Industry 4.0 and the Futur Revolution for Human-Centered Industry

Adrien Brunet, Steffen Scholz
Institute for Applied Computer Science
Karlsruhe Institute of Technology
Karlsruhe, Germany
E-Mail: [adrien.brunet;steffen.scholz]@kit.edu

***Abstract*— The development of new technologies namely in the microelectronic and the communication domains drives a new industrial revolution. As every revolution, industry 4.0 will change our way of working and bring new opportunities and challenges. This paper presents the new technologies and human-centred applications related to industry 4.0. and concludes on what it will bring to humans and societies.**

Keywords-Human-centered industrial technology; additive manufacturing; Augmented reality; industry 4.0; Robotic.

I. INTRODUCTION ON INDUSTRY 4.0

The first industrial revolution appeared in the end of the 18th century in Europe. It has seen the development of the steam engine that tremendously increased the work force of the industry. Tasks that required before many men and horses have been replaced by machine. This new invention lead to the creation of railway systems with the steam locomotive.

The second revolution came at the turn of the 20th century with the electrification of the industrial production and the adoption of the Fordism and Taylorism for the mass production.

The third industrial revolution appeared in the second part of the 20th century. It concerns the development of semiconductors and programmable logic. Repetitive tasks executed my human workers have been replaced by robots and only the most complex jobs have been left to human.

Each previous industrial revolution happened simultaneously with changes in how human live and work. Today a new revolution is coming, it has different names, some call it the industrial internet of things [1] and others call it the industry 4.0. or even smart factories [2]-[4] This new revolution is emerging from the digitalisation and the connection of the industry to the internet. Figure 1 summarises the evolution of the industry since the first industrial revolution.

Considering those changes, it is important to ask the question: what will bring and change industry 4.0 for the human. The technological evolution that enable this new revolution are presented in Section II. In section III are listed the new human-centred applications. Then the hurdles on the road of lifework and societal improvement are given in Section IV and Section V is the conclusion.

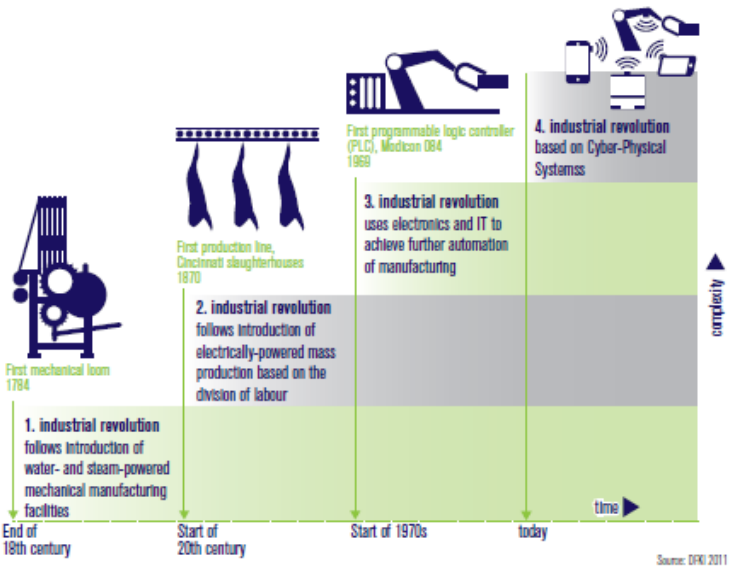

Figure 1. The four stages of the industrial revolution source DKFI 2011 [2]

 ISBN: 978-1-61208-538-8

II. THE ORIGINE OF INDUSTRY 4.0: TECHNOLOGICAL EVOLUTIONS AND INVENTION

Various technological evolutions and inventions (described in the following paragraphs) appeared in the last decades enabling the emergence of industry 4.0.

A. Miniaturisation

The first enabling technology for the industry 4.0 is actually an incremental development of the chip and semiconductor industry. Computer calculation power went in few decades from basic logic to complex meteorological model calculations. The miniaturisation and cost reduction of micro electro-mechanical systems (MEMS) filled our world of sensors, recording huge amounts of data. Dozens of sensors can be found in a smartphone such as accelerometer, gyrometer, heart rate monitor, fingerprint, light sensor, etc. In modern cars, even more sensors can be found.

