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Digital Innovation Hubs for Enhancing the Technology Transfer and Digital Transformation of the European Manufacturing Industry

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Abstract. The European manufacturers are dealing with shorter product life-cycles and smaller batch sizes. Especially, the high-value products tend to be fully personalised, which makes the automatisation of the production difficult. However, the trend is that the production needs to be predictable and fully traceable to the process and even to the tool level. This adds pressure to have better data collection methods and also to increase of automation in different levels of production. The emergence of new technologies in the field of robotics allows the utilisation of automation in flexible manner. Within all areas of robotics, the demand for collaborative systems is rising as well. The level of desired collaboration and increased flexibility will only be reached if the systems are developed as whole e.g. perception, reasoning and physical manipulation. However, at the same time there is concerns on how to attract capable personnel to the factories. In order to fully implement and utilise the new robotics technologies the industry needs capable resources. For answering these needs there has been several attempts to build different types of industrial ecosystems to facilitate better the technology and knowledge transfer, and share of expertise. The main aim of the paper is to review recent actions regarding the robotics projects forming industrial ecosystems in the Horizon 2020 framework programme, and then introduce the TRINITY Digital Innovation Hub (DIH) project approach to form an industrial ecosystem in the field of robotics.

Keywords: Digital innovation hubs · Robotics · ICT · Skills

1 Introduction

The demand for industrial robots (market) is anticipated to be growing to 65 billion Euros by the year 2023 [13,31,34]. At the same time there is a rising need for more flexibility and collaboration with robots and humans in the factory floor. The need for collaborative robots in the automation industry is acting as

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a driver for this market and is expected to serve as a market opportunity for future growth. In addition, various countries across the world are reviving their electronics and consumer goods industry, which is in turn contributing to the growing demand for collaborative robots. The continued rise of industrial robots certainly seems to be an inevitability being driven by a variety of production demands, including the need for safer and more 'simplified' robotic technologies to work in collaboration with humans, increased resource efficiency, and continued adaptation to the proliferation of automation and the IoT [13,31].

The use of industrial robots in large manufacturing companies is generally well established and understood. However, In 2015, enterprises employing fewer than 250 persons represented 99% of all enterprises in the EU. In manufacturing the SMEs employ 57% of workforce [11]. In order to stay competitive, smaller scale and SME manufacturing need to embrace smart robotics to maintain efficiency and create jobs. Raising the output and efficiency of SME manufacturers will have a significant impact on Europe's manufacturing and employment capacity. In turn this will increase overall employment as companies expand into markets considered inaccessible given Europe's comparative labour costs. Increasingly Europe will not only be competing against low wage economies but also, increasingly, highly automated ones. Leadership in secure robotics technology will be a key differentiator of market share in many sectors.

1.1 Emerging Robotics Trends

The term 'robot' has also been undergoing a major change in the recent years. Robots are no longer standalone operation units such as in the 80's. Today a robot is a part of a bigger system with multiple interfaces and related components such as flexible fixtures and grippers. Robots receive commands from the internet and may even have no fixed sensors on their mechanical body, rather a combination of external sensors providing feedback to the mechanical system directly or indirectly. The term 'robot' includes digital aspect, as robots embedded in cars/consumer electronics/mobile phones and any electronic appliances that can communicate through internet or other wired/wireless communication. This offers a huge business potential [20]. The next-generation robots that have the potential to realise agile production processes are based on transformation of industrial robots to something that everyone can accept, understand, and utilize [13].

Human safety raises an issue. The footprint of the safety protected robot cells are large, and static safety measures prevent reconfiguration of the cells, thus reducing the efficiency of work, especially small batch-size production. Noteworthy, the human-robot interaction research has been focusing world-wide on small, "human friendly" robots or inherently safe robot systems, such as Kuka iiwa, ABB YuMi and Baxter [6]. However, the future robotic systems will need carry also large loads with long reach to serve better the European manufacturing industry [15]. These systems are designed to carry large loads with maximal speed and a long range and at the same time the systems need to be highly re-configurable [22] and adaptable to changing customer needs [27]. The level of desired collaboration and increased flexibility will only be reached if the systems are developed as a whole including perception, reasoning and physical manipulation. Industrial manufacturing is going through a process of change toward flexible and intelligent manufacturing, the Human-robot collaboration (HRC) will have a more prevalent role in future [26].

