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Review Article

How the Third and Fourth Industrial Revolutions Differ

[1]Sarafadeen Leye Lawal,[2]Livingston Sunday Aduku, [3]Muhammad Ahmad Baballe*

[1, 2, 3]Department of Mechatronics Engineering, Nigerian Defence Academy (NDA), Kaduna, Nigeria.

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***Corresponding author:** Muhammad Ahmad Baballe
Department of Mechatronics Engineering, Nigerian Defence Academy (NDA), Kaduna, Nigeria.
ORCID: 0000-0001-9441-7023

Abstract

With its rapid technical developments and integration of state-of-the-art digital technology into everyday life, Industry 4.0, also known as the Fourth Industrial Revolution (4IR), is revolutionizing the world. Building on earlier industrial phases, this revolution propels important advancements in engineering, business, manufacturing, and technology. Industry 4.0 presents significant obstacles in addition to its many advantages, which include increased productivity, economic expansion, better quality of life, informed decision-making, and sustainability. These include escalating inequality, increasing cybercrime, technological dependency, job displacement by AI, and privacy concerns. In order to guarantee that technology advancement benefits humanity, this paper explores the contradictions of Industry 4.0, highlighting the necessity for equilibrium. The study promotes the use of technology to increase human flourishing, societal well-being, and equitable economic growth. The distinction between the third and fourth industrial revolutions has been covered in this study.

Keywords: *Third Industrial Revolution (3IR), Digital Globalization, Fourth Industrial Revolution (4IR), Digital Transformation, Internet of Things (IoT).*

I. INTRODUCTION

The Fourth Industrial Revolution and its Impact on the Development of the High-Tech World. Today, a new phase of the scientific and technological revolution is coming with the relocation of the world's industrial, manufacturing, and scientific centers. The Fourth Industrial Revolution, which includes three areas, such as information, physics, and biology, is changing its shape. Technological innovations include global collaboration, digital capabilities and acceleration, and use of basic research facilities and equipment. The 2030s will require a strong scientific and technological nation and scientific and technical talent, which will be expanded with new discoveries, technologies, and scientific and technical talent that are more diversified and internationalized in the context of the development of digital transformation of education in the European Union [4]. The concept of the Fourth Industrial Revolution, which is already evolving to 5G, has extremely significant and far-reaching implications. In recent years, technological advances such as next-generation information, new materials, new power, and life sciences have continuously given rise to emerging industries, and transformative sectors such as artificial intelligence (AI) and blockchain have developed rapidly. The concept of the Fourth Industrial Revolution (4IR) has been increasingly recognized by all segments of society and has also gradually gained attention. The Fourth Industrial Revolution (4IR) affects technological innovation, social progress, and economic development in a comprehensive manner, as well as talent demand, especially scientific and technological ones. The new conditions of globalization, modernization, and internal contradictions of the knowledge and technology systems are giving rise to a new round of scientific and technological revolution characterized by environmental friendliness, intelligence, and omnipresence. As a result of these processes, there is a profound expansion of information technology, biotechnology, new material technologies, and new power technologies, which are contributing to the emergence of new digital innovations. The Fourth Industrial Revolution (4IR) is the embodiment of the scientific and technological revolution in its industrial transformation, which is evolving into the Fifth. Dominant technologies are emerging in the form of technology clusters, including next-generation information technologies, new energy technologies, low-carbon green technologies, and life sciences. Interdisciplinary integration and development are affecting people's cognitive structure and working methods. Major breakthroughs in interdisciplinary issues require new demands on systems thinking and teamwork. The frontier fields are constantly expanding, and materials science is evolving towards micro-depth, macro-extension, and extreme conditions. Digital breakthroughs are occurring in major scientific fields such as the structure of matter, the evolution of the universe, the origin of life, and the nature of mind, which require the development of smart education and smart business [5]. The development of a new generation of information technology and equipment industry directly affects the way of scientific research and innovation. The development of neurocognitive science contributes to a deeper understanding of cognitive models, which has a positive impact on the progress and breakthroughs in other areas. The actual needs of the ecological civilization are contributing to major breakthroughs in many fields of technology. A significant part of people's quest for a better life is the desire for a better ecological environment. Previous scientific advances and technological revolutions have brought human progress to unprecedented heights but also caused many deep-rooted environmental problems. A significant part of creating a new stage of the scientific and technological revolution is to meet the real needs of improving the ecological environment and to achieve harmonious coexistence between humans and nature, which will be one of the important components of the current stage of the digital revolution.

