Industry 4.0: Opinion of a Roboticist on Machine Learning

By Francesco Missiroli

History of Industry 4.0 tracks the advancement in the manufacturing process that changed the way we think about human labor in the industry. In the second half of the XVIII century, we find the birth of the first industrialization process with the development of the first steam engine by James Watt as key factor of the first industrial revolution. It was largely beneficial in terms of manufacturing a number of various goods and providing a better standard of living for a wide part of modern world population. Machines allowed faster and easier production, and they made all kinds of innovations and technologies possible as well. Around 1840 the second industrial revolution picked up. Historians sometimes refer to this as "The Technological Revolution" occurring mainly in Britain, Germany and United States.

Such a new step was ignited by the use of different sources of energy and the advent of electricity was the key point of the second step of the industrialization as well as the birth of modern automotive assembly line with Henry Ford. One had to wait more than a century and two world wars to start talking about the third industrial revolution.

Around 1970 we can set the beginning of the third industrial revolution involving the use of electronics and IT (Information Technology) to further automation in production. Industry 3.0 introduced more automated systems onto the assembly line to perform human tasks, i.e., using Programmable Logic Controllers (PLC). In Industry 3.0, too, human work was increasingly taken over by machines, although automated systems were in place, they still relied on human input and intervention. The end of the 20th century is considered the beginning of Industry 4.0. The fourth phase is characterized by the introduction of the Internet and thus increasing digitization. Terms such as, robotics, artificial intelligence (AI), IT, clouds, self-learning algorithms and Big Data have emerged in recent decades. The proper adoption of relevant industry 4.0 technologies should lead to significant efficiency improvement and cost reduction in various industrial sectors: in this context of fast technology development the use of machine learning algorithms is a powerful tool to manage and extract trends from large datasets and convert them into useful information that can be integrated in assembly lines to have an efficient production and hence reduce the human workload. To explore this aspect, we asked to Professor Nicola Vitiello from the Scuola Superiore Sant'Anna (SSSA, Pisa, Italy) a few questions regarding the use of machine learning in the industrial environment. We selected him as a professional figure involved both in the research field of the university as in the industrial environment. Here below we report the short interview that we conduct with Professor Vitiello giving us the opportunity to explore the challenges of industry 4.0

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"ACCORDING TO YOUR EXPERIENCE, WHICH IS THE MAJOR CONTRIBUTION OR APPLICATION OF MACHINE LEARNING IN INDUSTRY 4.0?"

In my scientific activities, in large part on wearable robotics, the use of machine learning as a tool is for sure needed to improve control robustness especially in human–robot interactions. For what concerns the inclusion of machine learning in industrial environment, it is a diffused opinion that it provides chances to improve manipulators' capabilities in prediction of human behavior and hence promoting safety as well as efficiency arising from synchronization between the operators and the robots.

However, using of machine learning for such a purpose requires a large amount of data to extrapolate and predict motor behavior and hence extending the capability of industrial robots.

Yet, it is important keeping in mind that machine layer is not the main approach in control system design, but it represents an upper layer which add on top of classic control schemes, deriving from automation, a further refinement improving, prediction capability, stability and overall robustness.

In most cases, classic motion/force control can still result in a viable and reliable solution even in absence of a machine learning algorithm running in parallel.

Considering the extended computational capacity nowadays available, machine learning easily has become an extremely powerful tool, however,

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in robotics we cannot put aside classic control approaches, and it is my opinion that they still are the core for controlling robot interaction in a physical domain.

When we use machine learning, we rely on the algorithm decision to lead toward the optimal solution: yet, there is always a probability that the result is far from optimality, and this is highly dependent on the information we used to train the algorithm itself, which are always affected by uncertainty and errors.

In regulation of human robot interaction, physiology is still paramount, and yet partly unknown to us for many of its domains.

A deeper understanding of Neurology, Psychology, Neuroscience, associated to a wider knowledge of the physical phenomena underlying their working principles can provide more reliable information and datasets that can be used to better train those aforementioned algorithms and lead to a more robust regulation of human machine interaction.

Since my PhD studies in neurorobotics, I have been always entrenched by the idea that comprehension of the complementary dynamics of interactions between humans and robots is the key to fast forward industry 4.0, and machine learning can speed up such a process and provide viable solutions.

"WOULD YOU RECOMMEND A MASTER IN DATA SCIENCE OR A MASTER'S IN ANOTHER SPECIALISED FIELD IF YOU WISH TO FIND JOB OPPORTUNITIES IN THE INDUSTRY?"

Big data are an important trend in industry 4.0, extract and process them is fundamental in the development of a company and shape the future of industry especially because ML provide us with the chance of predict trends.

Development of new technologies is not the main challenge in industry, the turning point is to start a business out of it.

Data science and similar research fields are becoming a key ingredient in the development of a successful business; extract information from the market segment allows the manager of a company to have a clear understanding of the direction that has to take in order to lead properly the business.

Being able to manage big data, it is worth also for collaborative robot in the production line or every analysis that you want to perform inside a company to increase the productivity.