Traditionally fences prevent the operators from moving into the robots' working area. This evolution means breaking with the established safety procedures as the separation of workspaces between robot and human operator is removed [18]. Also due to economic reasons, there is a need to decrease the factory footprint, allow existence of shared workplaces, and maintain and reconfigure the production environment while production is running [15,36]. Hence, when considering especially the large-sized robots with significant mass of inertia, all sensory solutions that help robots react to danger are useful now, not just years from now.

1.2 Ecosystems

Based on the discussion and vision papers from the European technology platforms and communities, the innovation ecosystems will play major role in future research, development and innovation developments. In the visions the ecosystems are expected to contribute to economy and business creation from advanced technologies, building of innovation ecosystems, and facilitating the skills development in Europe [2,25].

Big Data Value Association and euRobotics [2] in their joint vision expect Innovation Ecosystems to have following features:

- European focal point for exchange and coordination of the AI, Data and Robotics innovation communities
- National and regional alignment
- Engagement of Stakeholders

Manufacture Vision 2030 [25] described the future manufacturing ecosystems to be complex, multi-facetted, highly networked and, dynamic socio-technical system. The emerging technologies such as Artificial Intelligence (AI) and Digital Security and Connectivity increase the vertical and horizontal integration, considering the whole life cycle of manufactured products. Physical products and service offerings are fully integrated into the lifecycle, including design and engineering, embedded systems, process support systems, production technology and support services. AI will enable increased levels of automation and human interaction, while Cyber Security will be a prerequisite for global collaboration and interaction. In this broad ecosystem, the manufacturing impact and strategic importance can be measured in terms of value added and created direct and indirect jobs.

1.3 Future Skills

In small and medium-sized enterprises (SMEs), training needs arise from the increased use of modern digital manufacturing tools, cybersecurity new additive manufacturing processes and novel engineering of intelligence solutions. As a direct result, workers need to develop new skills and competences to work effectively [16]. From an educational perspective. It is especially critical that people with few prior successful experiences in fully applying the key information-processing skills should obtain adequate comprehension to guide them in structural changes in their future working lives. Human capital is the main enabler for adopting the emerging technologies such as robotization and digitalization [23]. However, the number of science enrolments and graduates in Europe has been slowing down over the last decade, declining from 24.3% in 2002 to 22.6% in 2011 according to Eurostat. The males still predominate the field of engineering, by representing more than 80% of graduates in particular in the fields of computing and engineering [10].

The key challenge in addressing the evolution of future education in the manufacturing sector involves developing skills and expertise as well as pedagogical and technological approaches that match the changing needs of today's and future workplaces [3,25]. While the discussion is indeed about the skills gap and how to improve existing skills, there is little attention paid to demographics. The population of Europe is not growing, and the decrease is expected to start around 2040–2050 in Europe [14].

2 Review of Digital Innovation Hubs in Robotics

The Digital Innovation Hubs are expected to have both a local and European functioning. Member States will be expected to co-invest in the hub through funding the facilities and services with a local impact in their regions/country, whereas the European dimension (opening up the facilities to all of Europe and importing missing expertise) will be funded through a grant of Digital Europe. The main reason for developing the DIH concept is to facilitate the digitalisation of the European industry. The level of digitalisation of industry remains uneven, depending on the sector, country and size of company. Many organisations still struggle to make the most of digital opportunities due to lack of knowledge or difficulties to find finance [9]. The need for enhanced technology transfer is highlighted in both ManuFuture [25] and EuRobotics [2] Vision documents.

During the H2020 Framework Programme several Digital Innovation ramp-up projects were funded. The Fig. 1 shows the list of funded and/or currently running project. The state of the art review is based on material found from Cordis database [4]. The keywords used to find robotics projects were "robot", "robotics", "fstp", "cascade", "re-configuration", "automation". The search was limited projects in Horizon 2020 programme within the H2020 Industrial Leadership - Leadership in enabling and industrial technologies - Information and Communication Technologies (ICT).

Based on the review there is a number of Digital Innovation Hubs emerging offering funding for SMEs with slightly different manners. The projects maturity level is defined by the call, which is Innovation Action. The expected technology readiness level (TRL) is mainly between 5 and 7, where the TRL5 stands for

