DIGEP POLITECNICO DI TORINO

AWARD "TESUN-83486178370409 FINANZIAMENTO DIPARTIMENTI DI ECCELLENZA CAP. 1694 TIT. 232 ART. 6."

FIRST YEAR REPORT

This document is split into four main sections. The first section provides the research activity carried out in 2018. The second section presents the current situation in terms of staff recruitment and refurbishment and renovation of laboratories. The third section presents the dissemination activities. The last section provides indications on the year 2020 activity.

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1 Research activity

As indicated in the project presentation, the aim of the activity of DIGEP is to deal with human-machine and technology interaction intermingling three complementary disciplinary areas, namely, the technological perspective, the management perspective and the economic and legal perspective. Below are summarized the activities within the above main topics.

Technological perspective

Additive manufacturing and finishing processes

Additive Manufacturing offers a great deal of opportunities and enables to overcome constraints set by conventional manufacturing processes. In particular, integration with novel smart production system within the paradigms of Cyber Physical System and Industry 4.0 may yields unforeseen application for this technology. However, productivity and process control have still to be improved, as well as understanding of process parameters effect, before addressing finishing. The activities developed in 2018 in additive manufacturing processes for metal and polymer materials are illustrated in the following sections:

- ***Directed Energy Deposition (DED) of metal powder with laser beam***

  In order to ensure the quality of parts produced by Directed Energy Deposition (DED) with metal powder as feedstock and laser as energy source, it is necessary to identify the optimal combination of process parameters. Currently, process parameters are typically selected

using a trial-and-error methodology, this is very expensive and time-consuming. Thus, research effort is focused on developing numerical modelling of the DED process. Using the finite element modelling approach, a thermal model of the DED process is in development. In this model, a novel element activation strategy is adopted, in order to model the volume of the deposited material as function of process parameters. Preliminary results show that the proposed model is able to predict the dimensions of the melt pool and, consequently, if a specific set of process parameters guarantees adequate adhesion between layers. At the same time studies are being carried out on the finishing of the parts [A1], since with the DED technology the surface roughness is high if compared the laser powder bed fusion (L-PBF) technology.

- ***Process automation for DED systems***

  The collaborative robotics offers the possibility of cooperating in close contact with robots specifically created for this purpose, and therefore intrinsically safe. The technological context refers to a robot able to "perceive" the presence of an operator or other systems and to adapt its movement, always avoiding contact and providing for immediate arrest in the event of even minimal contact. This technology opens up countless innovative scenarios. New technical solutions can be developed in order to perform highly complex operations through secure and effective interaction between operators, machines, and workstations. Moreover, it is possible to Implement advanced collaborative robotics solutions on production systems, with safe human-robot cooperation environments.

- ***Fabrication of plastic parts by photopolymerisation***

  Additive manufacturing process allows multifunctional components to be fabricated. Especially, techniques based on photopolymerization can be used to achieve a very high control on the structure and the material properties. In addition, the resin can be signed to have a high dispersibility at a high content of post added organic conductive and semiconductive materials. Since structures with linear features extending from the exposure surface, such as lattices and honeycombs can be formed with high precision it is possible to fabricate high technology sensors already included in the part during the fabrication to obtain smart devices. The better approach for performance characterization of the AM systems for fabrication of high technology sensors is through test artifacts or benchmarking parts [A2].

- ***Interaction between polymer-based AM systems with the economic and organizational environment***

  One aspect that has been created with the diffusion of low-cost polymer-based AM technologies, and which we have begun to analyze, is linked to the change induced in the relationship between producers and consumers. The end user has new possibilities of carrying out activities that previously were exclusive to manufacturing activity or specialized technicians (for example, replace the parts of a damaged product), buy 3D printers in kits to assemble or build at home following the directions provided in Blogs and magazines or to buy 3D pens for children. This new role involves a rethinking of traditional models of responsibility and complicates the dynamics of existing ones. In other words, it becomes less clear who should cover the costs of repair, product quality certification and to what extent a user can modify a product he purchased.

Publications related to the activities described (apart from those cited and already published) are currently in preparation.

[A1] Ribezzo, A., Calignano, F., Salmi, A., Atzeni, E., Pietrobono, F., Trovalusci, F., and Rubino, G., 2018, Finishing of metal additive manufactured parts by abrasive fluidized bed machining, European Society for Precision Engineering and Nanotechnology, Conference Proceedings - 18th International Conference and Exhibition, EUSPEN 2018, pp. 271-272.

[A2] Minetola, P., Galati, M., 2018, A challenge for enhancing the dimensional accuracy of a low-cost 3D printer by means of self-replicated parts, Additive Manufacturing. DOI.org/10.1016/j.addma.2018.05.028

Collaborative robots

Collaborative robots represent one of the greatest challenges and opportunities of Industry 4.0. In fact, by means of this human-machine interaction robots can actively cooperate and share the working space and volume with human operator. This opens the field to the robotic application and integration in all cases in which human dexterity and smartness are still core, once robot has been properly trained, for example by demonstration.

Interactions between human and robot were studied along with model for task assignment. For the case of welding operation, pick-and-place, welding and assembly both off-line and on-line task oriented control algorithms were tested both for on- and off- line programming. Furthermore, vision systems for robots were analysed and their integration by means of machine learning was addressed as well as the possibility to exploit deep learning to carry out task assignment and deployment of human-machine interaction for collaborative robots. Additionally, development of interfaces for human-robot collaboration in assembly tasks based on deep learning and machine learning was addressed [B1], along with study and characterization of the servitization process [B2,B3].

[B1] Bruno, G., & Antonelli, D., 2018, Dynamic task classification and assignment for the management of human-robot collaborative teams in workcells. The International Journal of Advanced Manufacturing Technology, 98(9-12), 2415-2427.

[B2] Mastrogiacomo L., Barravecchia F., Franceschini F., 2018, Definition of a conceptual scale of servitization: Proposal and preliminary results. Forthcoming on CIRP Journal of Manufacturing Science and Technology.

[B3] Mastrogiacomo, L., Barravecchia, F., Franceschini, F., Propensity to servitization of manufacturing companies: structural factors and implications for strategic positioning. Flexible Services and Manufacturing Journal, under review.

Sensors

Sensors are an enabling technology for Industry 4.0. In fact, integrated and distributed sensors network are necessary to operate, i.e. teach, work and collaborate with, collaborative robots and to achieve on-line continuous quality control, e.g. identify, track, locate, trace, etc., automated systems, hereby including also automated guide vehicles.

Challenges are the several sensors type which will require, to infer information, data fusion, the technical requirements to cope with on-line and real time controls and also facing the environmental conditions of the site where the network is installed, and the flexibility of the system.

Consequently, having investigated features of quality-inspection procedures for short-run productions [C1], which may best suit, amongst the others, additive manufacturing quality control and collaborative robots control, sensors development has been addressed, beginning with analysis of solutions for cobots control. Those basically require large volume metrology (LVM) (e.g., laser trackers, rotary-laser automatic theodolites, photogrammetric systems, etc.) technologies and some diagnostic tests were developed for combinations of LVM systems that

are equipped with distance and/or angular sensors [C2], because it was demonstrated that combined use of LVM systems can lead to a systematic reduction in measurement uncertainty and a better exploitation of the available equipment.

[C1] Franceschini F., Galetto M., Genta G., Maisano D.A., 2018, Selection of Quality-Inspection Procedures for Short-Run Productions. THE INTERNATIONAL JOURNAL OF ADVANCED MANUFACTURING TECHNOLOGY. - ISSN 1433-3015. - STAMPA. - 99:9-12(2018), pp. 2537-2547.
[C2] Maisano D.A.. Mastrogiacomo L., 2018, Cooperative diagnostics for combinations of large-volume metrology systems. INTERNATIONAL JOURNAL OF MANUFACTURING RESEARCH. - ISSN 1750-0591. - ELETTRONICO. - 14:1(2019), pp. 15-42.

