



TRANSFORMATION OF THE MACHINES FROM LEARNER TO DECISION MAKER: INDUSTRY 4.0 AND BIG DATA


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Abstract

When the historical journey of industrialization was reviewed, a particular paradigm shift can be observed because of every technological change and innovation. These paradigm shifts, called industrial revolutions, have changed the core from mechanics to electrical energy, from electrical energy to electronics and automation. Today's economy is about to face the fourth industrial revolution triggered by social, economic, technological and political changes. That revolution, known as Industry 4.0, is based on smart manufacturing, the implementation of cyber-physical systems in production (CPS), Internet of Things (IoT), cloud computing, and big data. In addition to the difference in production processes, the concept is planned to reveal personalized products and services. The fulfillment of all this depends on the continuity of the environment regarding innovation and learning. This continuity will be ensured by analyzing every data that may directly or indirectly affect the production process. Establishing such a data processing policy for today's classic factory structures is an essential competitive advantage. However, when it comes to smart factories, this policy will evolve into the big data analytics-driven one, and become a necessity beyond the competitive advantage. From this point of view, the role of big data in the Industry 4.0 concept and its impact on each stakeholder, which has different and variety contribution from production processes to qualified human resources, should be carefully examined. In this study, it is aimed to show the role and effectiveness of big data by presenting industrial applications and cyber-physical system architecture under the concept of Industry 4.0.

Keywords: Industry 4.0, Smart Factory, Big Data Analytics

MAKİNELERİN ÖĞRENENDEN KARAR VERİCİYE DÖNÜŞÜMLERİ: ENDÜSTRİ 4.0 VE BÜYÜK VERİ

Öz

Endüstrileşmenin tarihsel yolculuğuna bakıldığında, her teknolojik değişim ve yenilik nedeniyle paradigma kayması yaşandığı görülmektedir. Endüstriyel devrim olarak adlandırılan bu paradigma kaymaları, merkezi; mekanikten elektrik enerjisine, elektrik enerjisinden elektronik ve otomasyona değiştirmiştir. Günümüz ekonomisi, toplumsal, ekonomik, teknolojik ve politik değişiklikler tarafından tetiklenen dördüncü endüstriyel devrim ile yüzleşmek üzeredir. Endüstri 4.0 olarak bilinen bu devrimin temelinde, akıllı üretim, üretimde siber fiziksel sistemlerin uygulanması (CPS) nesnelerin interneti, bulut bilişim, büyük veri bulunmaktadır. Kavram sayesinde üretim süreçlerindeki farklılığa ek olarak, kişiselleştirilmiş ürün ve hizmetlerin ortaya çıkarılması planlanmaktadır. Tüm bunların yerine getirilebilmesi ortamın, inovasyon ve öğrenme bakımından süreklilik kazanmasına bağlıdır. Bu süreklilik ise ancak üretim sürecine giren-çıkan, üretim sürecini dolaylı ya da doğrudan etkileyebilecek her verinin analiz edilebilmesi ile sağlanacaktır. Klasik fabrikalar için rekabet avantajı sağlayan verinin analizi; söz konusu akıllı fabrika olduğunda büyük veri analitiklerine evrilecek ve rekabet avantajının ötesinde zorunluluk haline dönüşecektir. Bu açıdan değerlendirildiğinde büyük verinin Endüstri 4.0 kavramı içindeki yeri ve üretim süreçlerinden nitelikli insan kaynağına kadar her paydaş üzerindeki etkisi dikkatli bir biçimde incelenmelidir. Bu çalışmada Endüstri 4.0 kavramı altında büyük verinin rolü ve etkinliği, endüstriyel örnekler ve siber-fiziksel sistem mimarisi bakımından sunulmaktadır.

Anahtar Kelimeler: Endüstri 4.0, Akıllı Fabrikalar, Büyük Veri Analitikleri

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1. Introduction

The German government first introduced the concept of Industry 4.0 in November 2011 via the article 2020 High-Tech Strategies. This new type of industrialization which includes the effective use of the information-mechanic-electrification trio was named Industry 4.0, and that concept was put on Germany's agenda again in the industrial exhibition held in April 2013 in Hannover and was soon accepted as a national strategy [1,2,3]. Figure 1 presents the historical developments of industrial revolutions and their scope [4].