II. LITERATURE REVIEW

In this paper, we explore the literature on the evolution of the Industrial Revolution as well as the characterization of each phase. The characterization forms part of the foundation towards the development of a comprehensive body of knowledge on the Digital Industrial Revolution as well as its evolution over the years in tandem with the Industrial Revolution. The outcome of the body of knowledge is to establish a foundation for a broader study on the socio-economic dynamics of the Digital Industrial Revolution and how such dynamics can be exploited for socio-economic development in Africa [1]. This research will provide academics with a better knowledge of evolution theory and digital leadership and recommendations for additional research on must-have issues to gain a better knowledge of digital leadership in the public sector throughout the industry. 4.0 transformation [2]. The article analyzes the fifth generation of 5G mobile telecommunication systems, which is a new wireless communication standard that will bring significant improvements in the data transfer speed of connecting many devices simultaneously [3]. This revolution also brings challenges, such as the need for project managers to continuously update their skills and resistance to cultural change within organizations. To adapt, it is essential to invest in digital training and agile methodologies. Recent studies highlight that the proliferation of technologies such as robotics, AI, and big data is transforming the job market and requiring new competencies. Research also shows how 5G and IoT are transforming industrial applications, necessitating new decentralized communication mechanisms. In summary, the Fourth Industrial Revolution presents a landscape full of opportunities for innovation and efficiency, but it requires project managers to develop new approaches and adapt to the demands of a constantly changing environment [6]. This paper presents the first integration of industrial digital models with a 5G digital model, implemented as an Asset Administration Shell (AAS) of a 5G system. The two models are interconnected using an OPC-UA-based interface. We evaluate the impact of the integrated model using a use case where automated guided vehicles (AGVs) transport material from a warehouse to production lines. The AGVs periodically exchange their positions over 5G to avoid potential collisions. If the communications fail, the AGVs stop for safety reasons until a reliable 5G connection can be guaranteed. We demonstrate that, by integrating 5G and industrial digital models, it is possible to account for and quantify the impact of 5G communications on the operation and productivity of industrial processes. This result highlights the importance and necessity of integrating 5G into industrial digital models for their joint design and optimization [7]. This research delineates specific technological, policy, and social challenges constraining 5G's change potential across contexts. It also compiles exemplary interventions by regulators, operators, and civil society promoting efficient and responsible rollouts. Our findings highlight urgent imperatives for collaborative action on standards, spectrum cooperation, security frameworks, and digital inclusion if 5G is to foster inclusive prosperity. We propose evidence-based and context-specific policy and investment recommendations tailored to local institutional realities while upholding ethical principles. By elucidating high-potential spaces for 5G innovation alongside risks of technological fragmentation, uneven access, and unintended consequences, this research provides a multidimensional decision-support framework for policymakers, regulators, operators, and enterprise leaders invested in promoting digitally enabled growth. It combines rigorous longitudinal data analysis with social impact forecasting to promote 5G ecosystems that responsibly widen opportunity and safeguard the interests of marginalized communities. The study sets the agenda for continued scholarship at the intersection of next-generation infrastructure investment, productivity growth in core economic sectors, and equitable expansion of digital capability sets across societies [8]. This paper investigates the security challenges associated with various access technologies, such as Fiber to the Home (FTTH), 4G, 5G, and broadband connections, in the context of Software-Defined Wide Area Network (SD-WAN) deployments [9]. This article presents the architecture and implementation of the industrial internet identification and resolution system of a digital learning factory driven by 5G. This article also elaborates on the design of digital asset management training courses in the Advanced Manufacturing Technology Center (AMTC). This study seeks to advance the continuous improvement of digital module platforms within learning factories and foster the development of compound engineering talents through relevant theories and technologies in fully connected digital learning factories. The objective is to establish a benchmark that will stimulate further exploration in the direction of digital-intelligent, environmentally sustainable, and integrated industrial transformation and enhancement [10]. In the realm of digital manufacturing workshops, Huang et al. [11] introduced a real-time localization platform designed for various elements within discrete manufacturing environments. This platform integrates area localization techniques based on Radio Frequency Identification (RFID) and Ultra-Wide Band (UWB) precision localization methods. Segura et al. [12] explored the potential of employing an Internet of Things (IoT) tag system in the fabrication and assembly of crankshafts to capture and transmit production data. Cao et al. [13] presented a collaborative framework for tracking materials and production processes from a supply chain perspective, leveraging IoT tags and information technology (IT) systems to gather real-time production data. However, there remains a lack of uniformity in asset identification research across workshops, factories, industry chains, and even cloud platform manufacturing.