Quality

Human-machine interaction systems can be exploited to set up highly customised manufacturing, here including assembly, processes or be part of unconventional processes, e.g. additive manufacturing. These processes often entail short-run production and are not yet understood thoroughly. Therefore, devoted quality assessment tools, which do not rely upon statistical process control are required because of short-run production. Similarly, product and process characterisation are still required to achieve thorough control of the process and technological surface characterisation is core to understand manufacturing processes. In fact, surface topography affects material properties, such as optical, mechanical and tribological ones, and its concurrent characterisation to mechanical properties evaluation can be exploited to gain it.
Consequently, quality-inspection procedures and a robustness analysis of inspection design parameters for short-run production have been addressed, also developing model of defects generation for short-run which is now limited to assembly processes [D1-D3]. Furthermore, catering for the possibility that inspections may yields non-normally distributed data, case that is overlooked by the current “Gauge R&R study”, process capability assessment under this hypothesis has been studied [D4]. In general, within total quality management, a critical analysis of quality management system certification has been performed, considering correlation with the failure risk of the company [D5].
Furthermore, surface topography measurement has been studied from the perspective of surface metrology measuring instruments metrological characterisation [D6,D7]. Moreover, non-conventional hardness test, such as instrumented indentation, can be exploited to achieve mechanical characterisation across a wide range of properties by means of a, at most, semi-destructive test. Instrumented indentation test criticalities have been addressed from the metrological perspective highlighting criticalities of standards from the stand point of modelling of underlying hypotheses and calibration [D8-D10].
Interest of firms to the aforementioned subjects allowed to establish a collaboration with FCA as industrial partner, for the year 2018, to apply developed methods to additive manufacturing selective laser melting process.

[D1] Galetto M., Verna E., Genta G., 2018, Robustness analysis of inspection design parameters for assembly of short-run manufacturing, Proceedings of 3rd International Conference on Quality Engineering and Management pp. 255-274. Barcellona (Spagna) nel 11-13 Luglio 2018.
[D2] Franceschini F., Galetto M., Genta G., Maisano D.A., 2018, Selection of Quality-Inspection Procedures for Short-Run Productions. THE INTERNATIONAL JOURNAL OF ADVANCED MANUFACTURING TECHNOLOGY. - ISSN 1433-3015. - STAMPA. - 99:9-12(2018), pp. 2537-2547.

[D3] Genta G., Galetto M., Franceschini F., 2018, Product complexity and design of inspection strategies for assembly manufacturing processes, 56:11(2018), pp. 4056-4066.
[D4] Genta G., Galetto M., 2018, Study of measurement process capability with non-normal data distributions. Proceedings of 15th CIRP Conference on Computer Aided Tolerancing 75, pp. 385-390. CIRP CAT 2018 tenutosi a Milano (Italia) nel 11-13 giugno 2018.
[D5] Franceshini F., Galetto M., Mastrogiacomo L., 2018, ISO 9001 certification and failure risk: any relationship? TOTAL QUALITY MANAGEMENT & BUSINESS EXCELLENCE, 29:11-12, pp. 1279-1293.
[D6] Maculotti G., Feng X., Galetto M., Leach R., 2018, Measurement noise evaluation, noise bandwidth specification and temperature effects in 3D point autofocusing microscopy Proceedings of the 18th international conference of the European society for precision engineering and nanotechnology, pp. 155-156. EUSPEN Venezia (ITA) nel 4-8 June 2018.
[D7] Maculotti G., Feng X., Galetto M., Leach R., 2018, Noise evaluation of a point autofocus surface topography measuring instrument, MEASUREMENT SCIENCE & TECHNOLOGY. - ISSN 0957-0233. - ELETTRONICO. - 29:6, p. 065008.
[D8] Maculotti G., Genta G., Lorusso M., Pavese M., Ugues D., Galetto M., 2018, Instrumented indentation test: Contact stiffness evaluation in the nano-range, Proceedings of 6th International Conference on nanoManufacturing , pp. 675-682. Nanoman a London (UK) nel 4-6 July 2018.
[D9] Maculotti G., Genta G., Lorusso M., Pavese M., Ugues D., Galetto M., 2018, Instrumented indentation test: Contact stiffness evaluation in the nano-range, NANOMANUFACTURING & METROLOGY, in stampa.
[D10] Genta G., Maculotti G., Barbato G., Levi R., Galetto M., 2018, Effect of contact stiffness and machine calibration in nano-indentation testing, Procedia CIRP. - ISSN 2212-8271. – ELETTRONICO. – 78(2018), p. 208-212.

Product and Process design

Industry 4.0 and modern Cyber Physical System entails deep interaction between human and machine. Therefore, they might require devoted tools to enable for Product Life Cycle Management, Model Based Enterprise and CAD Cloud-based strategies definition method development for an extended enterprise.
First, state of the art analysis of the impact of scientific research on enterprise and human resources management, business model and technology has been performed [E1,E2]. Furthermore, study of explicit explanation models of interactions between human operator, e.g. designed, manager, worker, etc., and enabling competence level for proper exploitation of innovative technologies [E3-E5]. Moreover, variability of implementation of Industry 4.0 paradigm across several Countries, according to their industrialisation (e.g. mature Countries as Italy and France and emerging, such as Uzbekistan and Brazil), has been addressed [E6].
Additionally, methods to model new digital technologies have been developed, e.g. Gap Analysis tool, Business model canvas, Balanced scorecard, benefit evaluation grid, to assess risk and resilience of innovative solution, also in collaboration with ENSAM – Paris [E7,E8]. Furthermore, simulation for sizing innovative, scalable and modular AVS/RS systems have been proposed to improve system operationality [E9].

[E1] L. Tirabeni, G. D'Antonio, P. De Bernardi, P. Chiabert. Technological innovation and the emerging Enterprise 4.0. Multi-faceted insights on Industry 4.0. Submitted to the International Journal of Technology Management

[E2] G. Bruno, D. Antonelli. Ontology-based platform for sharing knowledge on Industry 4.0, The IFIP 5.1 15th International Conference on Product Lifecycle Management (PLM18). Torino, 2-4 luglio 2018.
[E3] G. D'Antonio, P. Chiabert. How to manage people underutilization in an Industry 4.0 environment? The IFIP 5.1 15th International Conference on Product Lifecycle Management (PLM18). Torino, 2-4 luglio 2018.
[E4] D. Antonelli, G. Bruno, K. Aliev. Assembly Planning and Task Assignment in a Human Robot Collaborative Workcell. International Conference on Virtual and Networked Organizations (VinOrg), Póvoa de Varzim, Portugal, 7-9 Novembre 2018.
[E5] G. Bruno, D. Antonelli. Dynamic task classification and assignment for the management of human-robot collaborative teams in workcells, International Journal of Advanced Manufacturing Technology, 98 (9-12), pp.2415-2427
[E6] I. Kambarov, G. D'Antonio, K. Aliev, P. Chiabert, J. Inoyatkhodjaev. Uzbekistan towards Industry 4.0. Defining the gaps between current manufacturing systems and Industry 4.0. The IFIP 5.1 15th International Conference on Product Lifecycle Management (PLM18). Torino, 2-4 luglio 2018
[E7] F. Laverne, E. Bottacini, F. Segonds, N. Perry, G. D'Antonio, P. Chiabert. TEAM : a Tool for Eco Additive Manufacturing to optimize environmental impact in early design stages. The IFIP 5.1 15th International Conference on Product Lifecycle Management (PLM18). Torino, 2-4 luglio 2018.
[E8] K. Audoux, F. Laverne, G. D'Antonio, F. Segonds, O. Kerbrat, P. Chiabert, A. Aoussat. Multicriteria evaluation method in PLM environment: a pilot study. The IFIP 5.1 15th International on Product Lifecycle Management (PLM18). Torino, 2-4 luglio 2018.
[E9] G. Bruno, G. D'Antonio. Flexible reconfiguration of AVS/RS operations for improved integration with manufacturing processes, 6th CIRP Global Web Conference (CIRPe 2018)

Plant logistics

One of the elements characterizing the organizational evolution of the factories in view of the digital revolution is the information and operational integration between the parties involved in the production chain. In the meaning of Industry 4.0, this integration is extended to subcontractors and customers, with an inter-company value. The project in question mainly takes into consideration the physical environment of a factory, as an essential link in a supply chain, but also aims to create the conditions for integration with the downstream and upstream phases of the purely analysed [F1].