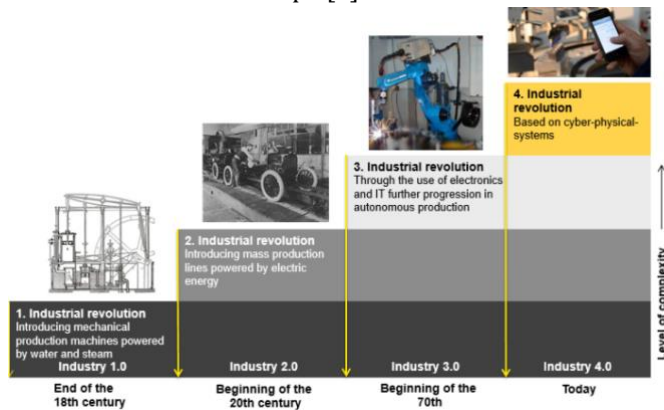


Figure 1. Industrial revolutions.

The fundamental idea of the Industry 4.0 is to build an interactive production process by creating the machines (robots [5], cobots and etc. that are quick learning and responding. Execution of such an idea is based on the internet of objects, big data analytics, and the active use of cyber-physical systems (CPSs) [6, 7, 8, 9]. The results of that execution can be divided into three hypotheses [10,11]:

- Hypothesis 1: Effective use of the machines (robotization/automation), which have a robust communication infrastructure and ability to rapidly access the information they need, in every process from engineering to diagnosis, from industrial production to agriculture. The most basic example of this hypothesis is the smartphones, which is an indicator of the individual's need for information and being connected.
- Hypothesis 2: (Existence of data-tsunami). In the design of CPSs, every single unit, from the machines to a straightforward product, must be connected to the internet. Thus every piece of the production process becomes a data object in the digital world. Additionally, those objects have an active role in producing the data.
- Hypothesis 3: In conjunction with Hypothesis 2, those objects will be able to store all kinds of information about themselves and their tasks. Thereby they can make the necessary updates within milliseconds in their functions and structures in order to optimize the process without an asking for continuous permission. Such

kind of transformation will turn that objects into the living things in the digital world. The idea of drifts of mankind to chaos, related to the rise of machine fall of human, can be based on that hypothesis.

Including all three hypotheses, Industry 4.0 presents a new perspective based on improvement not only the production process but also individuals' daily life. By taking the low-level tasks from human workers, by creating new jobs opportunities based on human skills and building individualized products and services, an individual's lifetime will become more qualified. Giving the vehicles the ability to adjust their speed and fuel needs according to their destination, building the smart traffic lights that balance the time of red and green lights based on traffic flow can be accepted as the most basic examples of that idea. Despite the possibility of building those examples by using existing technologies, the main difference that revealed via Industry 4.0 is to transform them into the objects can make instant optimum decisions. Even taking into consideration only one of the examples, such as the traffic light, it is clear that the objects, balance the traffic flow, should deal with big data comes from weather, date, daytime information, news, location, historical data. Besides, those objects, interact with each other, contribute not only to make decisions but also increase data. In this context, creating a successful Industry 4.0 strategy is distinctly related to focus on the concept of "big data analytics".

2. Industry 4.0 and Human Role

Technologies, designs, and ideas that have not yet been realized with the concept of Industry 4.0 have also come to the agenda. That explorative change and renew is not just object-based, individuals should also need to upgrade themselves. The invited speaker of the Conference of Digitalization of Industry and Evolution of Industry 4.0, Eric Weik (Secretary General of the German Chamber of Industry and Commerce) stated: "as in every industrial revolution the individual will find his/her place by renewing himself/herself and this is inevitable". The self-renewal of the individuals and upgrading their role in the production process from low-level jobs to high-level ones are closely related to the improving his/her skills that be required in the new industrial revolution. The most critical skills expected of the individual with the transformation brought by Industry 4.0 are given in Table 1 with today's expectations and 2020 estimates [12].

