The Robotization of Extreme Automation: The Balance Between Fear and Courage

Jinan Fiaidhi
Sabah Mohammed
Lakehead University

Sami Mohammed
Victoria University

Editor:
Jinan Fiaidhi, Lakehead University;
jinan.fiaidhi@lakeheadu.ca

In our last column,[1] we have illustrated how FabLabs network can play an important role in shaping the future of manufacturing and automation. The focus was on people taking a collaborative role to design and build the most extraordinary things using tools and techniques that are available at FabLabs. In this direction, FabLabs is a platform of a community of makers who collaborate and learn from each other to build highly specialized products, rather than settle for the legacy mass production products. In this column, however, we are shifting our focus on the use of robots for extreme automation. Actually, "none of humanity's creations inspires such a confusing mix of awe, admiration, and fear as those associated with robots. We want robots to make our lives easier and safer, yet we can't quite bring ourselves to trust them. We're crafting them in our own image, yet we are terrified they'll supplant us".[2] The fears from the outcome of using robots reached some kind of far end as apocalyptic, resembling the biblical Apocalypse or the end of world.[3] These reactions describe the wind of change related to automation and manufacturing as many prominent people are asking important "what if" questions like what happens if a new technology based on robotics causes millions to lose their jobs in a short period of time, or what if most companies simply no longer need many human workers? Bill Gates, as well as many politicians, believes that governments should tax companies for using robots instead of people as a way to compensate the loss in employment and for retraining.[4] Others like legislators and lawmakers are trying to mature a robot law.[5] Actually, the notion that workers' skills can suddenly become obsolete

> The line between industrial robot tasks and collaborative robot tasks is beginning to blur, and collaborative robots may be poised to take market share from industrial robots. With the added capabilities of working with human safely, as well as being smart to achieve common goals, cobots and microbots are changing our future.

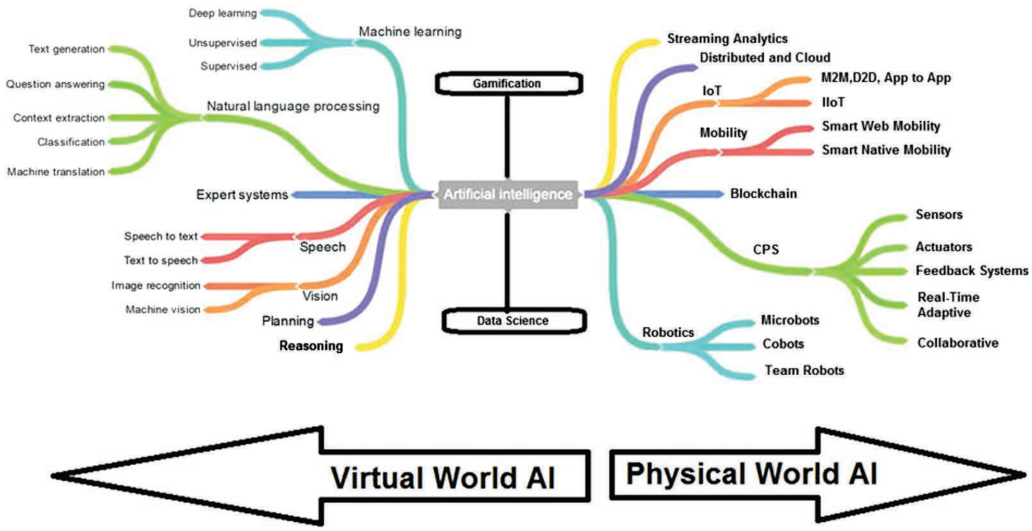

Figure 1. Robots as part of the physical AI world.

highlights a lively debate over how much and how fast technology will take over the workplace, and there's concern about whether the governmental institutions and social safety nets are equipped to deal with this increasing problem. These kinds of fears and concerns are growing in pace and scale, which is likely to be highly disruptive, and so, the growing anxiety cannot be easily wished away. Thus, many policies have begun to circulate, where some are still controversial, like universal basic income, negative income tax, and the government job guarantee among others. The fact that we have got a lot of jobs including new types of jobs is a good thing and automation is proved to be beneficial in general.[6] We cannot surrender to our fears, and we have to have the courage to make such balanced decisions in supporting robotization, as well as dealing with the cost associated with this new ecosystem. As Winston Churchill said, "Fear is a reaction. Courage is a decision." We need to make decisions to move forward boldly by rebooting our thinking on automation, taking the stuff from the past that still works, and remix it for this new world. The most important thing that we need to keep in mind is that as robots and machines get smarter and smarter, it becomes more important that their goals, what they are trying to achieve with their decisions, are closely aligned with human values. We need also to learn how to work alongside the robots that had replaced many of our jobs. Actually, robots have contributed to the new technological initiative, which is called Industry 4.0 or the artificial intelligence (AI) revolution, as they are providing the arm for implementing the smart applications that interact with the physical world. This means that by implication the AI paradigm is based on two worlds (virtual and physical), as Figure 1 illustrates, where the robotics is an important player of the AI physical world.

