 2D with the help of a tablet. This trajectory is filtered and automatically transferred to the CAD model. The robot then follows this surface trajectory with a force based control approach. The user is able to directly adjust the computed trajectory using Programming-by-Demonstration.

Urko Esnaola (TECNALIA): Program Less, Setup Fast, Be Safe

We present a system that aims to make process automation faster, hazardless and more social with robots. In this approach, robots have a set of preprogramed skills. Programming of a new automation process becomes a skill parameterizing task which is done graphically from the CAD models of the assembly parts of the process. Users don´t need to be experienced programmers. This makes possible to program less by more people. AR markers are used to make setup (initial referentiation of the parts) fast. A 3D multi-camera system provides an occlusion-less 3D image of the scene. Using this information robots are able to re-plan trajectories online avoiding collisions and making workers, working near or with the robot, be safe.

Section III: Applications

Edwin Lotter (LP Montage Technik GmbH): Robot-assisted Riveting

A mobile robotic workstation for joining processes, such as riveting. Here human can execute manual difficult work while a robot takes care of repetitive, strenuous tasks as for example placement on pop rivets. The system is integrated into a mobile height-adjustable robot platform and can be docked with nearly every manual workdesk if required. This allows the assembly tasks to be optimally shared according to ergonomic and economic criteria. Safe human-robot collaboration is ensured by the stationary fixture of the riveting tool.

Uwe Müller (InSystems Automation GmbH): Mobile Symbiotic Robot Soldering Unit for human interaction

At this mobile workplace worker and robot can act in cooperation e.g. to apply solder on several boards by executing different tasks. The soldering device is fixed on a light-weight robot UR 10 without any delimiting protection shields. The whole process is secured by retract and surround the soldering iron. So human are prevented from reaching the hot iron surface.

Section IV: Safety

Ramez Awad (Fraunhofer IPA): Design Conceptualization Tool

Algorithm and Software tool for risk assessment of HRC cells during conceptualization phase. It is able to interactively derive the potential hazards from the Bill-of-Resources and suggest suitable safety measures for relevant hazards (where risk is high).

Prof. Gordon Cheng (Technical University of Munich): The artificial skin in Factory-in-a-day

One important aspect of Factory-in-a-day is to provide safe robots (arms and mobile robots). This can be achieved with a novel proximity-sensing skin and dynamic contact-avoiding behaviours, allowing ubiquitous use of robots in shared workspaces with humans. The presentation will explain the advantages and potential of using the self-configuring skin developed by TUM.

Dr. Carlos Hernandez Corbato (TU Delft): Robot software in human-robot collaboration

Given its widespread adoption, ROS can be considered the de-facto standard software framework for service and mobile robotics. It is rapidly expanding into the industrial domain also thanks to initiatives such as ROS-Industrial. Its features are an excellent match for the advanced capabilities required in applications involving human-robot collaboration (HRC). However, the lack of quality assurance for ROS components hinders their use in HRC applications, where the requirements for robustness and dependability are critical given the safety implications. To address this situation, as part of the Factory-in-a-Day (FiaD) project toolbox we developed the Automated Test Framework (ATF). The ATF supports executing integration and system tests, running benchmarks, and monitoring the code behaviour over time. It is one of a number of tools developed within public and private projects with the overall goal to provide better tooling and thus improve the quality and streamline the development & deployment process of ROS-based robotics software.

Nicola Pedrocchi (ITIA-CNR): Modular composition of HRC applications using industrial standards

Fast deployment and reconfigurability of HRC applications are key figures for the success of collaborative experiences. Using either well established industrial standards or de-facto domain-specific standards, we show the composition of complex tasks by assembling modular logical blocks. The key properties are the separation between logic and physical resources applying such logic, e.g. changing hardware and directly redeploying the tasks; the event-based architectures coupled with closed-loop controls; the coordination of multiple concurrent tasks to be scheduled/planned; integration of smart interfaces for intuitive workflow management.

Christian Vogel (Fraunhofer IFF): Safe Human-Robot Cooperation with High-Payload Robots in Industrial Applications - SAPARO

The presentation introduces and describes an innovative and trendsetting solution for safeguarding collaborative human-robot workplaces with high-payload robots through a combination of safeguarding technologies addressing both hard- and soft- safety considerations. This consists of a tactile floor with spatial resolution as a hard-safety sensor for workspace monitoring together with a projection system as a soft-safety component to visualize safety-, process- and robot-specific information. The generation of safety zones is based on the approach formula described in ISO TS 15066 that incorporates not only the current robot's joint angles and velocities but also the current human's behaviour.