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A Review on Robotics and Automation in the 21st Century: Shaping the Future of Manufacturing, Healthcare, and Service Sectors

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Abstract - **A detailed examination of the literature reveals the significant effects that automation and robotics have had on the modern industrial, healthcare, and service sectors. This research explores the acceptability, challenges, and advantages of robots in various industries, tracing their evolution from simple machines to extremely intelligent and complex entities today. The report demonstrates how robots have evolved from conventional manufacturing roles to become essential in Industry 4.0, healthcare, and service sectors, utilizing academic research, real business data, and technical advancements. Robots have greatly increased production efficiency in the industrial sector, decreased error margins, and resulted in cost savings and higher-quality goods. The introduction of networked production systems and smart factories highlights the importance of robotics in contemporary manufacturing techniques. In healthcare, robots are revolutionizing the industry by transforming clinical settings, enhancing patient monitoring and diagnostics, and increasing the precision of minimally invasive surgical operations. This change illustrates the potential for robots to completely transform patient care and the healthcare sector as a whole. The study also examines the growing importance of robots in the service sector, where new technologies are altering the way people interact, shop, and entertain themselves. Automation and robotics are redefining how individuals engage with services, highlighting the dynamic relationship between technology and human interaction. This study underscores the potential of robots to revolutionize multiple industries and emphasizes the necessity of further research and adaptation to fully realize these advantages. Automation and robotics are key drivers of technological progress, offering prospects for ongoing innovation and improved productivity, precision, and overall quality across various sectors.**
Keywords: **Automation and Robotics, Healthcare, Industry 4.0, AI, Technology Impact**

I. INTRODUCTION

A robot is a machine that is controlled by a computer program [1]. Robots are designed to perform tasks much faster and with greater accuracy than humans, resulting in reduced time and increased efficiency in various industries such as medicine and services. In addition, robots can work in hazardous environments where human safety is at risk. The first programmable digital robot was invented by George Devol in 1954 [2]. The sector of robotics has made incredible progress recently, having major impacts on many different domains. The goal of the review of the literature is to examine how robotic technologies and applications are developing. Robotics is becoming more and more integrated into business, healthcare, and education, which has produced some challenging issues and interesting possibilities. This review aims to offer a thorough overview of the state of robotics today by analyzing the major trends, problems, and innovations in this area. The review is organized to look into relevant research within the context of the past decade, including scholarly publications and reports. We hope to bring out the revolutionary possibilities of robotics in modern times through this approach.

The vital role of artificial intelligence, networking, and information technology in advancing the robotic revolution is a recurring subject in this analysis. This not only changes how businesses operate and how services are provided, but also enables robots to carry out a variety of jobs, from simple manual labor to complicated decision-making. Robotic connectivity and reliance on information networks herald a fundamental transformation in how work is completed and decisions are made. Robots are no longer constrained to physical areas and are instead becoming more and more reliant on digital connectivity. Understanding that robots usually function inside a network of information technologies, including the Internet, is essential if one wants to fully appreciate the promise and comprehend the constraints of this new robotics era. The deployment of robots in diverse industries is not without ethical concerns, as this review makes clear. These moral concerns include those pertaining to data security, privacy, and the potential replacement of human workers in specific positions. Even though robots have advanced significantly, they still have some limits, especially in the areas of high-order intellect, emotional comprehension, and sympathetic qualities.

Nevertheless, the advent of Industry 4.0 [3], characterized by the fusion of digital technologies with physical processes, and the ongoing pace of technological advancement promise a future where robots will continue to play an increasingly substantial role in reshaping industries, healthcare, and the service sector. This evolution signifies a profound transformation in the way we work, interact with technology, and leverage automation to enhance human capabilities. It ultimately redefines the nature of work and

service delivery in our ever-advancing world, where robots are poised to become not just tools but integral collaborators and contributors to our daily lives and the global economy.

A. Robots in Industrial Sector

Robots have revolutionized how products are produced and services are provided, becoming crucial components in the current industrial landscape [4]. Robotics represents a crucial revolution that has altered manufacturing processes, and the industrial sector has always been at the forefront of technical innovation. This survey of the literature intends to look into the significant effects that robots have on industries, following their development from the early days of automation to the current era of Industry 4.0. Information and communication technologies are being introduced in manufacturing businesses to increase competitiveness. Machine vision systems and confirmed sensors are increasingly employed for human-robot collaboration to solve complicated automation challenges in industries where human expertise is essential. Traditionally, robots and operators were kept apart [5].

