European Robotics Forum 2015 – Workshop Digest

12th of March, 08:30 – 10:00 (Room 3)	
Session Title:	**Flexibility and dexterity in industrial robots: Demonstrators of new frontiers in industrial applications**
Organiser(s):	Dr. Ferdinando CANNELLA, IIT, Italy ferdinando.cannella@iit.it Dr Sotiris MAKRIS, LMS – University of Patras, Greece, makris@lms.mech.upatras.gr Dr. Matteo ZOPPI, University of Genoa, Italy zoppi@dimec.unige.it
Content:	The increasing need for High Mix and Low Volume production pushes the industry to investigate new solutions for increasing flexibility. Radical changes can be achieved by introducing autonomous production/handling units which can change task (from joining to handling and vice versa) and position (around the shop floor), eventually cooperating among themselves, reacting quickly to stoppages and reducing losses as much as possible. Technologies in this direction involve: - Reconfigurable tools to enable autonomous and flexible assembly equipment to adapt production process to process/market variations, - Intelligent, Control & Monitoring systems enabling enhanced performance and high level re-configurability of production processes - Open integration & communication architectures to allow easier integration and networking of the control systems utilizing agent-based, web-services and ontology technologies. This workshop will focus on presenting the latest advances in these topics, ranging from flexible grippers, dexterous robots and intelligent decision making software, aiming at concluding to challenges for the future.
Agenda of the workshop:	08:30-08:35: Introduction 08:35-09:45: Project Presentations 09:45-10:00: Round Table Discussion on Industrial robots needs on Dexterity and flexibility
Speaker(s):	Dr. Ferdinando CANNELLA, IIT, Italy Dr. Sotiris MAKRIS, LMS-University of Patras, Greece, Prof. Rezia MOLFINO, UNIGE, Italy Mr. Aldo BOTTERO, COMAU, Italy Dr. Damien SALLE, TECNALIA, Spain Dr. Dragoljub SURDILOVIC, Fraunhofer IPK, Germany, Control Dr. Fei CHEN, IIT, Italy
Further information:	Link to relevant projects: • AUTORECON: http://www.autorecon.eu • X-act: http://www.xact-project.eu • Tomsy project: http://www.cas.kth.se/tomsy/ • SwarmItFIX: http://www.swarmltfix.eu
Workshop website link:	http://www.iit.it/it/aia-news.htm

PROGRAM

- Introduction by the moderators, **Dr. Ferdinando CANNELLA, IIT, Italy**
- Cooperating robots in manufacturing environment, **Dr. Sotiris MAKRIS, LMS-University of Patras, Greece,**
- Multi-agent and swarm fixturing and manufacturing in aeronautics, **Prof. Rezia MOLFINO, UNIGE, Italy**
- Adaptive, Camera Based approach for User Frame Determination in Industrial Robotic Application, **Mr. Aldo BOTTERO, COMAU, Italy**
- Robotics for flexible manufacturing system, **Dr. Damien SALLE, TECNALIA, Spain**
- Force/impedance based dexterous manipulation for assembly applications, **Dr. Dragoljub SURDILOVIC, Fraunhofer IPK, Germany, Control**
- Development of a Metamorphic Robotic Hand and Its Applications, **Dr. Guowu Wei, KCL, Research associate**
- Dexterous Manipulators: from Consumer Goods to Automotive Applications, **Dr. Fei CHEN, IIT, Italy**

ABSTRACTS

Introduction by the moderators, Dr. Ferdinando CANNELLA, IIT, Italy

Nowadays, in the manufacturing factories one of the main tasks is the manipulation and assembling; these operations are organized like a sequence of manual and automated procedures repeated each cycle time. For increasing the productivity they are the most suitable and optimized. The efficiency is guaranteed only for the maximum capacity or considering no halt situation due to technical problems. In case of need to mix in the same plant assembly operations of either different products at the same line or even different models of the same product then the complexity increases dramatically. To overcome of this limit one of the solution can be to increase the reconfigurability of system that adapts to different handling and assembling. This objective will be reached by the reconfigurability: the key point of this solutions are the transformers like tools that enable autonomous flexible assembly equipment to easily adapt the production process to process disturbances and market variations.

Cooperating robots in manufacturing environment, Dr. Sotiris MAKRIS, LMS-University of Patras, Greece,

This presentation discusses the key features of cooperating robotic cells in the assembly of customized products. Existing production paradigms use fixtures and ground conveyors for the fixing and transportation of parts. These elements need to be replaced when product changes take place and the reconfiguration of an assembly cell is not possible without physically relocating these resources. In a more flexible approach, robots can be engaged in a cooperative operation among themselves and are able to recover from failures in any robot/tool by switching position/job. They may also be auto reconfigured in order for the tools and the line to answer quickly to potential production changes. The main issues, affecting the performance of cooperating robotic cells, are discussed with the aid of industrial case studies where different forms of cooperation have been applied.