Within the factory, the integration is guaranteed by the coordination of the operations and the availability of information between the production phases of the materials, up to considering the individual moved pieces.

In the laboratory, the physical and IT modeling of the flows provides the creation of work areas (present in other areas of the laboratory) and interconnected storage between them, through an automatic transport system. A reading of data relating to objects in motion through systems of RFID detection is also implemented. The usage of a simple storage system will simulate the warehouse management. The integration with other areas will take place progressively.

We intend to understand which impacts on handling and production performance can be improved by comparing situations with and without the use of automatic and / or interfaced systems. By configuring exemplary production processes, we will define methods for reading and detecting data on products, tracking methods and their processing, also with a view to prepare downstream production phases. The activity will be carried out in parallel between physical simulation and IT, in order to compare multiple scenarios at the same time.

The possibility of integration with simulated upstream and downstream phases in terms of flows will also be assessed to understand the impacts on the supply chain effects. This is a step

forward in the direction of being able to treat unknown demand processes that have to be estimated both in terms of process type and parameter values [F2].

[F1] Cagliano A.C. , Grimaldi S., Schenone M. (2018). Proposing a new framework for lean warehousing: first experimental validations. Proceedings of the XXIII Summer School "Francesco Turco" – Industrial Systems Engineering, Academic Discipline ING-IND/17, Palermo, Italy, 12th September – 14th September 2018, pp. 156-163.

[F2] Schenone M., Mangano G., Grimaldi S., Cagliano A.C. Estimating Travel Times in Dual Shuttle AS/RSs. A Revised Approach. Submitted.

Sustainability

The development of adequate techniques to control the performances of product and process within a process that involves human-machine interaction requires the adoption of distributed and integrated sensors network. In fact, by measuring the consumptions of energy and resources, such as material and fluid flow, data for process assessment are acquired.
Furthermore, in order to achieve thorough understanding of the process, several analysis level through the whole Supply Chain shall be catered for, to eventually design for sustainability. Process optimisation for sustainability can be performed from the environmental and the economical perspective.
An integrated and distributed sensors network has been exploited to study machining process of titanium alloys. A holistic approach has been proposed to achieve concurrent optimisation of both the environmental and the economic targets for Ti-alloys turning and, within certain range of process parameters, it has proved effective, thus enabling a new concept of high-efficiency machining range to be defined [G1].
Also, Additive Manufacturing processes, not being bound by conventional constraints, offers wide range of opportunities, and sustainability of powder bed process was investigated. The research demonstrated that knowledge and applications of the rules of Design for Additive Manufacturing are core not only for proper exploitation of this process capability, but also to achieve environmental sustainability level of interest [G2]. Firms are deeply committed to sustainability; as such, a collaboration with FCA as an industrial partner was established, to develop part of the research committed to additive manufacturing process sustainability.

[G1] Priarone, Paolo C.; Robiglio, Matteo; Settineri, Luca (2018) On the concurrent optimization of environmental and economic targets for machining, In: JOURNAL OF CLEANER PRODUCTION, pagine 630-644, ISSN: 0959-6526
[G2] Priarone, Paolo C.; Ingarao, Giuseppe; Lunetto, Vincenzo; Di Lorenzo, Rosa; Settineri, Luca (2018) The Role of re-design for Additive Manufacturing on the Process Environmental Performance, In: PROCEDIA CIRP, pagine 124-129, ISSN: 2212-8271

3D modelling and simulation

For what concerns human machine interaction issues, the research activity has been focused on exploiting the potential issues provided by 3D digitalization, modeling, simulation and advanced digital visualization.
3D modeling and digitalization have been used to analyze the human body with particular attention to face analysis. The study was mainly focused on the analysis of facial expressions with the aim of evaluating human interaction with complex products, usability and compliance

with expectations in a strategy of continuous improvement according to the philosophy of interaction design and design for emotion.
Thanks to the collaboration with the Department of Human and Social Sciences of the University of Valle d'Aosta, the basic principles of Face Perception were analyzed, aimed at improving the methods of facial expressions recognition starting from the concept of "mental representation" of the human face. The exploitation of the potentials of neural networks has also been analyzed to support better performance and reliability in facial recognition. Some more discriminative geometric features have been initially outlined to distinguish the subjects through Pattern Recognition techniques. These features have been then further selected through the GH-EXIN neural network in order to identify those with the highest discriminatory power [H1].
As part of the collaboration with UTC-Sorbonne Universités, a new approach has been developed to monitor facial movements through motion capture, reducing the dataset of facial markers required from 109 to 19, while maintaining high recognition rates [H2, H3].

Still in the field of automatic recognition of facial expressions, a specific study has been developed on the comparison of 2D and 3D methodologies with particular attention to emotional design and user experience, in a product life cycle logic [H4,H5].

[H1] Gabriele Ciravegna, Giansalvo Cirrincione, Federica Marcolin, Pietro Barbiero, Nicole Dagnes and Elio Piccolo: Assessing discriminating capability of geometrical descriptors for 3D face recognition by using the GH-EXIN neural network, 28th Italian Workshop on Neural Networks (WIRN 2018), June 13-15 Vietri sul Mare, Salerno, Italy.

[H2] Dagnes, N., Ben-Mansour, K., Marcolin, F., Marin, F., Sarhan, F. R., Dakpé, S., & Vezzetti, E. (2018). What is the best set of markers for facial movements recognition?. Annals of Physical and Rehabilitation Medicine, 61, e455-e456.

[H3] Nicole Dagnes, Khalil Ben-Mansour, Federica Marcolin, Fréderic Marin, Stéphanie Dakpé, Enrico Vezzetti Optimal Marker Set Assessment for Motion Capture of 3D Mimic Facial Movements, Journal of Biomechanics, under review.

[H4] Stefano Tornincasa, Enrico Vezzetti, Sandro Moos, Maria Grazia Violante, Federica Marcolin, Nicole Dagnes, Luca Ulrich, and Giorgio Fantini Tregnaghi (2019). 3D Facial Action Units and Expression Recognition using a Crisp Logic, Computer-Aided Design and Applications, 16(2), 256-268.

[H5] E. Vezzetti, F. Marcolin, S. Tornincasa, F. Baldassarre, D. Buisán Vicente (2018). 3D Face Expression Recognition via Geometry A Preparatory Path, International Journal of Imaging and Robotics, 18(4), 1-40.

Management perspective

Digital transformation of organizational and industry architectures

The digital transformation of the Italian automotive supply chain
This research project focuses on the impact of digitalization and automation on a particular industry setting: the upstream value chain of automotive. This industry is indeed very important for the employment and GDP of Italy and, therefore, it is of great importance to analyse the challenges as well as the opportunities that the new technological paradigm, called Industry 4.0, determine at many units of analysis. At firms' unit of analysis, many companies reveal a shortage of skills and competencies, an increasing competitive pressure due to new potentially disruptive entrants (e.g. firms leading the electric car and artificial intelligence revolutions) and system integrators, and a lack of organizational "readiness" due to poor implementation of lean management practices. At the same time, they acknowledge great opportunities in cost reduction, product quality and flexibility. It is therefore of great importance to analyse the barriers as well as the enablers that will shape the competitiveness of these firms during this shift of the technological paradigm. The analysis of these barriers and enablers could support policy makers to formulate the correct policy that could support the competitiveness of the Italian automotive value chain. Moreover, given the international outlook of this survey (a similar survey occurred in US during 2017 and further survey replication are expected in other European countries) it would be possible to compare how firms in different legislations deal with these challenges and opportunities. This research will investigate these aspects by employing a quantitative survey (which has been already undertaken in the USA) and it will be replicated in Italy with slight modifications based on the Italian context. Given the wide spread of digitization in every business process, the survey requires three different respondents: sales manager, plant manager and HR manager. Before the data collection, the research team will conduct pilot interviews in different Italian regions to validate the questionnaire. The translation and adaptation to the Italian context, the testing, the data collection and the interpretation of results will be done in collaboration with the Center for Automotive and Mobility Innovation (CAMI) of the University Ca' Foscari of Venice (which provides scientific coordination of the Italian Observatory on Automotive Supply Chain) and the Collegio Carlo Alberto. Therefore, this project will benefit on one side from expertise of the CAMI on the Italian automotive supply chain and on the other side from the expertise of Collegio Carlo Alberto on economics and policy-making.