When Table 1 is examined, it is seen that problem-solving skills will be essential and that the creativity at the bottom is increased to the top level. This shows that, with the execution of on any standard work that done without creativity by machines/robots, the human can play the role of explorer and creator in the production process.

Table 1. The most critical skills expected by the individual, today's expectations and 2020 estimates.

2020 Estimates	Today's Expectations
Complex Problem Solving	Complex Problem Solving
Critical Thinking	Coordinating with Others
Creativity	People Management
People Management	Critical Thinking
Coordinating with Others	Negotiation
Emotional Intelligence	Quality Control
Judgment and Decision Making	Service Orientation
Service Orientation	Judgment and Decision Making
Negotiation	Active Listening
Cognitive Flexibility	Creativity

3. Industry 4.0 and Big Data: The Industrial State of Mathematics

In order to ensure decision-making and to improve the in business processes, it is essential to obtain as much information as needed from the data. In today's world, enterprises collect and process data at high speeds, integrate the result into production processes and thus provide a competitive advantage [13]. The concept of Industry 4.0 foresees a radical change in production processes shortly. That radical change refers to the transformation of an ordinary machine used in production into a machine, which is self-learning, instant decision-making, and in interact with its environment. For example, when that machine is assigned a task, it will be able to make itself compatible with the task. By calculating the predecessor and successors of the task, it will be able to optimize the quality and efficiency in the production process. In that transformation of the machine, the actions like access to data, analysis and extracting the valuable information, must take place very quickly. However, Lee et al. claim that existing data analysis methods are insufficient to provide such transformation [14]. This will require big data analytics platforms and also data scientists with the knowledge and skills to follow and manage the process on these platforms [15]. However, it is expected that this need cannot be met by qualified human resources and this need will increase by 20% -50% by 2020 [16,17]. Additionally, satisfying the need and building big data platforms is not sufficient to complete the transformation focused on the new industrial revolution in the establishment. The process based on big data analytics needs to be implemented by constructing a model that conforms to the Industry 4.0 structure. GTAI (Germany Trade & Invest) claims that 10 V of big data will be discussed with 6 C in the world based on Industry 4.0 [18].

- Connection (sensors and networks)
- Cloud (computing and instant requests)
- Cyber (models and memories)
- Content / Context (meaning and correlation)
- Community- (sharing and cooperation)
- Customization (personalization and value)

The concept of Industry 4.0 will ensure that every object and every product involved in the production is transformed into a machine that produces large amounts of data. Dieter Becker (automotive specialist) from KPMG stated that every produced car is a big data production machine. This requires big data analytics as a core area of expertise in all production sectors in order to create innovative products/services. The main source of that is to understand the customer better and even to create objects that can update itself by giving individual-specific responses. One of the best examples of this expectation is an application, which is self-learner of customer needs, developed by the Fraunhofer Institute for Intelligent Analysis and Information Systems, Nolte & Lauth consultants and Berylls strategists. That application, which is presented as a new lifestyle configurator of Mercedes-Benz, also contains a simultaneous recommendation system for identifying the future needs of the automotive sector in particular. The configurator can configure and customize a possible hundred thousand vehicles by evaluating some different parameters [19]. It Execution of such an object, which is a self-learner and has an expanding information base, requires expertise in big data analytics. The other best example, based on big data analytics, is a special system that increases the learning capacity of the machine, it was developed by the ITRI (Industrial Technology Research Institute). That system that contains advanced machine learning algorithms can predict the problems, system errors and the quality of the product. It also provides 96,49% accuracy and 3.51% false alarm rate to predict the quality of the next component (Go / No Go)[18]. Both examples, Mercedes and ITRI, show the significance of big data environment in order to create self-learner and responsive systems that has artificial conscious. Lee et al. (2014: 3-8) state that big data analytics are key to establishing sustainable and innovative factories in the world of Industry 4.0. Table 2 presents the differences between the current and the Industry 4.0 factories [21]:

Table 2. Comparison of current and Industry 4.0 factories.