B. Communication technology

The communication technologies made great improvement, such as in wireless communication system; nevertheless, the development of the internet was the breakthrough. It is now possible for anybody with an access to the World Wide Web to communicate with somebody else everywhere in the world. This changed radically our ways to exchange data and to conceive services. Nowadays many exchanges are dematerialized: books and music are files that can be download and read from everywhere at anytime. Object are less and less things that are made of atoms but made of bytes. This phenomenon of digitalisation is named the internet of things (IoT) [5].

C. Cyber physical system

Cyber physical systems (CPS) integrate computation, networking and physical process. It is this ability of machine to calculate ("to think") and to communicate that make the current evolution of the industry a revolution. Indeed, machine can harvest data, compute them locally, and adapt their reaction without human actions to be taken. For example, on a manufacturing line a temperature sensor send a voltage analysed by the machine as a value out of the safety range, then using an adapted algorithm the machine stops the process, and reduces the heat. The same machine connected to the internet and knowing more about the product history could take another decision.

D. Cloud and big data

The cloud and "big data" are enabling the CPS. As explained before sensors took place everywhere in our lives and this is even true in the manufacturing processes. Those sensors create data that are usually thrown away. The cloud enables company to store and compute big amount of data while they do not have locally super computer and important storage capacity. Big data analysis make it possible to answer the questions : "what is the pattern?", "what will happen next?" "what if we try this?" and "what is the best action?" This new way of analysing big amount of data is called predictive and prescriptive data analysis [1].

E. Digitalisation and additive manufacturing

Improvement in the previously quoted technologies as well as development in computer assisted design (CAD) technology and more recently 3D scanning of objects, accelerated the digitalisation of the industry. Nowadays libraries of 3D object exist in open source (3Dwarehouse, thingiverse, archive3D) [6]-[8] accelerating the democratisation of additive manufacturing. Additive manufacturing made possible for everyone to print a wide range of object, creating a breakthrough in spare part but also rapid prototyping and health along with other markets.

F. General consequences of the tecnological evolutions and inventions

It is expected that with the ability of factories to store, access and compute an increasing amount of Data, they will be able to:

- Control their energy consumption. They will be connected to a smart grid and will know when the power is available and the cheapest.
- Know the incoming and outcoming flows of raw materials, products, energy, waste, ect.
- Know when is the raw material at its best price and adapt purchasing to the manufacturing, stock and market situation.
- To be informed when a delivery will be made and if some delays are to be expected.
- Compare the actual data with previously recorded data and improve decision-making.

III. NEW HUMAN-CENTERED APPLICATIONS

Section II listed the technological evolutions that enable industry 4.0 and some of their consequences. This section focuses on the human-centred applications derived from the previous section and presents how industry 4.0 could change labour and human life in the new industrial revolution.

A. Safe Human-Robot cooperation

The German companies Festo [9][10] and ABB (ABB's YUMI) [11] designed robots that can work in cooperation with human. Indeed, standard robots move fast and are made of stiff material that if they interact with human they would most probably hurt them. To avoid any problem most of the robots are isolated and kept in a safe room. The idea of this new type of robot is to be able to help the worker in his tasks while preventing to hurt him. Repetitive, tiring and strength demanding task are ideal for robots while human have more dexterity and can solve more complex task.

 ISBN: 978-1-61208-538-8

B. *Augmented reality*

Augmented reality (AR) is "a technology that superimposes a computer-generated image on a user's view of the real world, thus providing a composite view". AR and namely smart glasses such as the famous "google glass" [12] can improve work experience and productivity. AR has many different applications. Among the applications that already exist are the (1) IKEA AR catalog application that can be downloaded on tablets and allow the user to visualise virtual furniture in his/her apartment using the tablet's camera [13]; (2) Converse AR catalog application that let users to try shoes while they stay home [14]. Implemented in the industry, augmented reality could guide the worker through complex tasks, for example assembly and reduce the potential mistakes [15]. It could help localizing an object in a store house, to visualise the inside of an object for maintenance or to guide worker by superimposing useful information on real object to achieve complex processes such as in Figure 2.