From electrons to bits. Work transformation in the electrical sector
The research project "Dagli elettroni ai bit. Le trasformazioni del lavoro nel settore elettrico", carried out by the Politecnico di Torino for Elettricità Futura and Utilitalia, the two main employer associations in the electrical sector, is aimed at studying how digital transformation changes the mix of competences and skills in the organizations, and the organization of work within electrical utilities.

This project draws from the experience of members in the department in studying the relationship between Human Resource Management and production systems in context of lean experiences [I1].
The project on work transformation was carried out in the electrical sector since this is one of the first where the digital technologies like Internet of Things, artificial intelligence have a profound impact in the business models, managerial practices, the way of working and

operational processes of companies. The rapid diffusion of digital technologies in this sector is explained by many contextual conditions, as the rapid climate changes that characterize the last decade, the diffusion of renewable sources, and new regulations. All these phenomena have increased the complexity of producing, distributing and selling electrical energy.

In order to investigate the influence of the digital transformation on the changes of the workers' competences and the way people work, a qualitative approach based on collecting field evidence from the electrical sector was applied. Specifically, interviews and focus groups were conducted with the CEOs and/or the first line of managers of 20 companies that operate at several stages of the electric value chain in Italy. Overall, the interviews and the focus groups with the experts of the electrical sector led to define three main conclusions on the way work is changing due to the digital transformation. Three orders of findings emerged from the analysis: 1) a tighter integration between the technostructure and the operating line due to the need of constantly improving algorithms and information systems used to manage the electrical grid and energy generation assets. 2) the empowerment of line operators and the increasing use of lateral coordination mechanisms; 3) the increased relational dependence on system integrators and data analytics companies that electrical companies may incur in the moment their operations become increasingly data driven. Firms can reduce such dependence by empowering line workers and by putting them in a context of increasing horizontal coordination with specialists and other technical roles.

So far this project led to the publication of a working paper presented to an international conference and selected for a special issue including the best papers presented at a conference [I10].

The transformation of managerial capabilities in manufacturing SMEs
The digital revolution (e.g. Industry 4.0) imposes threats for Small and Medium Enterprises (SMEs) in their strive for higher growth and profits, and in their competition with larger firms. In this vein, it is crucial for such firms to change and update their capabilities and to align their competences to embrace and take advantage of the opportunities introduced by Industry 4.0. This study draws on a previous series of studies conducted in the Department, which highlighted the limited business growth SMEs face when they combine R&D investments and export [I17], and the limited degree of investment on digital technologies especially in conditions of limited environmental munificence and high dynamism [I5].
Starting from this result, the research group focused its attention on the analysis of the capabilities of SMEs to understand their evolutionary process regarding the new technologies introduced by the paradigm of Industry 4.0. More specifically, the study has three complementary streams: first, to map and identify the current set of capabilities of SMEs; second, to analyse their fit with the opportunities of Industry 4.0; third, to advance a proposal about the actions required to fill the competences gap of SMEs.

To accomplish to the first two tasks, it has been activated a line of intervention in partnership with the Digital Innovation Hub to map the state of the art about the digitalization and the digital capabilities of SMEs belonging to the local ecosystem (Piedmont region). In order to increase SMEs awareness about the new technologies, the research team created (drawing from the academic and grey literature), tested and implemented a survey (plus some interviews) aiming to map the digital level of firms and to their increase consciousness about the potential threats and opportunities they will have to face due to the change in the technological paradigm.

At the same time, another line of intervention – operating more at the managerial level - has been developed together with Fondazione Agnelli in order to map and illustrate the best

managerial practices of the territory and their link with the past. Managers could be tempted to think that the new technological paradigm requires a complete replacement of the capabilities developed in the past with new competences and routines. Instead, with this line of research, we would demonstrate that it is necessary to draw from competences hold back in the tradition of the territory and of the firms to successfully integrate new technological changes in SMEs. The project is currently still running, but we have the first evidences about the ordinary and dynamic capabilities critical for the prosperity in the medium term of SMEs.

Finally, a third line of intervention has been directed toward the managerial training needed by managers to successfully face the changes of the next years. For this project a series of specific managerial education programs have been developed thanks to a tight collaboration with Skillab, the training center of the Unione Industriale.

The evolution of Vocational and Education Training in the electrical industry

The project aims to study the evolution of vocational and education training methods and approaches in e-distribuzione, the business unit of Enel specialized in distribution grid and one of the leading company in smart grids at the international level. The project finds its motivation and industrial relevance in the technological evolution of the electrical grid taking place in the utilities. Such evolution implies an upskilling for the operating line and a tighter integration and coordination between specialists in the technical core (e.g. specialists in the installation and maintenance) and the field workers operating on the grid. Such upskilling consists in a greater demand for workers on the field for using digital technologies (like augmented reality, tablets provided with data analytics solutions and dashboard) and for innovation and continuous improvement skills. Such evolution obliges Enel and e-distribuzione to upgrade its Human Resource Management (HRM) system, and in particular its Vocational and Education Training (VET) methods.

DIGEP is supporting ENEL and e-Distribuzione in this challenge of making the VET and HRM systems evolve. The activities of DIGEP-PoliTO in the project can be grouped in three work packages:

1. Study the evolution needed in VET approaches to sustain the upskilling trend of the workforce described above. Such evolution regards content (i.e., new needed skilling) and approaches and method, with particular attention to the way digital technologies (e.g. simulation methods, virtual and augmented reality) can be used to make training and education more effective.

2. Provide a blueprint of recommended actions to ENEL to make its VET system evolve. This work package is based on a close interaction with the technical high schools collaborating with ENEL in dual study programs like apprenticeships and work-based learning. Along with the analysis of VET system, DIGEP-Polito is analyzing the evolution of other HRM practices that sustain training, like reverse-mentoring programs, job rotation routines, on-the-job and off-the-job training

3. Inform policy-makers on the way policies regarding VET (e.g. standards, norms, fund allocation processes) should evolve in response to the challenges faced by leading-edge companies like ENEL

Digital transformation in the tourism and cultural heritage sector
The relationship between "man" and the "machine" has been explored in recent years in the department also for what regards service sectors. Tourism and the hospitality industries have been selected to this purpose since they represent extreme cases of digital transformation, for the way big data technologies can make online visibility of hotels, museums and cultural institution a crucial variable to attract customers or to inform them about the peculiarities of their services.

In line with these arguments, particular attention has posed on conceptualizing the role of big data technologies for value creation [I3, I4, I6, I13 and I16], especially for what regards the role they have in supporting online visibility [I12]. Along with this focus on big data technologies, other works have analysed the role of digital technologies in general for value creation both at a general level [I15, I16] and for what regards the museum industry [I7, I8, I9, I14].

Lastly, an empirical paper has analysed from an empirical standpoint how investments in digitalization (measured at the industry level) impact on competitive dynamics [I2], comparing dynamics in service and manufacturing industries.

Entrepreneurship, technology transfer and open innovation regimes
According to a logic of "openness", this stream of research studies the role that universities play in the gical trajectories. In this respect, the following aspects are object of investigation:

- The fundamental role that universities plays for regional specialization as key sources of knowledge, which are transferred to the local ecosystem in the form of new scientific and technological knowledge. The research is investigating how this knowledge is shaping the local ecosystems in terms of innovation capabilities firms are able to develop. In particular the research investigated the role R&D and spillover from research have in international development of SMEs [I17];

- The importance of methods and practices for the diffusion of an entrepreneurial culture among students and academics, and their role in developing and applying new technological knowledge [I18, I19, I22];

- How Technologies Transfer activities that universities perform (including patenting, licensing, research collaboration, consulting, networking, etc.) are stimulating the creation of new firms within the ecosystem [I20, I21].