Multi-agent and swarm fixturing and manufacturing in aeronautics, Prof. Rezia MOLFINO, UNIGE, Italy

***Purpose**: While the use of thin sheets with 3D geometries is growing in quantity due to current trends towards life-cycle design and sustainable production; and in geometrical complexity due to aesthetic and quality issues, the manufacturing equipment is not growing in flexibility in parallel with the same trends. The new reconfigurable fixture is proposed to shorten this gap*

***Design/Methodology/Approach:** The new concept of self-adaptable swarm fixtures composed of mobile agents that can freely move on a bench and reposition below the supported part behaving as a swarm, all without moving/removing the part from the fixture has been developed by adopting a multi-disciplinary, life-cycle approach. Modularity and eco-sustainability paradigms addressed the design work.*

***Findings:** The performance of the physical prototype in an industrial scenario, concerning the reconfigurability actions and the accuracy of the manufacturing operations performed on typical thin sheets used in aeronautical industry is satisfactory*

***Research limitations/implications:** Coordination between the machine-tool numerical control and the fixture control is not complete and its improvement will make more robust and autonomous the manufacturing process*

***Practical implications:** The system reduces the number and inventory of the fixtures in the shop floor. Respect to any other reconfigurable fixture this is smarter, more flexible, lighter and presents shorter reconfiguration time, easy set-up, good adaptability to large shape ranges and to different shapes of the part to support.*

***Originality/value:** This idea is breakthrough, suggested by the need of hyper-flexible and adaptable to different thin sheet shapes fixtures with full respect to the sheet geometry. The value is great and great for production of mass customized and small series products.*

Adaptive, Camera Based approach for User Frame Determination in Industrial Robotic Application, Mr. Aldo BOTTERO, COMAU, Italy

The interest for mobile industrial robotics is growing. One big obstacle in developing and deploying applications with standard industrial manipulators placed on mobile platforms is the extreme uncertainty in defining accurately the cell's frame position and orientation. Without an extremely accurate cell's frame calibration, "Ontology based", off-line programming of "blind" industrial manipulators can never work. The vision technology is good for visual servoing or for "look and move", "look and grasp" applications, but not for extremely accurate cell's frame automatic calibration/learning.

COMAU Robotics developed an adaptive, camera based, calibration procedure for cell's frame localization and cell alignment, using an iterative "look and move" procedure. The cost of this calibration procedure, that proved to be effective, is the calibration time.

Extreme adaptation always costs cycle time.

Robotics for flexible manufacturing system, Dr. Damien SALLE, TECNALIA, Spain

Even if robotics and vision have been used for many years, there are still a huge number of tasks that remain performed manually, due to their complexity, the size of the components or the lack of profitability of a standard robotic cell when there is a large number of product variants to produce or a very small production batch size. The aeronautic sector is a clear case of low penetration of robotics.

Tecnalia is developing a solution to these flexibility issues, combining single or dual-arm robots with advanced perception and auto-programming techniques.

The talk will illustrate this solution with real examples of the flexible automation pilot cell co-developed between Tecnalia and Airbus Puerto Real, based on a humanoid torso robot achieving aeronautics assembly tasks.

Force/impedance based dexterous manipulation for assembly applications, Dr. Dragoljub SURDILOVIC, Fraunhofer IPK, Germany, Control

Dexterous manipulation includes multiple robotic arms and/or fingers that cooperate to grasp and manipulate objects. Flexible manufacturing requires increased dexterity of robots. Using force and impedance control, by integrating force sensing technology in fingers and robot joints, allows to compensate for uncertainties in part placements and fixturing, and supports skilled manipulation required to assembly complex parts, usually performed manually by human.

The short talk presents force/impedance based control algorithms for dexterous assembly with single and dual-arm industrial robots. Novel applications with articulated hands will also be addressed. A specific focus is on programming and robust execution of complex assembly tasks. Several examples, implemented in industrial robot systems with open control, demonstrate the current capability of advanced robot control in performing dexterous manipulation in comparison with the human, and identify future development needs.

Development of a Metamorphic Robotic Hand and Its Applications, Dr. Guowu WEI, KCL, Research associate

Based on the principle of metamorphosis, a metamorphic robotic hand with a reconfigurable palm has been invented and developed at King's College London and University of Salford which is capable of implementing flexible manipulation in an augmented workspace.

Compared to the traditional robotic hand designs which mainly focus on the design of the fingers, the metamorphic hand considers design of both palm and fingers. The novelty of the metamorphic hand lies in the design of a reconfigurable palm leading to a dexterous hand that is capable to change its structure, topological configuration and mobility for performing a large range of grasping and manipulations with the changeable and foldable palm that makes the hand more dexterous and reconfigurable.

With the articulated reconfigurable palm, the metamorphic hand not only has the intrinsic merits of foldable, contractible and expendable, but also gives additional dexterity, adaptability and manipulability in comparison with

the current robotic hands. Under the under-actuated scheme, the metamorphic hand is a light-weight hand with the capability of providing stable gasping and manipulation of various objects including those in the unstructured environments, where object properties are not known and sensing is prone to error. This robotic hand has been used in three EU FP7 projects.

Dexterous Manipulators: from Consumer Goods to Automotive Applications, Dr. Fei CHEN, IIT, Italy

High flexibility and high speed is the dreamed gripper for industrial applications. The reason is that, currently, when one of the two characteristics increases, the other one decreases, because the reconfigurable complexity is time consuming. In this presentation a new idea of gripper is presented: thank two degrees of freedom per finger is high flexible and strong for several industrial applications; at same time the simple kinematics permits to be fast in the reconfigurability. Inserting this kind of devices in the factory plants, there is an increasing of the flexibility of the assembly operations and that transforms the fixed special purpose automation to the flexible automation. Moreover the fingers can be used as modules, because their number can be adapt to the application requirements.