ROBOTS FOR EXTREME AUTOMATION

Robots are coming as the new workforce of manufacturing to work alongside humans. They are mainly classified as industrial robots and typically they are sort of articulated arms featuring six axes of motion (6 degrees of freedom). This design allows for the maximum flexibility. There are six main types of industrial robots: Cartesian, SCARA, Cylindrical, Delta, Polar, and Vertically Articulated. However, there are several additional types of robot configurations. Each of these types offers a different joint configuration. The joints in the arm are referred to as axes. Typical applications of industrial robots include welding, painting, assembly, pick and place for printed circuit boards, packaging and labeling, palletizing, product inspection, and testing, all accomplished with high endurance, speed, and precision.

Robot adoption in the manufacturing industry increased by an annual global average of 12% between 2011 and 2016, concentrated heavily in the automotive and electronic/electrical manufacturing sectors. According to the International Federation of Robotics, more than 3 million industrial robots will be in use in factories around the world by 2020.[7] Global sales of industrial robots reached the new record of 387 000 units in 2017. That is an increase of 31 percent compared to the previous year (2016: 294 300 units). China saw the largest growth in demand for industrial robots: up 58 percent. Sales in the USA increased by 6%—in Germany by 8% compared to the previous year. These are the initial findings of the World Robotics Report 2018.[8]

However, the customer demand for greater product variety is driving an increase in low-volume, high-mix manufacturing. Industrial robots, although they can be programmed to work for different settings, they cannot adapt and rapidly repurpose their production facilities in the same demanding speed. The need for smart factories, in which machines are digitally linked, is ever growing with the new notion of Industry 4.0.[9] Smart factories create a supply chain that shortens product development time, repurpose quickly, reduce product defects, and cut machine downtime. The smart factory ecosystem is used to describe the seamless communication between all levels of extreme automation to a fully connected and flexible system—one that can use a constant stream of data from connected operations and production systems to learn and adapt to new demands. Central to the issue of such ecosystem is the notion of "smart manufacturing units (SMU)," which signifies the opportunity to drive greater value both within the four walls of the factory and across the supply network. Every SMU is a flexible system that can self-optimize performance across a broader network, self-adapt to and learn from new conditions in real or near-real time, and autonomously run entire *production* processes. SMUs can operate within the four walls of the factory, but they can also connect to a global network of similar production systems and even to the digital supply network more broadly. SMU enables all information about the manufacturing process to be available when it is needed, where it is needed, and in the form that it is needed across entire manufacturing supply chains, complete product lifecycles, multiple industries, and small, medium, and large enterprises. In fact, the new advances in collaborative robots and assistive technologies such as exoskeletons expand the scope of tasks robots can perform in support of the SMUs integration and adaptivity. Other significant advances are also adding more positive effects in the era of smart factories like "Cloud Robotics," "Robot as Service," and Microbots. In the next section, we shed some light on some of these advances that have an important effect in increasing the uptake of robots for extreme automation. However, we may address some of these issues in our next columns as they relate to other aspects of the extreme automation initiative.

Advanced Low-Cost Robotics for Manufacturing

The current industrial robots are still pretty rudimentary—and expensive. They are typically been large, caged devices that perform repetitive, dangerous work in lieu of humans. These robots suffer from many problems like the vision issues as robots do not have the ability to identify and navigate around objects (including people) and dexterity issues as their gripping, maneuvering, and mechanical capabilities are still limited. As the digital technology advances and development of autonomous vehicles have driven down costs of off-the-shelf hardware, smaller, more dexterous robots have come onto the factory floor. Actually, low-cost robot designs poured in from around the world in response to many initiatives around the world like the Kickstarter campaign (www.kickstarter.com) advocating for a basic low-cost industrial arm for nontraditional markets like Fablabs. These lighter weight, lower cost robots can be outfitted with sensors that allow them to work collaboratively alongside humans in industrial settings, creating "cobots" or "FabLab robots"—robots that can perform tasks like gripping small objects, seeing, and even learning to tackle "edge cases." Niryo One (https://niryo.com/) is one example from the Kickstarter campaign where the low-cost industrial robot is a six-axis robotic arm, made for makers, education, and small factories. The robot is 3-D printed and powered by Arduino, Raspberry Pi, and Robot Operating System. STL files and code on the robot are open source. Niryo One is also the first industrial robot that can be connected to your home and can be accessed and controlled via the Internet. The introductory price of Niryo One is less than $1000. There are other examples like the Franka Emika (www.franka.de): a rather remarkable cobot arm. It is designed to be easy to set up and program and can operate right next to people, assisting them with tasks without posing a risk and it can build copies of itself. Now, all the big industrial robot makers are trying to develop their own cobots, but the most innovative designs have come from startups like the Rethink Robotics who pioneered the Baxter dual-arm robot in 2012 and, later, the single-arm robot called Sawyer. Both cobots are simple to use as their Intera software platform provides a train by demonstration experience unlike any other cobot. You can train these cobots by simply moving their arm and demonstrating the movements. With the introduction of Intera 5, Rethink Robotics has created the world's first smart robot that can orchestrate the entire work cell, removing areas of friction and opening up new and affordable automation possibilities for manufacturers around the world. Intera 5 is driving immediate value while helping customers work toward a smart factory and providing a gateway to successful industrial internet of things (IIoT) for the first time.[10]

