Full-day Workshop on
IC³ - Industry of the future: Collaborative, Connected, Cognitive.
Novel approaches stemming from Factory of the Future & Industry 4.0 initiatives
Workshop Objectives

This workshop will trace the current trends in manufacturing with the expected impact of promoting safety at work, increasing efficiency and competitiveness, and improving the eco-sustainability of industrial processes.

Keywords

Industry 4.0 and Factory of the Future;
Collaborative, connected and cognitive robots for manufacturing industry;
Wearable robots to reduce fatigue and increase safety of workers;
Health & safety at workplace;
Eco-sustainability of industrial processes;
Aerial, ground and marine robotic vehicles;
Disassembly and dismantling.
Why IC³?

Because the industry of the future will be:

**Collaborative**
Robots are out of the fences and can safely interact with humans; human-centered factory; bio-automation

**Connected**
Internet of things; factory in cloud; remote access to productive processes; remote maintenance; personalized products; lot-1 production

**Cognitive**
Product quality; zero defects; virtual metrology: combining physical inspections and virtual analysis; predictive maintenance and supply chain
Organizers

Organizers from Academia

**Paolo Dario** Scuola Superiore Sant’Anna
Professor of Biomedical Robotics,  
Director of The BioRobotics Institute of Scuola Superiore Sant'Anna, Pisa, Italy,  
IEEE Fellow, IEEE RAS Past President

**Alois Knoll** Technische Universität München  
Professor of Computer Science,  
Head of the Robotics and Embedded Systems Group,  
IEEE Senior Member

**Lakmal Seneviratne** Robotics Institute Khalifa University, Abu Dhabi, UAE  
Professor of Mechanical Engineering,  
Associate Vice President for Research,  
Director of the Khalifa University Robotics Institute (KURI)

Organizers from Industry

**Massimo Maffei** Piaggio & C. S.p.A.  
Vice President Manufacturing Technologies and Infrastructure-Facilities Manufacturing Technologies,  
Piaggio & C. S.p.A.

**Arturo Baroncelli** Comau S.p.A.  
COMAU Robotics Business Development Manager,  
Past President and present member of the Board of the International Federation of Robotics (IFR),  
Member of the euRobotics AISBL Board of Directors
Invited speakers

Yannick Morel
Research Associate
Robotics and Embedded Systems
Technische Universität München, Germany
Project Manager of the European Horizon 2020 Echord++ project

Maria Chiara Carrozza
Professor of Biorobotics
The BioRobotics Institute
Scuola Superiore Sant’Anna, Pisa, Italy
Member of the Italian Parliament

Henrik I. Christensen
Professor of Computer Science
Department of Computer Science and Engineering
University of California, San Diego, USA
Director of the Institute of Contextual Robotics
Industry 4.0

A new model of automation and data exchange in manufacturing technologies.

Source: Italy’s Plan Industria 4.0, Italian Ministry of Economic Development
Manufacturing: key to economy

- Europe, as well as all world economies, recognises relevance of manufacturing to overcome crisis & create new opportunities for growth and jobs

- Manufacturing important for Europe:
  - 14% direct jobs
  - 67% exports
  - 65% business R&D expenditure

- 20% of GDP from industry is the goal of Europe 2020

- Development of more competitive & sustainable EU industry needs support

Design Principles of Industry 4.0

- **Interoperability**: Cyber physical systems/humans connecting and communicating with each other via the IoT/loS (Services)
- **Virtualization**: Creating virtual copy of everything while linking to physical systems and humans
- **Decentralization**: CPSs/humans making decisions on their own
- **Real-Time Capability**: Collecting and analyzing data and providing derived insights in real-time
- **Service Orientation**: Offering services via the IoS
- **Modularity**: Flexible adaptation to changing requirements
  \[\Rightarrow\] Self-optimization, self-configuration, self-diagnosis, cognition and intelligent support of workers
- All good. Lessons from history?

Courtesy of Peter B. Luh
Keynote talk on “Industry 4.0 – Automation and Robotics” @ICRA 2017
Key Technologies of Industry 4.0?

- **IoT infrastructure**
  - Sensing and communication technologies
  - The cloud and edges; Cyber and physical security
  - Big data analytics, ..

- **Integration**
  - Vertical and horizontal system integration
  - Cyber, physical and human integration, ..

- **Disruptive Technologies**
  - 3D printing
  - Robots
  - Virtual metrology
  - Optimization
  - ...

Courtesy of Peter B. Luh
*Keynote talk on “Industry 4.0 – Automation and Robotics” @ICRA 2017*
Robotics

- Robotics empowered by Industry 4.0?
  - Decentralized intelligence, machine learning, and real-time data/computation power to boosted performance/flexibility

- Major advances:
  - Cloud robotics/Internet of Robotics
  - Collaborative robotics; Drones

- Challenges:
  - Technical issues addressed at ICRA’17
  - Empowering robots with Industry 4.0 and vice versa
  - Ethics: Unemployment + robotic weapons
"...robots used to operate inside closed cages and kept separated from workers, namely within different areas. In the Industry 4.0 scenario, workers and robots will cooperate inside common spaces, instead, and the robot will become a work-mate and will not be anymore a potential replacement..."
Survey on Benefits of Industry 4.0

Keynote talk on “Industry 4.0 – Automation and Robotics” @ICRA 2017

Optimization. Also, decentralization with self-optimization!!

