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INDUSTRIAL ROBOTS AND THEIR EVOLUTION IN MODERN MANUFACTURING

Б. ОЗДЕМИР
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The research investigates the effects of robotics on modern manufacturing while tracing its evolution from basic industrial robots to today's intelligent lights-out factories. An industrial robot functions as a programmed, multi-axis apparatus that performs additive operations – like assembling, welding, gluing, and painting – and subtractive operations – such as milling, cutting, grinding, and polishing – with high precision and quality. The importance of this research focus is attributed to the need for manufacturing companies to optimize productivity and minimize costs. This need also makes automation an indispensable instrument for increasing competitiveness.

The industrial robot industry has developed rapidly in a relatively short period.

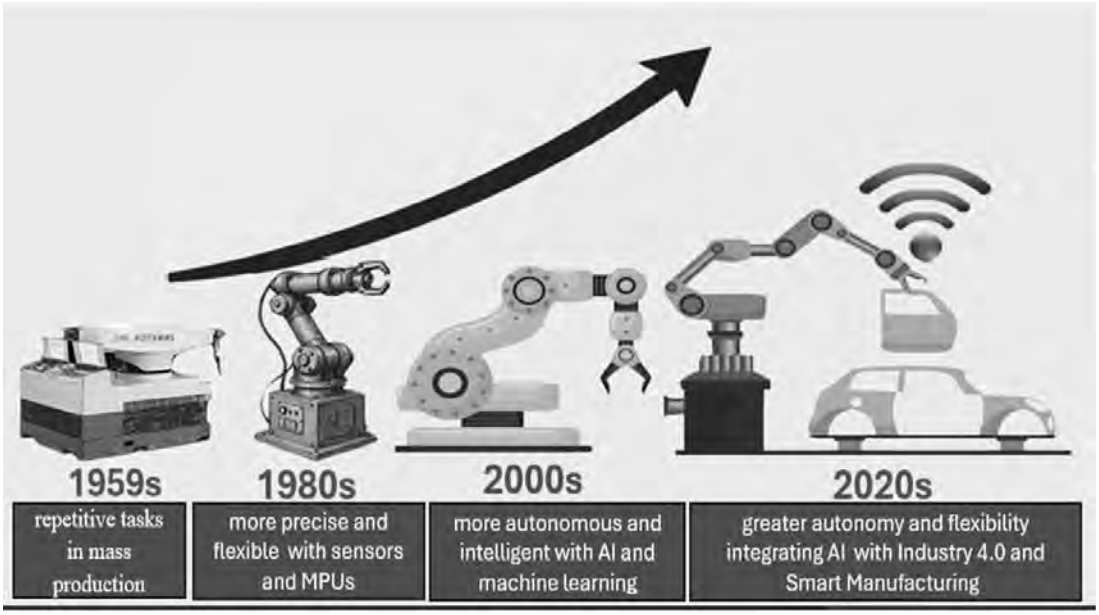

Figure 1. Historical Evolution of Industrial Robots

The historical evolution of industrial robots has shown a development in accordance with Figure 1. The first industrial robots in history were introduced to the market in the late 1950s to perform repetitive and straightforward operations on assembly lines. These robots were relatively modest and crude compared to today's modern robots. The most famous example of these robots produced under the conditions of that time was Unimate, which General Motors installed in its factories.

GM installed the first spot-welding robots at its Lordstown assembly plant in 1969. The Unimation robots boosted productivity and allowed more than 90 percent of body welding operations to be automated vs. only 20 percent to 40 percent at traditional plants, where welding was a manual, dirty, and dangerous task [1]. In the 1980s, these robots were further developed and made more usable. The added sensors and microprocessors made the robots more flexible and accurate. Thus, they began to perform more precise and flexible tasks to meet the needs of changing production conditions. Another milestone took place in 1978, when the first programmable universal machine for assembly (PUMA) robot was used at Rochester Products, a GM division that specialized in carburetors, fuel injectors and exhaust systems. It featured a robotic first-a special programming language that allowed the device to be controlled offline [1]. In the 2000s, these robots became truly intelligent with the addition of AI and Machine Learning and began to act autonomously. As a result of this development, they began to make and implement decisions independently of direct human involvement and to learn and improve their assignments. Thus, this fostered the development of artificial intelligence algorithms and machine learning techniques that allow them to understand processes and enhance their performance. Industry 4.0 provided smart factories in the 2020s that enabled thousands of robots to interact with big-data platforms and cloud services for automated control of complete production cycles without direct human intervention.

