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Industry 4.0: Key features, adoption, and barriers

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Abstract

Industry 4.0 (I4.0), which has captured the attention of many industrialists, governments, and institutions since its publication in 2011 has led to digital transformation**.** Digitization and integration are central to I4.0, which involves the entire product life cycle. I4.0 focuses mainly on the development of smart manufacturing by utilizing innovative technologies in order to develop smart products. Businesses in the 21st century need I4.0 to survive. In this study, the basic features of I4.0 are presented and the various barriers to implementing it are described. The study concludes with a few observations based on the findings of the research.

Introduction

The fourth industrial revolution is the result of innovative technologies being integrated into production environments. The cyber-physical systems and the industrial internet of things are important components of Industry 4.0 (I4.0) that connect types of machinery, devices, workforce, and enterprise platforms [1]. Different enabled technologies are expected to enhance the quality of parts and various services offered by business firms autonomously under dynamic environments [2]. Sustainable performance with the use of available resources is one of the essential features of I4.0. The I4.0 concept is basically invented to create a strong interaction base among human – systems/services in production environments to improve the working atmosphere and thereby increase the quality standards of parts produced [3].

The I4.0 systems may help improve manufacturing firms' agility to produce smart products by integrating various production machines with autonomous decision-making resources. The I4.0 approach make autonomous interest among industrialists around the globe to reach customers with the best possible quality products. This is made possible with the use of information technology, computer, and electronic systems in the production and service sectors. With I4.0 technologies like digitalization and high-level automation, factories become flexible and intelligent in dynamic working environments by equipping sensors and objects. The main goal of the I4.0 methodology is to produce a variety of products flexibly at high production rates with reduced costs and wastage.

The I4.0 initiative is new, and its adoption is not the same in different countries geographically due to a lack of appropriate information. Some developed nations like Germany, the USA, Japan, China, and Europe countries have adopted and implemented the I4.0 approach in their manufacturing firms and progressing to obtain the best possible results from it. Economically and socially backward or developing Nations like India, the Middle East, and African Nations have been negatively affected because of high levels of technologies, cost, and low levels of information. There is an argument that the gap between developed and developing Nations has constantly increased to the adoption and implementation of the I4.0 ideology. From the major research databases, it is understood that investigators are trying to provide information about the adoption and execution of I4.0 principles. The present work is an attempt to discuss the key features and barriers to the understanding of the I4.0 philosophy and implement it effectively and efficiently.

The main features of I4.0 paradigm

The term Industry 4.0 can be expressed in several ways and can be explained as the combination of various emerging concepts and main components that compose I4.0 [2], such as artificial intelligence, big data, autonomous robotics, cloud computing, simulation, augmented reality, and Internet of Things. By transforming centralized and analog workflows into decentralized and digital manufacturing operations through the use of advanced technologies found in I4.0, the potential for restructuring all production systems is vastly improved. The main features of I4.0 are described as follows [4-5]:

i. Industrial internet of things (IoT): The IoT is a communication network that allows interconnected computer systems to communicate with each other and provide a worldwide service to users by connecting to the Internet and is becoming extraordinarily necessary for a wide variety of modern applications.

ii. Cloud Computing: A cloud computing system is a system with a virtual server, which stores the required software applications, programs, and data, and which can be accessed from any computer system. In addition to that, the CC service allows users to store their data online, quickly and conveniently, using the web-based tool that CC provides.

iii. Big Data: There will be a large amount of data generated as products are manufactured in any industry due to the interconnected heterogeneous systems and processes that are used to produce them. There are three types of data generated through this method: structured, semi-structured, and unstructured data. Studying and analyzing the three large data sets requires a lot of time and money as the method of analysis requires more time and money.

iv. Simulation: In accordance with the I4.0 guidelines, a concept of digital manufacturing has been outlined through the integration of various systems and processes with the internet of things and artificial intelligence to enable digital manufacturing. The complexity of digital manufacturing systems makes it difficult to estimate the performance of these systems through the use of mathematical models conceived as a method of analysis.

v. Augmented Reality (AR): Modern human beings face a number of challenges when it comes to living in today's society. Augmented reality (AR) has proven to be a highly innovative way of overcoming these challenges. Using augmented reality technology can be used to enhance the performance of humans by providing the required information for a specific task at the press of a button, so that the efficiency of a task can be increased.

vi. Additive Manufacturing (AM): In additive manufacturing, parts are produced by layering data from CAD (computer aided design) files directly from the data input to the machine. A CAD platform is directly connected to an additive manufacturing system so that smart parts can be created by dropping them drop by drop, or layer by layer, as they are manufactured.

vii. Horizontal and Vertical Systems Integration: Industry 4.0 is regarded by many as the “new era” of smart manufacturing, as it is the result of combining automation with information sharing and working within a highly collaborative environment between various organizations. I4.0 refers to horizontal and vertical integration of systems as different types of system integration, which are considered distinct from each other.

viii. Autonomous Robots: By utilizing robots that can be reconfigured with programming technology, manufacturing sectors are rapidly moving away from mass production and focusing on batch production or personalized production. It is possible to have a wider range of variations when using this feature, enabling products to be more flexible and more customizable.

ix. Cyber Physical Systems (CPS): In today's digital age, almost all devices are automatically connected to the internet, creating IoT, virtual environments, and remote access to data that is stored in the cloud. This has a significant impact on all sectors of society, including business. It may lead to a significant risk of vulnerability changes in the connected people and the enterprise information at large, resulting in serious problems for those who are exposed to those vulnerabilities.

Implementation barriers of the I4.0 ideology

It is true that the I4.0 concept has numerous advantages, but there may also be some hurdles that prevent it from being adopted and implemented in real practice [6]. There are three types of barriers that can be classified as follows:

i. **Barriers caused due to governments:** a lack of support and inappropriate policies from the government, uncertainties surrounding the legal system, a scarcity of resources, potential security risks arising from value chains, the inability to integrate value chains efficiently, a lack of suppliers who are specialized and diversified, inadequate legislation and regulations, and inadequate fiscal policies.
ii. **Barriers caused due to management:** Poor organizational management support, lack of economic resources, lack of research and development activities, absent or low digital infrastructure, inadequate training sessions for the workers, uncertainty about return on investment, poor or no financial infrastructure, insecurity of data, and security of personal information.
iii. **Barriers caused due to employees:** A tendency to resist organizational change, a lack of experience among the employees, the unavailability of funds for self-improvement, misinformation, lack of awareness, an inadequate waste management system, a lack of leadership and responsibility on the part of the organization, and a lack of knowledge that combines a variety of disciplines.

Conclusion

Following is a summary of the major conclusions derived from the study:

i. Industry is a complex, agile process integrated with machine-human activity
ii. Manufacturing businesses benefit from Industry 4,0's technological innovations.
iii. I4.0 enables customer-centric solutions
iv. Improved product quality is ensured by I4.0 tools
v. I4.0 is reviewed in detail with a focus on its key features
vi. Industry 4.0 poses several technical, organizational, and management barriers to execute
vii. The key barriers that must be overcome by the government, management, and employees in order for I4.0 to be implemented are outlined
viii. For enterprises to remain competitive in a global environment, Industry 4.0 must be implemented.

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