Industry 4.0 – Building the Digital Enterprise, PWC, 2016

Optimisation of overall business planning and controlling
Better manufacturing / operations planning
Improvement of customer relationship and customer intelligence along the product life cycle
More efficient asset utilisation of operational efficiency
Development of new or optimisation of existing products/services
Increase of sales revenue
Optimisation of transport and logistics costs / efficiency
Improved product or process quality
Efficient maintenance / service of own assets or customer products
Better cooperation and decision-making with partner companies

Status quo Growth potential in 5 years
The major transnational programmes of Industry 4.0: Europe

Main European Commission initiatives related to Industry 4.0

- SPARC, the Public–Private Partnership for Robotics in Europe (EuRobotics community)
- Factory of the Future, the Public–Private Partnership for Manufacturing in Europe (ManuFuture platform)
To realize the robotics revolution in Europe
→ Maximize benefits for Europe, its Economy, its Society, its Citizens
Public–Private Partnership in Robotics

Mutual Commitment: €2.8Bn - 2014-2020
Mission

Manufuture mission is to propose, develop and implement a strategy based on Research and Innovation, capable of speeding up the rate of industrial transformation to high-added-value products, processes and services, securing high-skills employment and winning a major share of world Manufacturing output in the future knowledge-driven economy.

5 Pillars

1. New Added Value Products and Services
2. New Business Models
3. Advanced Industrial Engineering
4. Emerging Manufacturing Science and Technologies
5. Infrastructures and Education

The major national programmes of Industry 4.0: worldwide

**United States of America**
*Manufacturing USA*
Network of institutes and laboratories of excellence, to promote the diffusion of technology and competences, made of great private ICT groups and universities, promoted by the Government and financed by a public-private partnership.

**China**
*Made in China 2025*
- Applying the tools of information technology to production
- Upgrading Chinese industry, making it more efficient and integrated
- Raising domestic content of core components and materials to 40% by 2020 and 70% by 2025
- Supporting the creation of manufacturing innovation centers (15 by 2020 and 40 by 2025)

**Singapore**
*Industry Transformation Programme*
- The ITP aims to support Singapore's small- to medium-sized enterprises (SMEs) grow and compete internationally at a time when they face global economic headwinds and domestic constraints.
- The S$4.5 billion programme was designed to be targeted in order to better meet the needs of firms in each sector

**Korea**
*Innovation in Manufacturing 3.0*
Investment: 200 billion [US$172 million] annually
- Enabling customization and optimization of smart factories
- Enhancing manufacturing industry’s competitiveness.
- Building 1,500 smart factories by 2020
- Supporting local SMEs with a view to disseminating smart factory technologies
The major national programmes of Industry 4.0: Europe (focus on Italy on next presentation)

**UK**
CATAPULT – High Value Manufacturing
Strategic plan underpinned by the government and by the University’s Institute For Manufacturing which encompasses universities and industrial players
Main initiatives:
- Project financing and applied research

**France**
Industrie du Futur
Central Government steering the process which involves investing in technologies and devising industrial strategies compliant with I4.0 guidelines
Main initiatives:
- Fiscal benefit for private investments
- Facilitated financing for SMEs
- Tax credit for research expenditure
- Project financing including: "Industrie du Futur" and "Invest for the future"

**Germany**
Industrie 4.0
Strategic plan shouldered by the federal government and with the involvement of the main firms in the industrial and technology sectors
Main initiatives:
- Project financing and applied research
- Tax incentives bestowed to investments in hi-tech start-ups

**Netherlands**
Smart Industry
“A network centric approach” aiming at beefing up the traditional industrial system through the opportunities stemming from the I4.0 strategy, involving: FME², TNO³, Ministry of Economic Affairs, VNO-NCW⁴ and Chamber of Commerce

Source: Italy's Plan Industria 4.0, Italian Ministry of Economic Development
08:30 - 08:45 Welcome
Objectives of the Workshop
Paolo Dario

08:45 - 10:00 Session 1
Selected case studies of Industry 4.0 and Factory of the Future initiatives
Paolo Dario
Yannick Morel
Lakmal Seneviratne

10:00 - 10:30 Coffee break and networking session

10:30 - 12:10 Session 2
Industrial cases
Arturo Baroncelli
Massimo Maffei
Henrik I. Christensen
Maria Chiara Carrozza

12:10 - 13:30 Lunch break and networking session
13:30 - 14:30 Session 3
Oral presentations of papers solicited via call for papers

14:30 - 16:00 Session 4
Poster teasers of papers solicited via call for papers
Coffee break, poster viewing and networking session

16:00 - 17:00 Session 5
Round table discussion and closing remarks

17:00 End of the Workshop
Session 1

08:45 – 10:00 Introduction

08:45 – 09:10 Industry 4.0 and Factory of the Future initiatives in Europe: focus on Italy (Paolo Dario)

09:10 – 09:35 Industry 4.0 and Factory of the Future initiatives in Europe: focus on Germany (Yannick Morel)

09:35 – 10:00 Automating machining and assembly tasks for large aeronautic structures: scientific and technological challenges (Lakmal Seneviratne)

10:00 - 10:30 Coffee break and networking session
Session 2

10:30 - 12:10 Industrial cases
10:55 – 11:20 Example applications of Collaborative, Connected and Cognitive Robotics in the motor vehicles industry (Massimo Maffei)
11:20 – 11:45 The API (Application Programming Interface) Economy (Henrik I. Christensen)
11:45 – 12:10 The collaboration between Ericsson and Scuola Superiore Sant’Anna towards Industry 4.0: the case study of 5G Tuscany (Maria Chiara Carrozza)

12:10 - 13:30 Lunch break and networking session
Session 3

13:30 - 14:30 Oral presentations of papers solicited via call for papers


2. Schauer, J., Nüchter, A., “Digitizing automotive production lines without interrupting assembly operations through an automatic voxel-based removal of moving objects”


14:30 - 15:00 Oral presentations [Poster teasers] of papers solicited via call for papers


15:00 - 16:00 Coffee break, poster viewing and networking session
Session 5

16:00 - 17:00 Round table discussion and closing remarks

17:00 End of the Workshop
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