[I1] Neirotti, P. (2018). Work intensification and employee involvement in lean production: new light on a classic dilemma, The International Journal of Human Resource Management, 1-26

[I2] Neirotti P., Pesce D. (2018) "ICT-based innovation and its competitive outcome: the role of information intensity", European Journal of Innovation Management, https://doi.org/10.1108/ EJIM-02-2018-0039

[I3] Raguseo, E., Pigni, F., Piccoli, G. (2018) Conceptualization, Operationalization and Validation of the Digital Data Stream Readiness Index. Journal of Global Information Management, 26(4). DOI: 10.4018/JGIM.2018100106.

[I4] Raguseo, E. and Vitari, C. (2018). Investments in big data analytics and firm performance: an empirical investigation of direct and mediating effects. International Journal of Production Research, 56(15), pp. 5206-5221, 1366-588X (Online) (DOI: 10.1080/00207543.2018.1427900).

[I5] Neirotti, P., Raguseo, E. and Paolucci, E. (2018) How SMEs develop ICT-based capabilities in response to their environment: past evidence and implications for the uptake of the new ICT paradigm. Journal of Enterprise Information Management, 31(1), pp. 10-37 (DOI: 10.1108/JEIM-09-2016-0158).

[I6] Raguseo, E. (2018) Big data technologies: investigating their adoption, benefits and risks for companies. International Journal of Information Management, 38(1), pp. 187-195 (DOI: 10.1016/j.ijinfomgt.2017.07.008).

[I7] Pesce D., Neirotti P. (2018) "Digital transformation in the sources of value creation - an analysis in the cultural and creative industries" In: Strategic Management Society – SMS – 38th Annual Conference in Paris (France), September 22-25 2018.

[I8] Pesce D., Neirotti P. (2018) "Digital transformation in the sources of value creation - an analysis in the cultural and creative industries" In: 19th International CINet Conference in Dublin (Ireland), September 9-11 2018.

[I9] Pesce D., Neirotti P. (2018) "Digital transformation in the sources of value creation - an analysis in the cultural and creative industries" In: R&D Management Conference 2018 "R&Designing Innovation: Transformational Challenges for Organizations and Society" Milan (Italy), June, 30th -July, 4th, 2018.

[I10] Neirotti, P. and Raguseo, E. (2018). The new algorithm whisperers: implications for new organizational architectures for continuous innovation in data-driven operations. 19th International CINet Conference, Continuous Innovation: Spinning out and spinning in, 9-11 September 2018, Dublin, Ireland, selected for a special issue on Creativity and Innovation Management.

[I11] Neirotti, P., Raguseo E., and Gastaldi, L. Designing flexible work practices for job satisfaction: evaluating how job characteristics can support work disaggregation for different types of work arrangements. Submitted to New Technology, Work and Employment(under review).

[I12] Neirotti, P. and Raguseo, E. How Value is Captured through Internet Visibility: Exploring the Complementarities of the Presence of Hotels on Different Online Intermediaries. Submitted to Information & Management (under review).

[I13] Raguseo, E. and Vitari, C. Big data business value and firm performance: Linking with environmental context. Submitted to International Journal of Production Research (under review).

[I14] Pesce D., Lanzolla G., Neirotti P. (2018) "Digital connectivity and organizational change: an exploration of the co-evolutionary dynamics in the Van Gogh Museum", submitted to Organization Studies (under review)

[I15] Lanzolla G., Pesce D., Tucci C. (2018) “Old wine in a new bottle? Organizational implications of digital transformation”, submitted to Academy of Management Annals (under review)

[I16] Pesce D., Neirotti P., Paolucci E. (2018) “When cultural heritage meets digital platforms: value creation through Big Data”, submitted to Current Issues in Tourism (under review)

[I17] D Battaglia, P Neirotti, E Paolucci (2018) The role of R&D investments and export on SMEs’ growth: a domain ambidexterity perspective, Management Decision

[I18] Sansone, G., Battaglia, D., Landoni, P., Paolucci, E., (2018), "The creation of academic sIpinoffs: the role of entrepreneurship education", paper submitted at The Journal of Technology Transfer

[I19] Colombelli, A., De Marco, A.M., Paolucci, E., Ricci, R., Scellato, G., (2018), "University technology transfer and the evolution of regional specialization: the case of Turin" paper submitted to the Special Issue of The Journal of Technology Transfer "University technology transfer, regional specializations, and local dynamics: Exploring the recipes for successful innovation and growth in Italian industry"

[I20] Ricci, R., Colombelli, A., Paolucci, E., (2018), "Entrepreneurial activities and models of advanced European science and technology universities", paper submitted to the Special Issue of Management Decision "Strategic Knowledge Management Models and Tools for Entrepreneurial Universities"

[I21] Colombelli, A., Caviggioli, F., De Marco, A., Paolucci, E., (2018), "How Venture Capitalists evaluate Young Innovative Company patent portfolios: empirical evidence from Europe", paper submitted to the International Journal of Entrepreneurial Behavior & Research

[I22] Colombelli, A., D'Amico, E., Paolucci, E., Ricci, R., (2018),"Attività e modelli universitari di trasferimento tecnologico", paper submitted to the Special Issue of the journal Economia e società regionale: "Il ruolo dell'Universita? nella costruzione di un ecosistema innovativo"

[I23] Entrepreneurship Education Ecosystems in Engineering and Technology (E4T), varano, Mirko; Kähkönen, Elina; Aarnio, Hanna; Clavert, Maria; Kaulio, Matti; Thorén, Kent; Haenen, Chrisje; van Petegem, Wim; Colombelli, Alessandra; Sansone, Giuliano; Paolucci, Emilio; Scharnagl, Esther; Mendes, Rui; Caldas de Oliveira, Luis; Fergus, Stuart; Brennan, Ross, 46th SEFI Annual Conference, Copenhagen 17-21 September 2018 "Creativity, Innovation and Entrepreneurship for Engineering Education Excellence"

[I24] Ricci, R., Colombelli, A., Paolucci, E., (2018) "Activities and models of University Technology Transfer", paper presented at the 25th EurOMA Conference, 24-26 June, Budapest.

Algorithms and their influence on decision making processes

This year activity was particularly focused on production scheduling and packing problems in the context of approximation algorithms.

To this extent, significant achievements were reached for the identical parallel machines scheduling problem with the objective of minimizing the maximum completion time [L3]. Bearing in mind the well-known Longest Processing Time (LPT) rule that requires to sort jobs

in non-ascending order of processing times and then to assign one job at a time to the machine whose load is smallest so far, an improved approximation bound was derived. Peculiarity of the result is the use of problem independent Linear Programming (LP) modeling for the analysis of related approximation ratio. In a similar way, it was possible to determine a specialized improved linear time approximation algorithm for the case with two machines, the so-called partition problem [L5].

In the context of packing problems, the 0-1 Incremental Knapsack Problem was considered. This problem is a generalization of the standard 0-1 Knapsack Problem (KP) where the capacity grows over time periods and if an item is placed in the knapsack in a certain period, it cannot be removed afterwards. The problem calls for maximizing the sum of the profits over the whole time horizon. Again, by generating LP models to mimick the behavior of specific heuristic rules it was possible to derive improved approximation results particularly for the cases with two and three time periods when it is assumed that each item can be packed in the first time period [L1, L2}.

Two further promising research topics were also considered. In both cases, again, a non canonical use of LP modeling (summed to, in the second case, the application of constrained programming) was successfully applied.

The first topic, another packing problem in the quest of bilevel programming, is the so-called Bilevel Knapsack problem with Interdiction Constraints, an extension of the classic 0-1 knapsack problem formulated as a Stackelberg game with two agents, a leader and a follower, that choose items from a common set and hold their own private knapsacks. First, the leader selects some items to be interdicted for the follower while satisfying a capacity constraint. Then the follower packs a set of the remaining items according to his knapsack constraint in order to maximize the profits. The goal of the leader is to minimize the follower's profits. The presence of two decision levels makes this problem very difficult to solve in practice.

Here, again LP was profitably used by modeling as linear constraints the structural properties of the optimal solution of the follower problem. Correspondingly, it was possible to derive an effective lower bound allowing to enhance by more than one order of magnitude the size of the problems solvable to optimality in limited time [L4].