Collaborative robots are now defined by ISO 10218, which defines five main collaborative robot features: safety monitored stop, speed and separation monitoring, power and force limiting, hand guiding, and risk assessment.[11]

1. *Power and force limiting*
   Robot force is limited through electrical or mechanical means.
2. *Safety monitored stop*
   Robot stops when the user enters the area and continues when they exit.
3. *Speed and position monitoring*
   Robot slows down when the user nears and stops if the user gets too close.
4. *Hand guiding*
   The user is in direct contact with the robot while they are guiding and training it.
5. *Risk assessment*
   Risk assessment of the application should be done to determine all possible risks and proper devices and procedures to mitigate the risk should be implemented.

Many cobots were successful in following these guidelines and achieving the highest sales among manufacturing companies like the Universal Robots cobots (https://www.universal-robots.com/).

Robotization Trend: From Cobots to Smart Microbots

There are many other low-cost industrial cobots that you can find by a simple search like KINOVA Ultra lightweight robotic arm (www.kinovarobotics.com), which is weighing in at just 4.4 kg and give the workers a performance, flexibility, and ease all in on with plug-and-play option developed with open architecture and compatible with ROS. However, the main challenge with cobots is not just the hardware and following the ISO 10218 standard but also the software to make it easily accessible to nonexperts and smart enough to collaborate with other human coworkers and cobots. What it does mean is that cobots need to be equipped with sensors, smart technologies, and algorithms that are linked with the IoT and/or specific systems like the vision system. Vision systems allowing robots to identify and safely navigate around objects were largely an afterthought. In recent years, vision hardware (such as lidar) has become much cheaper, more effective, and subsequently more widespread. Lidar works much like radar, but instead of sending out radio waves it emits pulses of infrared light—aka lasers invisible to the human eye—and measures how long they take to come back after hitting nearby objects. It does this millions of times a second, and then compiles the results into a so-called point cloud, which works like a 3-D map of the world in real time—a map so detailed it can be used not just to spot objects but to identify them. Once it can identify objects, the cobot can predict how it will behave, and thus how it should move. A good example of such cobot is the CES2018 for its ping-pong playing perfection (https://www.cbinsights.com/company/omron). However, the capability of such cobot in distinguishing what an object is and deciding how to move it is still a challenge or bottleneck. What is needed is a cobot that recognizes people's movements and gestures as well as the objects it is surrounded by including other cobots. A cobot allows real-time mapping of the workspace, in this way being able to adapt the movements of the robots to which it is connected. Smart cobots according to DARPA[12] need to be a small object of moderate weight capable of instantaneously recognizing and interpreting everything that is happening in the workspace, enabling the cobot to become more flexible and to react to sudden changes in the work process. DARPA announced a new program called short-range independent microrobotic platforms (SHRIMP). The goal is "to develop and demonstrate multifunctional micro-to-milli robotic platforms for use in natural and critical disaster scenarios." To enable robots that are both tiny and useful, SHRIMP will support fundamental research in the component parts that are the most difficult to engineer, including actuators, mobility systems, and power storage. To help overcome the challenges of creating such smart microbots, the first required stage is to enforce such microbots with optimized size, weight, and power or what is known as SWaP, which are just some of the constraints that very small robots operate under. One of the very first microbot was a "push button" that can push nearly any mechanical button and makes such dumb buttons smart through controlling it via your smartphone or a tablet from any distance through WiFi connection. The push button microbot can turn ON any device like the coffee maker at a scheduled time or it can be controlled wirelessly.