Robotics Projects	RIA/IA/CSA	Theme in Rbotics	run-time	budget	No. Of Partners	No. Of regions	FSTP	Open Calls	Funding size	Vouchers	Multi-stage	Challenges	No. Expriments/demos	Digital platforms	investments	Match-making	Market Place	Digital Access Point	Toolkits	Catalogs	Tutorials	Training material
TRINITY	IA	Agile Production	2019-2022	16 335 949	16	14	8 100 000	2	50-300k€				50	ROS/ROS2		X		X		X	X	X
DIH^2	IA	Agile Production	2019-2022	16 834 085	36	36	8 000 000	2	50-300k€	X	X		26	FIWARE, COPRA-AP, IDS, ROSE-AP		X	X					X
agROBOfood	IA	Agriculture and Food production	2019-2023	16 658 045	39	39	8 000 000	3	50-300k€	N/A	N/A	X	N/A							X		X
HERO	IA	Helthcare	2019-2022	16 084 675	16	16	8 000 000	2	50-300k€	X						X						X
RIMA	IA	Inspection & Maintenance	2019-2022	16 048 605	13	13	8 104 546	2	50-300k€				50			X	X			X		
RobotUnion	IA	Robotics solutions cross-domain	2018-2020	8 074 961	13	12	N/A	2	10-200k€	X			20		X	X						
ESMERA	IA	Robotics solutions cross-domain	2018-2020	7 999 998	7	7	4 000 000	2	50-100k€			16	32								X	X
COVR	IA	Safety	2018-2021	10 705 434	5	5	6 400 000	3	60-100k€				60-80						X			
micro-ROS	IA	Embedded robot components	2018-2020	3 877 451	5	5	N/A	N/A	50-200k€				N/A	FIWRE,ROS2							X	X
L4MS	IA	Robotics & Logistics	2017-20121	8 764 550,00	15	14	3 000 000	2	10-250k€	X	X		23			X	X			X		
ReconCell	IA	Reconfigurable automation	2015-2019	6 306 457	9	9	N/A	2	50-150k€				6	ROS			X			X		
Horse	IA	flexible automation & robotics	2015-2020	8 851 778	15	9	N/A	2	50-150k€			3	7	OSGI, BPM, ROS		X		X	X			X
DIHNET	CSA	coordination	2018-2021	997 812	6	6	-															
RODIN	CSA	coordination	2019-2023	1 995 880	5	5	-															

Fig. 1. The analysis of DIH activities within past 5 years

'technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)' and TRL7 for 'system prototype demonstration in operational environment'. In some cases the demonstrations can reach TRL 8 e.g. demonstration called in RobotUnion [32]. Most of these are dedicated to publish smaller demonstrators that include training and set-up material to be used by companies later on. The Horse [19], L4MS [24] and Reconcell [29] were funded under ICT Innovation for Manufacturing SMEs (I4MS) where the special focus was on robotics applications. ESMERA [12], COVR [5] and RobotUnion [32] had the special focus on System abilities, SME and benchmarking actions, safety certification. The TRINITY [35], DIHsquared [7], agROBOfood [1], RIMA [30] and DIH-Hero [17] were funded under H2020 Industrial Leadership with the focus on building Digital Innovation Hubs for Robotics, with the special request for developing a marketplace and community for disseminating and exploiting results post-project. The Coordination and Support Actions (CSA) RODIN [33] and DIHNET [8] are mentioned as they intent to facilitate the collaboration among the cascade funded projects.

3 Trinity DIH - Concept and Approach

The main objective of TRINITY is to create a network of digital innovation hubs (DIHs) composed of Research Centers and University Groups specialised in Advanced Robotics and Internet of Things (IoT), supported by a DIH with experts in Robotics Cyber security to contribute to novel robotics solutions that will increase agility in production. The second objective is to continue this network after the ramp-up phase, by building a sustainable business model throughout the project lifetime. The third objective is to deliver a critical mass of use case demonstrations in collaboration with industry to support the industrial modernisation leading to more agile production and increase the competitiveness of

European companies. The modular and reconfigurable use case demonstrations will show how to combine robotics, IoT and Cybersecurity together. Furthermore, TRINITY will contribute to answer the European Industry demand for advanced, highly flexible and collaborative robotic solutions to keep companies competitive. TRINITY aims to bring together top researchers and industry from all over Europe with the objective of developing new, digital and human oriented robotic technology for improving agility of European manufacturing and innovation capabilities.

3.1 Use-Case Demonstrations

The TRINITY-project aims to deliver 50 use-case demonstrations to the market. Each of the demonstrations include different technical solutions, called modules. 20 of these are internal demonstrations that are openly disseminated. Part of these demonstrations are fully open source. The idea is that each module interfaces are described as public specification document. Each internal use-case demonstration module will in the end include set-up tutorials and training material associated to that particular technology.