The second topic is dedicated to a first attempt in merging the competences of two quite broad scientific communities, namely the operations research and artificial intelligence community and the combinatorial design community. The underlying idea is to exploit mathematical programming models as well as constraing programming models to solve large combinatorial design problems. This has a wide range of applications where cryptography is a well-known outlet. Preliminary ideas have been applied to the so called Oberwolfach problem where the proposed approach was able to find solution twice the size of the literature by applying consolidated operations research techniques while requiring much less CPU time. A paper summarizing these results is currently in preparation.

Finally, the presence of Prof. V. T'kindt as visiting (for 1.5 months, next 1.5 months will be in 2019), was not only related to approximation results in scheduling (see [5]) in the lines of the research indicated above, but also gave a boost to further activity in the bridge between low exponential complexity and approximation algorithms.

[L1] F. Della Croce, U. Pferschy, R. Scatamacchia, “Approximating the 3-period Incremental Knapsack Problem”, Journal of Discrete Algorithms, forthcoming, doi.org/10.1016/j.jda.2018.11.005.

[L2] F. Della Croce, U. Pferschy, R. Scatamacchia, “Approximation results for the incremental knapsack problem“, submitted.

[L3] F. Della Croce, R. Scatamacchia, “The Longest Processing Time rule for identical parallel machines revisited”, Journal of Scheduling, forthcoming.

[L4] F. Della Croce, R. Scatamacchia, “Lower Bound and a new exact approach for the Bilevel Knapsack with Interdiction Constraints”, submitted.

[L5] F. Della Croce, R. Scatamacchia, V. T’kindt, “A tight linear time 13/12-approximation algorithm for the P2||Cmax problem”, submitted.

Algorithms for complex production systems and supply chain

The research activity of the group has been directed toward two directions: (i) the study of complex production systems and the development of algorithms for their design and management; (ii) the analysis of variability propagation in supply chains.

The first direction (i) includes both practical aspects and theoretical studies. From a practical point of view, real systems have been studied with the aim to improve forecasting and planning activities. The algorithms developed to achieve such objective are mainly heuristic, due to the large dimension of the real problem and the need to have small computational time [M1]. From a theoretical point of view, new methodologies have been investigated to integrate system simulation and optimization in a different way with respect to the current state of the art. Specifically, integrated simulation-optimization models are being studied, whose solution can give both the optimal system configuration and its performance evaluation at the same time. Moreover, simulation is also being studied as a means to increase the efficiency of standard decomposition techniques for the solution of large mixed-integer (or even non-linear) programs [M3].

Differently from the first direction, which is more related to manufacturing systems, the second one (ii) is at supply chain level. Considering a supply chain, the so-called bullwhip effect has been studied from a theoretical perspective, evaluating the impact of not knowing the parameters of the demand process (always assumed perfectly known in the literature, together with the demand process) and developing new analytical models to predict the amount of bullwhip effect. This is a step forward in the direction of being able to treat unknown demand processes that have to be estimated both in terms of process type and parameter values [M2].

[M1] C. Castiglione, A. Alfieri, E. Pastore. Decision Support System to balance inventory in customer-driven demand. 16th IFAC Symposium on Information Control Problems in Manufacturing (INCOM), Bergamo, Italy, 2018. IFAC-PaperOnLine, vol. 51(11), 1499-1504.

[M2] E. Pastore, A. Alfieri, J. Boylan, G. Zotteri. The impact of demand parameter uncertainty on the Bullwhip Effect, submitted.

[M3] M. Zhang, A. Matta, A. Alfieri, G. Pedrielli. Simulation-based Benders cut: a new cutting approach to solve simulation-optimization problems. Proceedings of the 2018 Winter Simulation Conference (WSC’18), Gothenburg, Sweden, 2018. To appear.

Economic and legal perspective

Economic perspective

During the first year of the project, the Research group in economics has addressed the following themes: 1) Ultra broad band investments and adoption; 2) Artificial Intelligence (AI) modeling in economics and policy issues raised; and Additive Manufacturing (AM) adoption and effects on firm performance.

As for the first topic, the effect of regulatory interventions on the deployment of ultra-fast telecommunication networks on both incumbents and new entrants' incentives (N1) and on consumers' switch from old to new technologies (N2) has been analysed, thereby providing policy insights for the on-going revision of the EU regulation framework for the electronic communications industry. These results have been summarised in the keynote speech (N3). Furthermore, an ongoing research project (N4) aims at assessing the effect of ultra-broadband availability at the local level on local growth and companies' creation in Italy; the research is based on a novel dataset at municipality level from 2014 till 2017 (around 21 milions of observations).

As for AI, the way it has been modeled in very recent economic theoretical models and the main policy implications in terms of market failures, privacy and competition have been reviewed and discussed (N5). The purpose of these models is to derive the impact of AI and the automation of production on employment levels, income levels, labour and capital shares. Others look at the impact of AI on the internal organization of firms, i.e. skill composition, wage inequality and sectoral reallocation. Most view AI and machine learning as task-based technologies which substitute "tasks", instead of straightway "labour", but also generate new, high-skilled tasks, somewhat leaving intact low-skilled, manual tasks.

As for AM, a survey has been conducted in three specific Italian manufacturing industries (spare parts for the automotive industry, dental prostheses, and orthopaedic prostheses). By eliciting information on the first year of adoption and the amount invested in Additive technologies, the aim is not only to assess the actual adoption of this technology but also its impact on company performance and employment (N6).

[N1] W. Briglauer, C. Cambini and M. Grajek "Speeding Up the Internet: Regulation and Investment in the European Fiber Optic Infrastructure"."(2018) International Journal of Industrial Organization, forthcoming

[N2] W. Briglauer and C. Cambini "Does regulation of basic broadband networks affect the adoption of new fiber-based broadband services?" (2018), Industrial and Corporate Change, forthcoming

[N3] Keynote speech: "Ultra fast Broadband and Policy. How can better research help?", International Telecommunication Society Europe, Trento, August 2018.

[N4] Research project on the impact of ultra-fast broadband technologies on the local economic growth: the goal of the project is to analyse how municipalities with superfast broadband network tend to be more attractive for companies and company creation at local level. The project is financed by TIM-Lab.

[N5] Carlo Cambini e Laura Rondi "Modeling AI. Old Dogs, New Tricks?", Lunch Symposium "DDD4MP", DIGEP, 20 luglio 2018

[N6] Luigi Benfratello "AM adoption and its effect on firm performance and employment"

Legal perspective

During the first year of the project, the research programme carried out by the Department of Management and Production Engineering in the fields of Private Law and Business Law focused on the following main areas:

1) Data processing and data use (Big Data, machine learning, IoT) in the context of decision-making processes

2) Transparency and accountability in data-intensive systems

3) Data subjects' engagement, risk assessment and risk management concerning data-driven applications with a potential significant impact on individuals and society [N1, N2, N3]

4) HRI (Human-Robot Interaction) and use of smart devices, with a focus on the interaction between user and machine [N4]

5) The regulatory framework, encompassing ethical issues in technology development regulation to better address the challenges of today's data-driven society (risks concerning decisional biases, discrimination, underestimation of ethical issues, underrepresentation of the stakeholders, etc.) [N5]

6) Three dimensional printing and intellectual property rights (IPRs) with a view to analyse the impact of self-production – and the consequent shift from an economy based on scarcity to an economy of abundance – on the existing legal framework and on the level and type of protection to be granted to IPRs

7) Research on the introduction of fully and/or semi-automated systems in the automotive industry (so called self-driving cars) and, in particular, on the interplay between self-driving vehicles and insurance regulations

[N1] Mantelero, A. 2018. AI and Big Data: A blueprint for a human rights, social and ethical impact assessment. Computer Law and Security Review, 34 (4): 754-772 (open access).