The next expected stage is to provide such microbots with smart algorithms to enable their work and collaboration toward achieving common goals. For example, at the University of California, San Diego, a research laboratory managed to develop a tiny 3-D-printed robotic fish smaller than the width of a human hair that can be used to deliver drugs to specific places in our bodies and sense and remove toxins. These microfishes are self-propelled, magnetically steered, and powered by hydrogen peroxide nanoparticles.[13] Actually, AI and machine learning capabilities have been quickly making their way into industrial robotics technology and microbots. In the never-ending quest to improve productivity, manufacturers are looking to improve on the rigid, inflexible capabilities of legacy industrial robots and make these robots smart, small, and effective. Good examples on adding such smart capabilities to the existing cobots or microbots are the FANUC Intelligent Edge Link and Drive IIoTs platform to create an intelligent system of industrial collaborating or team robots.[14] Kuka and Huawei[15] signed a deal to develop what could be another global network—built on the IIoTs—to enable the connection of robots across many factories. The companies say they plan to integrate AI and deep learning into the system. Moreover, if the power of the robot team work is combined with a ground-breaking technology like blockchain, it will make the industrial robotic operations more secure, flexible, autonomous, and even profitable.[16] Figure 2 illustrates the trends of using industrial robots starting from the traditional industrial robots and ending with team robots. The enabling technologies for such trend include smart algorithms, internet of everything, mechatronics, and blockchains.

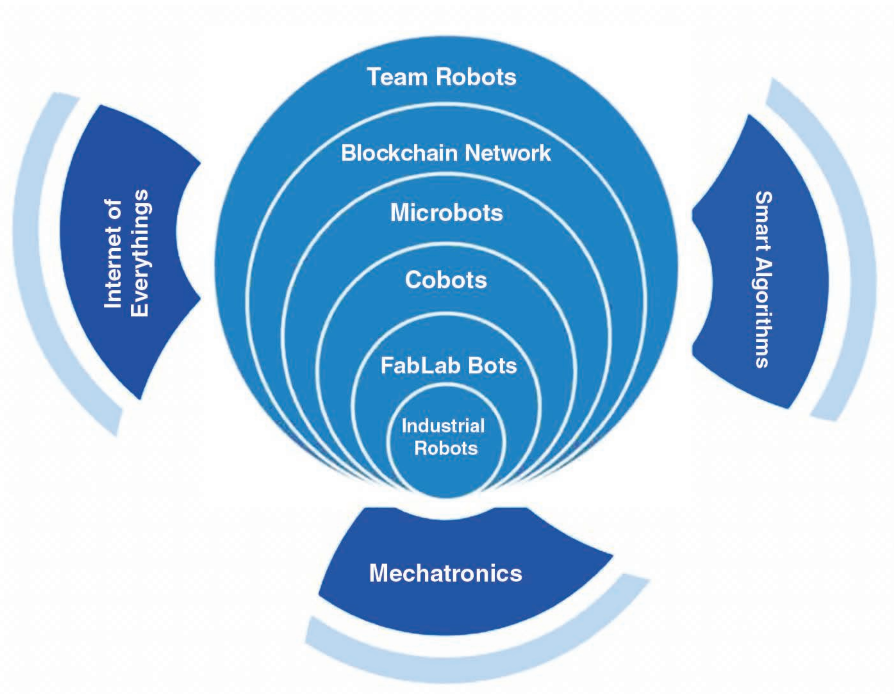

Figure 2. Robotization trends based on the notion of extreme automation.

CONCLUSION

Digitalization and the implementation of extreme automation as inspired by the Industry 4.0 will bring fundamental changes to industrial production and necessitate new products, solutions, and concepts. Robotization is the new reality that is going to change the manufacturing sector as well as our life. Robots are becoming smarter and cost-effective with time. Today a business may own few classical robots, but the day is not far when the significant parts of an industry would be managed by the new generation of robots. However, the main question that everyone asks is that we want robots to make our lives easier and safer, yet we do not want them to control our life and cause catastrophic loss of jobs. The challenge is to strike a balance between our fears and the benefits of such innovative technology, which can offer the enhancement to our life quality. This column has touched the surface of this exciting topic and we are encouraging you to contribute to this column by writing to the editor of this column on her email (jfiaidhi@lakeheadu.ca).

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ABOUT THE AUTHORS

Jinan Fiaidhi is a Full Professor and the Professional Engineer with the Department of Computer Science at Lakehead University. She is the Founder of Smart Health FabLab and an Adjunct Research Professor with the University of Western Ontario. She is also the Editor-in-Chief of the new IGI Global *International Journal of Extreme Automation in Healthcare*. Moreover, she is a Department Chair with the IT-Pro and the Chair of Big Data for eHealth with IEEE ComSoc. Contact her at jfiaidhi@lakeheadu.ca.

Sabah Mohammed is a Full Professor and a Professional Engineer with the Department of Computer Science and the Co-Founder of the Smart Health FabLab at Lakehead University. He is also an Adjunct Professor with the University of Western Ontario. He is the Chair of Smart and Connected Health with IEEE ComSoc. Contact him at mohammed@lakeheadu.ca.

Sami Mohammed is a Graduate Student with the Department of Computer Science, Victoria University. Contact him at smohamme@uvic.ca.

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