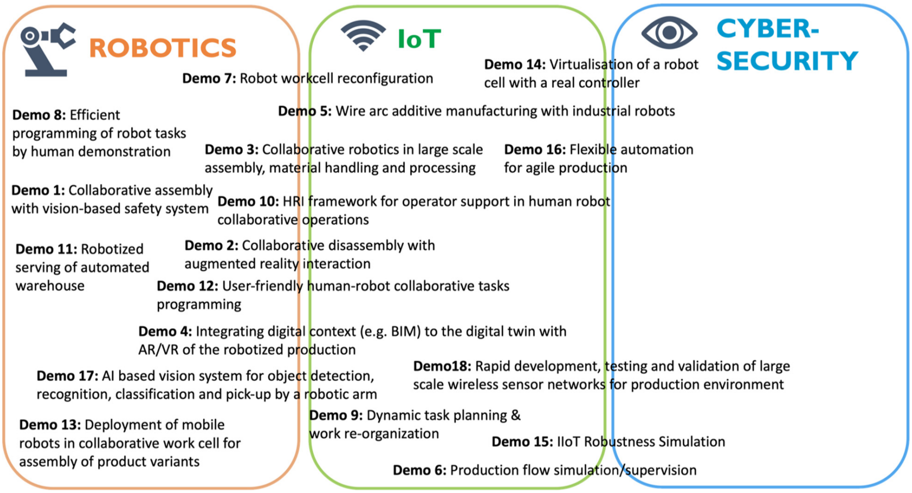

Fig. 2. The positioning of internal use-case demonstrations in the TRINITY project

The approach for building use-case demonstrations is divided into 4 stages.

- The first 12 months of the TRINITY was dedicated to the research and development of the internal use case demonstrations. This stage ensured that the project'a Internal demonstrations meet the market requirements and are appealing to the small batch and mainstream manufacturing and robotics sectors.

- The internal use case demonstrations and their modules will be enhanced and modified to fit the companies interests during year 2. Extensive testing will be carried out in all aspects related to the performance, effectiveness, deployability, and safety. This year is dedicated also for running the first open call and development of business plan for DIH and individual exploitable results.
- In the third phase the new demonstrations from the open call will be included to the digital catalog the TRINITY develops for marketing and dissemination purposes. This is expected to increase the visibility of possible robotics-related solutions among SMEs. During this year the second open call will be started.
- The final phase includes the finalisation of education management system and second round of 3rd party use-case demonstrations will be in the main focus. The results from both of these will be assessed and included to the business planning of DIH, internal demonstration and 3rd party demonstrations.

3.2 Concept for Approaching the Industrial Partners

The project aims to attract the new industrial companies by offering funding opportunities via open calls. The main aim is bring together partners who have not collaborated previously but wish to try collaboration in a European wide scheme. The open call for demonstrations is done in collaboration with participating cluster organisations and with an external advisory board in order to ensure that the maximum number of companies around Europe are reached. The consortium members will set up several web lectures on how to apply for funding for the demonstrations. It is expected that in the first open call there will be 30–50 applications for funding, majority focusing on the adoption and/or development of robotics technologies.

4 Conclusions

The main aim of the paper was to discuss of the future needs of the European industry and of the possibilities for improved technology transfer methods deployed in previous years. According to the visions referred there is a strong belief that with robotics European industry can increase the product quality, production capacity and production predictability, and with by applying IOT and AI the horizontal and vertical transparency of supply network could be increased while non-value added time in order-delivery processes could be decreased. The third expectation for the emerging ecosystems is to support the technology transfer from science to industry, support the resource and capacity sharing among the companies, and support life-long learning of working personnel. The population of the Europe is not growing, and at the same time there is a lack of interested and qualified workers coming to the markets. Partly this is because of demographics, and partly due to the decreasing interest towards STEM topics among younger generation. The Digital Innovation Hubs -concept in general aims to support the knowledge, technology and competence transfer and sharing among European SMEs.

This paper also provided a short overview of concrete and recent actions regarding the robotics ecosystem building and/or building of Digital Innovation Hubs having (or supporting projects with) a cascade funding dimension for experiments and/or demonstrators. The time perspective was set to projects funded from 2016 onwards. As the Fig. 1 shows there is a good number of projects running different types of cascade programs. The main idea in these is to bring H2020 framework programmes closer to the European SMEs and support them in digital transformation and adoption of emerging technologies. A more detailed overview of the project TRINITY DIH project was included into the paper. The TRINITY aims to increase the interest of the companies with different use-case demonstrations (or prototypes) that could be replicated to industrial setting. While there are no concrete KPIs of the success the previous cascade funding projects show increasing interest from the SMEs. Secondly the TRINITY DIH project intents to deliver both realistic use-cases and associated training material for using novel robotics technologies in the manufacturing.

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