[N2] A. Mantelero. La gestione del rischio nel GDPR: limiti e sfide nel contesto dei Big Data e delle applicazioni di Artificial Intelligence. In D. Poletti-A. Mantelero (a cura di), Regolare la tecnologia: il Reg. UE 679/2016 e la protezione dei dati personali, Pisa University Press (in press)

[N3] M.S. Esposito. L'impatto del trattamento sui diritti e le libertà delle persone fisiche: una valutazione alla luce della giurisprudenza delle autorità garanti italiana e spagnola. Ibidem

[N4] L. Greco-A. Mantelero. Industria 4.0 e conformità al GDPR (Regolamento UE 2016/679). In Dir. informazione informatica (under review)

[N5] M.S. Esposito. Trattamento dei dati personali nel prisma dei diritti e delle libertà fondamentali. In Dir. informazione informatica (under review)

Beside the publications listed above, the following chart summarises other results and outcomes of the legal analyses, which also benefitted from the synergy with the ongoing H2020 Virt-EU and the HuManS projects:

Field	**Conferences**
Data processing and data use	VI Conferencia Internacional, Cátedra Google sobre Privacidad, Sociedad e Innovación - Inteligencia artificial y economía del dato: Reglamento General de Protección de Datos. Desafíos actuales y futuros, Universidad CEU San Pablo, Madrid, 28 June 2018 (Mantelero, Invited Speaker) Artificial Intelligence and Law: Creation, Invention and Data, Universitat Oberta de Catalunya, Barcelona, 27 June 2018 (Mantelero, Invited Speaker) L'entrata in vigore del Regolamento (UE) 2016/679: la riforma alla prova della prassi in Italia e in Spagna - 1° Incontro di studi italo-spagnolo in materia di protezione dei dati personali, Università di Pisa, Pisa 8-9 giugno 2018 (Mantelero, Invited Speaker; Esposito, Speaker)
Transparency and accountability	13th International IFIP Summer School on Privacy and Identity Management - Fairness, accountability and transparency in the age of big data, AIT Austrian Institute of Technology, Vienna, 20 -24 August 2018 (Mantelero, Invited Speaker)

	Workshop on risk assessment and security measures for personal data processing, ENISA - European Union Agency for Network and Information Security, Rome, 8 February 2018 (Mantelero, Invited Speaker)
Risk assessment and management	Amsterdam Privacy Conference - APC2018, University of Amsterdam, 5 - 8 October 2018 (Mantelero, Invited Speaker; panel organised by the European Agency for Fundamental Rights - FRA on AI Transparency and discrimination) IPEN Privacy Engineering Workshop 2018, Universitat Politècnica de Catalunya, Barcelona, 15 June 2018 (Mantelero, Invited Speaker)
HRI	Europe Regulates Robotics, Scuola Superiore Sant'Anna, Pisa, 27 - 28 September 2018 (Mantelero, Invited Speaker) CPDP 2018, Processing personal data in a working environment, Bruxelles, 24-27 January 2018 (Mantelero, Speaker) The Internet of the human body: towards a habeas data?, EPRS | European Parliamentary Research Service, Bruxelles, 23 January 2018 (Mantelero, Invited Speaker) Human-Robot Interaction in the Industry 4.0 environment (HuManS project), Politecnico di Torino, Torino, 16 January 2018 (seminar organised by the Private Law research group)
Ethics & technology	Opportunities and Challenges in Regulating Robotics and Artificial Intelligence. A comparative approach, European University Institute, Florence, 18-19 May 2018 (Mantelero, Invited Speaker) European Data Protection Supervisor, IPEN-UPC Privacy Engineering Workshop 2018, Universitat Politècnica de Catalunya, Barcelona, 15 June 2018 (Mantelero, Speaker) Information Ethics Roundtable conference, University of Copenhagen, Copenhagen, May 17-18, 2018 (Mantelero, Invited Speaker)
3D Printing & IPRs	Participation to a call for papers with a proposed contribution that investigates whether (i) it is appropriate to refrain from any regulatory intervention or whether (ii) it is necessary to make a new extension of the content of the exclusive through a radical rethinking of the notion of non-commercial use or, again, (iii) if somehow intermediate solutions are possible, holding together the needs of industry under the traditional model and the instances of "prosumers" (Rivaro, under review)

Self-driving cars and insurance regulation	De-Mystifying InsurTech: a Legal and Regulatory View, AIDA Europe 7th Conference, Warsaw, 12 April 2018 (Rainelli, Speaker) AIDA XV World Congress, Rio de Janeiro 11-13 October 2018, New Technologies - Autonomous Vehicles, Cyber Risks and Insurance Process (Rainelli, Speaker)

2 Staff recruitment and laboratory facilities refurbishment and renovation activity

Staff recruitment

The following positions were activated

- 3 Associate professor positions (2 related to the technological perspective and 1 related to the economical and legal perspective) plus one currently on-going
- 2 RTDB positions (assistant professor grade B) positions (1 related to the technological perspective and 1 related to the managerial perspective)
- 1 RTD/A position related to the economical and legal perspective
- 4 post-doc grant positions (3 related to the technological perspective and 1 related to the managerial perspective)
- 2 PhD grants started.

Laboratory facilities refurbishment and renovation activity

Within the present research project, in order to develop the required activities related mainly to the technological perspective, laboratories with state of the art technologies are foreseen.

The locations have been determined at the ground floor and basement of "Fabbricato Area Sud – Parte 1" and at the first floor of "Palazzina C.so Trento 21". However, to host and operate state of the art equipments under adequate environmental conditions, structural measures must be executed.

The Central Refurbishment office of Politecnico, EDILOG, has approved the project, see Fig. 1, and has proceeded with ordering the building materials. In 2019, the related activities will proceed.

In the meanwhile, the equipment to be installed in the laboratories is being purchased. In some cases, to cope with long lead times, mostly due to public procurement processes, several tools will be delivered in advance and will be momentarily installed in existing facilities.

Below is indicated the equipment whose purchase is on-going and the related macro-area within the technological perspective.

- **Additive manufacturing and finishing processes**: DED and photopolimerisation systems with finishing equipment and items to upgrade the characterisation equipment.
- **Collaborative robots**: cobots.

- **Sensors**: Plug&play sensors for cobots with vision systems and motion tracking systems.

- **Quality**: SW and HW characterisation equipments with metrological performances for geometric (interferometer) and mechanical (indentation platforms).

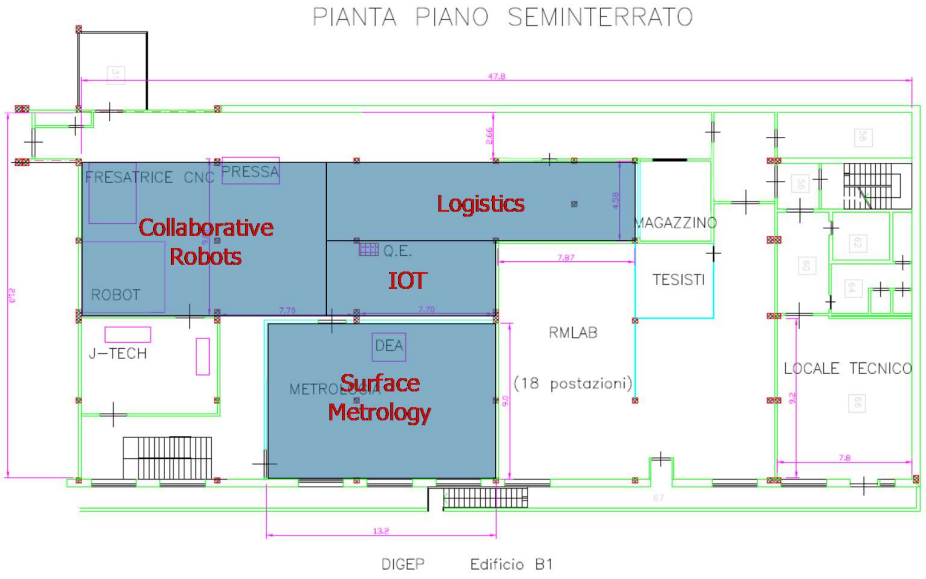
- **Product and Process Design**: several workstations, server, SW for CAD, PLM, ERP, MES and IoT infrastructure; upgrade of CMM cell both for CMM and its cell.