	Data Source	Classic Factories		Factories in Industry 4.0	
		Specification	Technology	Specification	Technology
Component	Sensor	Precision	Smart Sensors and Error detector	Self-Aware Self-Predict	Degradation Monitoring Remaining Useful Life Prediction
Machine	Controller	Producibility & Performance	Condition-Based Monitoring & Diagnostic	Self-Aware Self-Predict Self-Compare	Up Time With Predictive Health Monitoring
Production System	Networked system	Productivity& OEE-Overall Equipment Effectiveness	Lean Operations: Work And Waste Reduction	Self-Configure Self-Maintain Self-Organize	Worry-Free Productivity

When Table 2 is examined, it can be seen that with the frame of Industry 4.0, the trio (component-machine-production system) transforms into the able-capable things. Such design can be achieved by advanced machine learning algorithms and big data analytics.

Figure 2 shows the general framework of factories in the Industry 4.0[22].

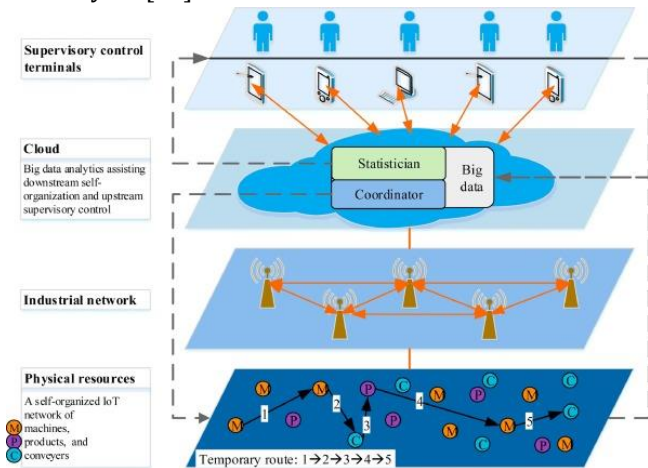


Figure 2. Smart factories in Industry 4.0.

Big data plays a significant role in the execution of the smart factory structure. It is seen that at least one of the systems such as intelligent analytics, multidimensional data correlations, estimators, decision support systems, is involved in all levels of the cyber-physical system's architectural designs. This is the most basic evidence that big data analytics is an element that cannot be ignored in the CPS architecture [21, 23, 24].

4. Conclusion

In today's organizations, data is often stored without any strategy and/or policy. Besides, desire for rapidly extracting the information from collected data directs the organizations to build a general environment for big data analytics whose success and suitability have not been investigated. Overcoming such a situation and the use of power provided by big data depends on the ability of organizations to employ individuals who know big data technologies and can strategically manage it [25]. From this point of view, equipping these individuals from the undergraduate level will ensure that the need for

qualified employees will be met. When considering the engineering and business based departments in Turkey, it is understood that there are data mining courses, based on general topics, and a minimal number of big data/big data analytics courses in the undergraduate level. Cooperation between academia and industry needs to be tightened [26] to ensure the successful implementation of the Industry 4.0 process. In order to achieve such cooperation, not only physical but also cyber laboratories should be established where academic and industrial developers can work together on solutions. Additionally, policies for secure data sharing between both organizations must be enabled. In fact, in his study published in the Nature, Kusiak emphasized that the lack of data strategies is one of the gaps in the realization of the innovation to be needed in Industry 4.0 [25]. In the article published by Drath and Horch in 2014, it was asked whether the concept of Industry 4.0 was a success (Hit) or a hype [1]. Today "is it a hope for building an developing societies?" has been added to that question. In Turkey, it is possible to say that the concept can be evaluated as Hit regarding the studies carried out in the field of Industry 4.0 and digitalization of industry and examples of good practices. However, the sustainability of that success (transformation of Hit into Hope) and obtaining the advantages for global competition depends on the knowledge and skill level of the young people working in these companies in the future. According to the research on students of Management Information Systems (MIS) and Information Technology (IT) based departments, conducted by Ozdemir and Erkollar, only 45% of the students have the necessary information about Industry 4.0 and its triggering technologies [27]. In this case, it is clear that the learning of the concept concerning opportunities and threats that supported theoretical and practical applications is essential. Design of that applications based on big data analytics and support of the Start-ups of undergraduate students will provide to be able entering the global market with the competitive advantage of data science and the internet of things.

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