Industrial robots have experienced substantial quantitative growth alongside qualitative advancements throughout the past decades.

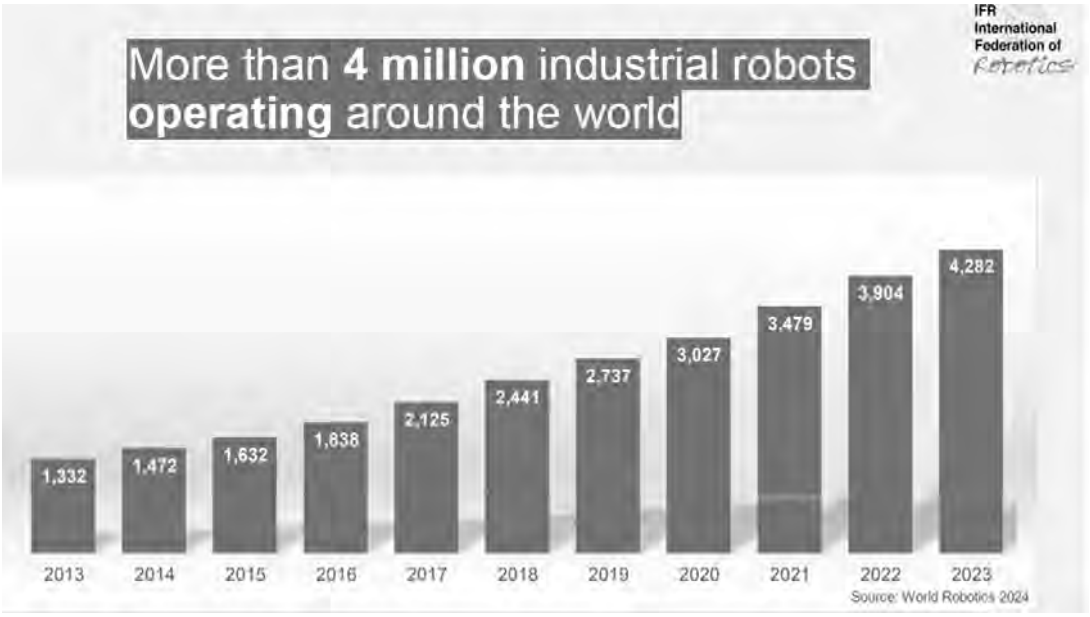

Figure 2. Operational stock of industrial robots – World (1.000 units) [2]

According to Figure 2, the International Federation of Robotics published its latest report, which shows that more than 4 million industrial robots are operating worldwide [2]. Industrial robots have increased steadily over the years, more than tripling in the past decade. This development has expanded rapidly, especially in the last two years, reaching 12 percent in 2022 and 10 percent in 2023. As supported by statistical data, the rapid growth in recent years indicates that industrial robots have become indispensable in the world manufacturing sector.

There are many reasons why a company might invest in robotic systems. Some factors include the positive effect on parts quality, increase of manufacturing productivity (faster cycle time) and/or yield (less scrap), improved worker safety, reduction of work-in-progress, greater flexibility in the manufacturing process, and reduction of costs [3].

This study demonstrates that developing industrial robots has altered manufacturing technology at its core to bring about greater precision, efficiency, productivity, flexibility, and quality. The rapid increase in their numbers in recent years shows that industrial automation is no longer a choice but a prerequisite to remain competitive. Industrial robot development has not yet achieved its full potential, and significant efforts are still needed to close the gap between academic research and industrial practice and foster scholarly research into innovative applications and flexible automation concepts. In the next few years, even more complex and independent answers through further assimilation of industrial robots with artificial intelligence, machine learning, and Industry 4.0 concepts will redefine the future of intelligent manufacturing. Engineers and scientists also need to be pillars of this transition by developing new systems and contributing to advancing high-tech production.

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