III. THE DIFFERENCE BETWEEN THE THIRD AND FOURTH INDUSTRIAL REVOLUTION

1. Decentralised Information
   Nowadays, sensors that gather a constant flow of data are found in many parts of the production process. In Industry 3.0, all of the data from a single system is often stored and managed on the local servers of each enterprise. There was very little cross-sector integration and data sharing. On the other hand, Industry 4.0 is the exact opposite. Multiple stakeholders can access data in real time because to its interconnected platforms and systems.
2. Real-Time Data Collection
   In real time, enormous amounts of data are being collected, processed, and used. There are various benefits to having decentralized information available and able to analyze it instantly. It facilitates better decision-making by facilitating more efficient collaboration between various organizations and aiding in the optimization of production and management operations. Predictive maintenance is one strategy that significantly lowers downtime.
3. Big Data Analytics
   Operational efficiency has been significantly impacted by big data. Numerous facets of manufacturing and business considerations, including consumer feedback and refunds, can now be examined and evaluated. Reducing outages, anticipating future demands, and improving decision-making are all made possible by these and numerous other contributing factors. Businesses can adjust to the demands of the market thanks to big data.
4. AI And ML
   Humans cannot handle the enormous amount of intelligent data gathered in today's operations. The AI and ML algorithms of Industry 4.0 have supplanted the data analysts of Industry 3.0. These systems are not only capable of handling large amounts of data, but they can also learn from its analysis how to enhance automation in all its forms. Overall efficiency, quality, and production all improve as a result. By combining automation and intelligence, Industry 4.0 makes it possible for machines and systems to become more intelligent, self-sufficient, and adaptable.
5. Interoperability
   Significant manufacturing technological advancements were made by Industry 3.0, although its primary goal was process automation. Additionally, it was limited to specific companies, each of which had its own systems. Connectivity and cooperation across business ecosystem stakeholders are key components of Industry 4.0. Manufacturers, their clients, suppliers, and even the equipment themselves may be among them. The goal is to encourage "collective intelligence" among organizations that exchange information and ideas in order to spur innovation and progress. As a result, various value chain elements work together in an ecosystem that is fully transparent, communicates easily, and is interoperable.
6. Heightened Flexibility
   Lean production was embraced by Industry 3.0, which reduced costs by automating and optimizing procedures. Instead, Industry 4.0 is focused on brilliant production, where data, not expertise, is used to make decisions. Without human input, automated systems make predictions and optimize operations by learning from the collected data. Different methods are being used to generate new revenue streams. In this case, systems are linked to the product rather than the process. They are improving the responsiveness and flexibility of industrial processes. This enables them to respond to shifting consumer needs and market conditions more effectively and quickly.

So, How Does Industry 4.0 Differ from Industry 3.0?
Industry 3.0 achieved limited technological advances in manufacturing with computers, automation, and PLCs. Industry 4.0 leverages far more advanced technologies through the IIoT, cloud computing, augmented reality, and robotics. Add to these AI, ML, and big data analytics, and you have real-time connectivity, autonomous systems, predictive maintenance, and data-driven decision-making. In addition, the physical and virtual worlds can be merged to enhance many design and manufacturing processes.

Industry 3.0 was all about automation in individual factories. It aimed to save money by improving efficiency and productivity. It optimized production lines by substituting machines and computers for human labor. Industry 4.0 has a much broader scope, integrating digital technologies into the value chain. Interconnected CPS can even manage distribution and customer interaction. This makes the digital transformation of the industry far more comprehensive. We're in a major shake-up of how things work, not just processes but business models and value creation. As Industry 4.0

gathers momentum, we need new skills for the latest technologies. At this stage, we need digital capabilities to be integrated into every organizational aspect of a business [19].

IV. BENEFITS OF THE FOURTH INDUSTRIAL REVOLUTION

a. Enhanced Efficiency: Productivity is increased and resource waste is decreased when smart technologies are integrated into manufacturing and other industries.
b. Economic Growth: Industry 4.0-driven innovation has the potential to generate new industries and business models, which will promote economic growth.
c. Better Quality of Life: Technological developments can result in smarter cities, better healthcare, and improved services, all of which can improve people's quality of life.
d. Better Decision-Making: Real-time data analytics aid in making informed decisions, optimizing business strategies and operations.
e. Sustainability: Smart technologies that maximize resource use and minimize environmental impact support sustainability.

V. DRAWBACKS OF THE FOURTH INDUSTRIAL REVOLUTION

a. Job displacement: AI and automation may make human labor less necessary, especially for physical and repetitive tasks, which would result in joblessness.
b. Increased Inequality: Income and social imbalances may worsen as a result of Industry 4.0's potential for unequal distribution of benefits.
c. Cybersecurity Risks: The interconnectedness of devices and systems heightens vulnerability to cyberattacks, posing risks to individual and public safety.
d. Privacy Issues: The extensive collection and analysis of data can infringe on personal privacy if not managed with robust protections.
e. Technological Dependency: If vital systems are interrupted, an excessive dependence on digital technology may lead to vulnerabilities [14].

VI. CONCLUSION

This study recommends the following strategies for individuals to thrive in the Fourth Industrial Revolution: upskill and reskill in emerging technologies, engage in lifelong learning through continuous training and retraining, leverage digital platforms for entrepreneurship, adopt remote work and flexible schedules, utilize AI-powered tools for personalized learning, and develop skills in Python, Java, AI, IoT, and big data [20].

For businesses, the study suggests undergoing digital transformation through adopting digital technologies, fostering innovation through research and development, making data-driven decisions using analytics and machine learning, investing in robust cybersecurity measures, cultivating collaborative ecosystems with startups, academia, and governments, and focusing on innovative technologies like Artificial Intelligence, IoT, cloud computing, virtual and augmented reality, blockchain, and 5G/6G. By embracing these opportunities, individuals and businesses can thrive in the Fourth Industrial Revolution and pave the way for the technological singularity era.

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