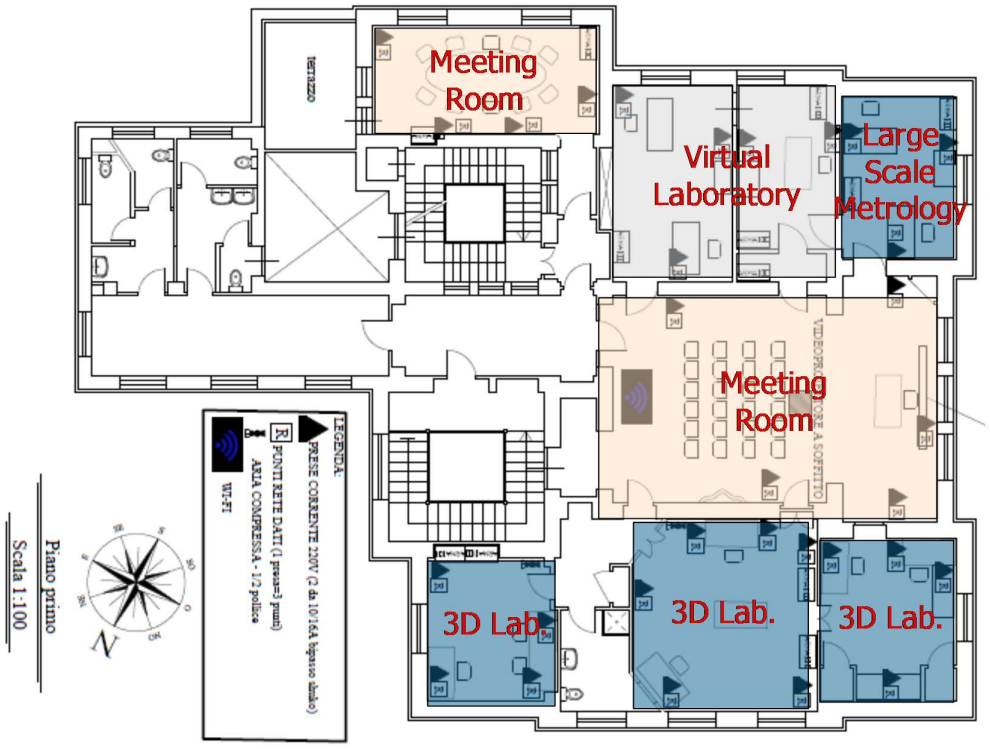
- **Plant logistics**: SW and servers to manage AGV, machine cubing and handhelds, bartag code machine, assembly benches, etc.

- **Sustainability**: sensors and workstation for data analysis.

- **3D simulation and modelling**: SW for 3D modelling, virtual and augmented reality, graphical modelling and acquisition scanning systems.

Below are shown the final status foreseen for the laboratories.





3 Dissemination activities

Within the previously described researches, dissemination and networking activities DIGEP hosted the 15th International Conference on Product Lifecycle Management (PLM18) held on 01-04 / 07 / 2018 with approximately 140 participants.

Also, the foreseen monthly lunch seminars regularly took place during the year. Below are indicated titles and authors.

25/01/2018
E. Pilone
Risk management and land use planning for environmental and asset protection purposes

15/02/2018
P. Ravazzi
Crescita economica e prospettive del capitalismo

26/04/2018
D. Lisitano
Spatial damping identification for enhanced dissipation layout design

24/05/2018
M. Galati
Development and validation of a model for the EBM process and visit at the IAM@PoliTo Center

21/06/2018
M. Orellano-Carrasquilla
Sustainable Business Models design for Product-Service Systems considering a collaborative pull-innovation approach

19/07/2018
F. Barravecchia
Service transformation in manufacturing companies & Service Matching

20/09/2018
I. Kambarov
Industry 4.0. Digital manufacturing framework for control industrial systems

25/10/2018
G. Piscopo
Mesoscale modelling of Directed Energy Deposition process

30/11/2018
G. Sansone
The Student Entrepreneurship Making Innovation (SEMI) project

4 Activity for the incoming year 2019

The future activities for the technological perspective are strictly connected to the reorganization of the laboratories. The due date for the completion of all the related works is the end of year 2019. For that time all the renovation work should be completed and the required equipment should be acquired and installed.

In any case, part of the experimental research is already active basing on the current laboratories and will be increased in the first part of 2019 by acquiring new equipment which will be temporary positioned in these laboratories. In particular, all the activities related to "Surface quality control" will be fully operational by the firs part of the year. The same for "3D modelling and simulation".

Part of the equipment for "Collaborative robots" and "Additive manufacturing" will also be ready for the beginning of the 2019. While, for the other areas of research, i.e. "Product and process design", "Plant logistics" and "Sustainability", the research will not be fully operational until the laboratories will be completed.

The expectation for the next year is to deeply increase the research in those fields that will benefit from the laboratories and the related equipment starting from the first part of the year, i.e. "Surface quality control", "3D modelling and simulation", "Collaborative robots" and "Additive manufacturing", and to intensify the activities in the other research areas, i.e. "Product and process design", "Plant logistics" and "Sustainability", when the laboratories will be ready.

Within the managerial perspective, based on the learning obtained in the projects on smart grids, workplace learning in the electrical sector and the digital transformation of the automotive industry, we plan to develop new research lines on the strategies and practices developed by firms, SMEs included, to face the middle skills gap produced by the technological change in place. Middle skills gap is the shortage in middle skilled roles that is complementary to technological change and that occurs due to the application of technologies like IoT, Big Data, AI on tasks related to product assembly, to installation, maintenance, repair of assets, to sales and marketing. In the same perspective, from the algorithmic point of view, we plan to prosecute the activity 2018 and search for different fields where the use of problem independent Linear Programming (LP) models could possibly enhance the performances of problem oriented algorithms.

With respect to the economical and legal perspectives, the aim is to further analyze the topics studied during the first year and start analysing new ones.

As for ultra-broadband, a full empirical analysis will be run in order to confirm the preliminary results which show that the presence of fast connections is a determinant for the creation of new enterprises at local levels as well as increasing the employment rate in those areas. Furthermore, a still preliminary analysis (Bourreau M., Cambini C., S. Hoernig and I. Vogelsang, "Co-investment, Opportunism and Potential Intervention", mimeo) on the role of investment sharing to improve the deployment of fiber networks and the regulatory policy problems related to such cooperation among companies will be hopefully completed.

As for AM, the survey will be submitted to firms operating in other industries in order to obtain a more representative picture of the adoption process and of the effect of the new technology.

The on-going project on AI will lead – in next months – first to draft a review of the economic literature to fix the main results and the approaches adopted. A second goal is to theoretically investigate the interplay between market mechanism, data availability and performance to understand the potential policy interventions by a regulator on data sharing and management. For example, an interesting avenue would be to investigate theoretically and empirically how privacy regulation (e.g. the trade-off between privacy intrusion and informativeness of advertising) can affect the structure of online markets, and the possible asymmetric effect of privacy regulation on small and large firms. A third research objective is to investigate the issues of skill composition of the work-force, changes in task-based production function and potential effect of Industry 4.0 fiscal interventions. To this purpose, we will first resort to the INPS micro data at the employee-employer level, as a possible source for the qualitative-quantitative microdata. The INPS database is in principle preferable because of its time-and cross-regional consistency. A fourth promising research avenue is to investigate the use of "smartworking contracts", which allows employees to work from home as incentive contracts that may substitute for the typical performance-related contracts. Anecdotal evidence suggests that many large companies and a growing number of mid-size firms have started to rely on these new contractual forms, lack of data has so far prevented a more systematic analysis of this change and not much is known about the costs, the effectiveness of (digitalized) monitoring, employees' preferences between monetary and non-monetary benefits, and kind of skills (tasks) that allow its implementation.

An additional topic which will be addressed is the effect of Industry 4.0 technologies on firm location choices, in order to assess whether these technologies induce the so-called back-shoring phenomenon as alleged by recent governmental programs.

In terms of dissemination, we plan to set-up a specific website of the project so as to provide there all relevant information. Also, as indicated in the project proposal, we expect to set-up in spring 2019 a daily workshop with presentation of the current research activity.

Finally, all the project activity will be integrated within the Department strategic plan which is requested to the Department as part of the general Politecnico strategic plan.