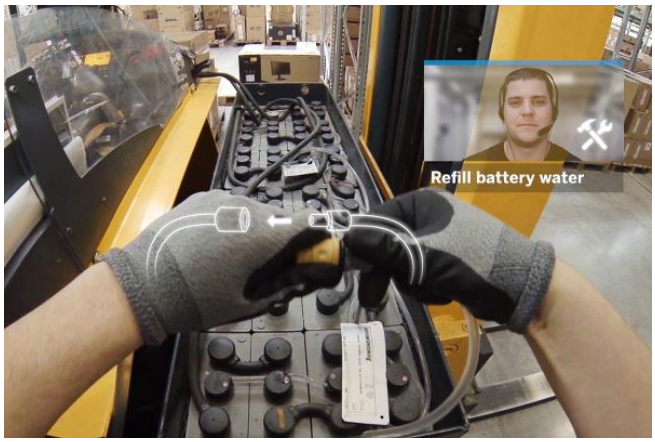

Figure 2. Augmented reality application to guide workers wearing smart glass [16]

C. *Telepresence/remote maintenance*

Thanks to the increasing number of sensors, many parameters of a machine can be harvested and coupled with a CAD model, thus creating a virtual twin of the machine. Instead of disassembling or coming on site for inspection, the employee can visualise and analyse the problem remotely from his office on screen. The telepresence allow the employee to remotely take action to solve the issue.

D. *Agile manufacturing*

Nowadays, manufacturing chains are dedicated mostly to one product and can accept changes in return for a substantial effort. With indusdustry 4.0 the production chain will be made of manufacturing modules that can be quickly reorganizised according to the demand and the available workforce while mastering the costs and the quality. This new way of conceiving production is called „Agile manufacturing" and is part of the answer to the increasing demand of mass customization and reduced lead time.

IV. THE HURDLE ON THE ROAD OF INDUSTRY 4.0

The report of the German federal ministry of education and research (Recommendations for implementing the strategic initiative INDUSTRY 4.0) [2] published in April 2013, lists the actual challenges as follow:

- Standardisation and open standards for a reference architecture
- Managing complex systems
- Delivering a comprehensive broadband infrastructure for industry
- Safety and security as critical factors for the success of industrie 4.0
- Work organisation and work design in the digital industrial age
- Training and continuing professional development for industrie 4.0
- Regulatory framework
- Resource efficiency

V. CONCLUSION

Similarly, to the theory of creative destruction expressed by J.Schumpeter [17] robots will have to replace the work previously done by human. Nevertheless, products are becoming more and more complex and so does the production; thus, skilled workers will be more than ever required in the factories. Nevertheless, in industry 4.0 the worker will not have to follow the pace of rigid and automated production, on the contrary robots will adapt to the workers.

The productivity will be improved by the new evolutions offered by the industry 4.0. Indeed, AR allow workers to efficiently complete more complex tasks in less time. An employee using telepresence can also improve his productivity by completing more task per day while he/she does not have to travel to carry out maintenance. This increase in productivity will reduce the costs and improve the competitiveness of every factory that will adopt industry 4.0. Because it allows machines to better control their energy consumption and reduce the travel of workers, the industrial internet of things is fundamentally environmental friendly.

To finish, it has been demonstrated that industry 4.0 will help our societies to sustain growth by increasing productivity and overcome great challenges, such as climate change, while keeping humans at the centre of the production.

 ISBN: 978-1-61208-538-8

REFERENCES

[1] A.Gilchrist, Industry 4.0 the industrial internet of things, 2016

[2] Forschungsunion & Acatech, Recommendations for implementing the strategic initiative INDUSTRIE 4.0, 2013

[3] K. Schwab, The fourth Industrial Revolution, 2017

[4] R Davies - European Parliamentary Research Service, Briefing, industry 4.0. Digitalisation for productivity and growth, 2015

[5] A. Rayes and S. Samer, Internet of Things From Hype to Reality: The Road to Digitization, 2016

[6] www.thingiverse.com [retrieved: february 2017]

[7] https://3dwarehouse.sketchup.com [retrieved: february 2017]

[8] archive3d.net [retrieved: february 2017]

[9] www.festo.com [retrieved: february 2017]

[10] S. Scholz, A. Brunet, T. Müller and A. Fuchsbauer, "Novel Nanoparticle Enhanced Digital Materials for 3D Printing and their Application Shown for the Robotic and Electronic Industry", proceding of the CENICS 2016 conference, pp. 27-30.

[11] ABB, A new age of industrial production. The Internet of Things, Services and People,2016.

[12] https://developers.google.com/glass/ [retrieved: february 2017]

[13] www.ikea.com [retrieved: february 2017]

[14] http://www.converse.com [retrieved: february 2017]

[15] World Economic Forum, Industrial Internet of Things Unleashing the Potential of Connected Products and Services, 2015

[16] www.itizzimo.com [retrieved: february 2017]

[17] J.Schumpeter, 1942, *Capitalism, Socialism and Democracy*

 ISBN: 978-1-61208-538-8