We need to reduce the human workload in the production line but we need also a clear evidence in terms of improvement of the business, sustainability and efficiency. Collect data and demonstrate by matter of evidence that it is worth to go in a certain direction, is the key point and it is possible if companies can rely on professionals that have a wide background not only in data mining or big data but also in the science related to the business they want to develop.

"DO YOU THINK THAT SOME COMPANIES OVER OR UNDERESTIMATE THE USE OF ARTIFICIAL INTELLIGENCE IN INDUSTRY?"

For what I experienced in industry and university, there are two different thoughts about this topic.

Some people are enthusiast about artificial intelligence, and they start to adopt early technologies relying on it mostly for what concerns artificial vision in industry.

It is a powerful tool, that can speed up the decision-making process in the production line and avoid specific paths leading to inefficiency but we do not have to overuse it.

On the other side, there are people that do not trust the use of artificial intelligence and they are still bounded to traditional methods.

In my opinion, we have to proceed with moderation, artificial intelligence and the possible applications that we can find for it are multiple and worth for the development of a company.

However, we have always to be able to evaluate whether the proposed solutions are applicable or not by matter of scientific evidence and, as mentioned earlier, with a solid knowledge of the physics behind.

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"DO YOU THINK THAT JOBS IN AN INDUSTRIAL ENVIRONMENT HAVE TO SWITCH FROM WORK STRICTLY RELATED TO THE PRODUCTION LINE, TO A ROLE OF SUPERVISION AND MAINTENANCE? WHAT DO YOU THINK ARE THE NEW JOB FIGURES TAKING A HUGE STEP IN WITH INDUSTRY 4.0?"

A clear and feasible prediction it is always a challenge in every scientific sector. Several job figures in industry 4.0 require having a solid background in physics, mathematics, chemistry and material science, as well in data science.

In my opinion, in this scenario of constant development, the figures that we can envision in the future of industry 4.0 are engineers with complementary expertise. There will be an increasing demand of engineers, in particular, engineers with a solid background, and with mature experience and resolution to address ill-posed problems.

The first step for these kinds of problems it is the identification of requirements; this it is already a challenge in a company where we have to identify the requirements of what you develop to be competitive in the market.

This is not something that we can acquire just with an engineer degree: it is a skill that you develop during a PhD program. Industry 4.0 will be every time more demanding for PhDs. It does not matter the topics that you address during the PhD, the important fact is that in the PhD you advance the knowledge in a certain field since PhD students are challenged with ill-posed problems. Robotics, Biorobotics, Material Science, Data Mining are all relevant for the 4.0 transition.

"IS THE ROLE OF ENGINEERS BECOMING A BASIC LAYER IN THE INDUSTRY? WHAT DO YOU WANT TO ADDRESS WITH ILL-POSED PROBLEMS IN INDUSTRY 4.0?"

One of the big challenges in industry is logistic; this it is an example of an ill-posed problem. There is a huge need of moving goods and this still relies a lot on human workforce provoking fatigue, physiological damages due to a prolonged effort by carrying heavy loads. In an ideal world, we do not want people incurring in fatigue or musculoskeletal disorders while working so we want to replace some jobs that are strenuous with others lead by the brain. Revolutionising the logistic it is an ill-posed problem because it means changing completely how goods are produced, managed, collected and distributed. This kind of transition in industry 4.0 for a sector as logistic requires PhDs able to face those challenges and understand the science behind. People could say that if we do this transition there will be jobs that can be lost but I am more positive and I believe that it will represent a transformation of the working life, and there will be other job figures that will emerge. If I were a young roboticist, I would like to revolutionise the logistic field and maybe try to produce wealth that can be then distributed to people that decide to do others kind of jobs. Due to aging of the population, in the future, there will be a dependency ratio between productive and not productive part of the population that will be biased toward the not productive one.

Therefore, it is important that in the long term, we start to face this problem and PhDs can be the key people in charge of this challenge.

NICOLA VITIELLO–FULL PROFESSOR SCUOLA SUPERIORE SANT'ANNA

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Nicola Vitiello (IEEE Member) (nicola.vitiello@iuvo.company) received the dual M.Sc. degrees in biomedical engineering (cum laude) from the University of Pisa, Pisa, Italy, in 2006, and from Scuola Superiore Sant'Anna (SSSA), Pisa, Italy, in 2007, and the Ph.D. degree in biorobotics from SSSA, Pisa, Italy, in 2010. He is a Full Professor with The BioRobotics Institute, SSSA, where he coleads the Wearable Robotics Laboratory. He is a coauthor of more than 100 ISI/Scopus papers and coinventor of more than 20 patents/patent applications. Dr. Vitiello was the Scientific Secretary of the EU FP7 CA-RoboCom project, and he was the Scientific Coordinator of the EU FP7 CYBERLEGs and the H2020-ICT-CYBERLEGs Plus Plus projects. He is currently the Scientific Project Coordinator of the national projects MOTU++ and BioARM, both promoted by INAIL, and is partner of the H2020-ICT-REHYB and H2020-ICT-CONBOTS projects. He is a Co-Founder, Director, and Advisor of IUVO Srl, a spin-off company of SSSA.

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