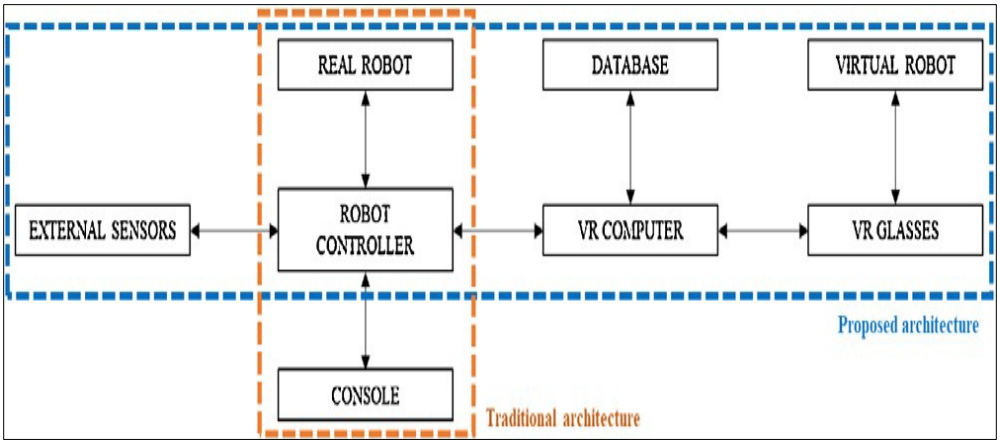

Fig. 1 System architecture, where the console is replaced by the VR system [6]

Two robots one actual and one virtual and a controller are the main components of the system, which also includes a VR computer and a database server. Also linked are VR glasses. In order to be accurate and safe, external sensors are required. A robotic manipulator is a mechanical device with moving joints that is controlled by kinematic and dynamic mathematical models [6]. This review will examine the adoption, difficulties, and advantages of robots in the workplace by examining several kinds of academic research, business data, and recent technological developments. We aim to clarify how robots are altering supply chain, logistics, and manufacturing processes as we make our way through this environment.

B. Robots in Healthcare Sector

Robot use in healthcare has been recognized as an innovative concept with significant consequences for patient care, clinical settings, and the entire sector. Robots, once restricted to factory floors, are increasingly stepping into the delicate world of healthcare, offering solutions to the many difficulties faced by institutions and suppliers of healthcare. The goal of this literature review is to investigate the complex relationship between robots and healthcare, as well as the revolutionary potential of these technological developments.

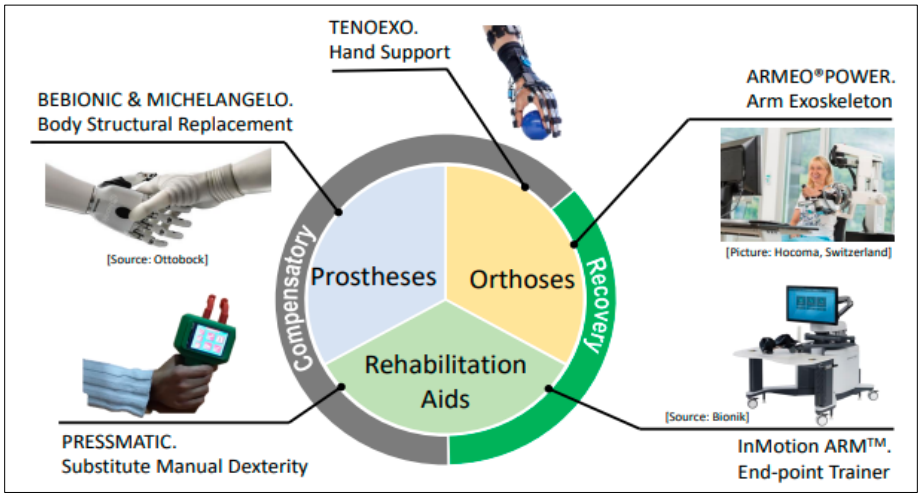

Fig. 2 Rehabilitation robotics domain [7]

Figure 2 illustrates various rehabilitation robotics systems, arranged according to physical contact level and device function. Based on their physical touch, these systems can be divided into prostheses, orthoses, and rehabilitation aids. Physical, cognitive, psychological, and medical treatment are frequently necessary for neurological problems. The normal results include limitations in limb motion, and conventional healing techniques entail mobilizing the extremities [7]. Recovery of motor function by neurorehabilitation enables patients to carry out daily tasks on their own. This review will explore the many ways that robots are used in healthcare, including telemedicine, patient care, and surgical help. We try to put light on the most recent advancements, ethical issues, and the effect of robots on healthcare outcomes by examining a wide range of literature sources, including academic papers, and publications.

The manufacturing business has undergone a transformation because to additive manufacturing, sometimes referred to as 3D printing, which makes it possible to create intricate and accurate parts that are not possible with old methods. This technology integrates design, production, and product support processes to handle the problems presented by growing global competitiveness, varied client demands, and quickly shifting market trends. Beyond creating anatomical models for use in teaching, 3D printing in the healthcare industry has progressed to produce prostheses, medical gadgets, and diagnostic implants. Applications in tissue engineering and regenerative medicine are recent developments in this discipline that improve the capacity to develop patient-specific devices and lower complications [15]. Modern 3D printing debuted roughly 40 years ago, but its origins are in early topography and photo sculpting techniques that date back more than 150 years. This technology is still essential for sustaining competitiveness, increasing research and development, and spurring innovation across a range of businesses.

C. Robots in Service Sector

The combination of robotics and automation leads to an important change in the service sector, which includes a wide range of industries like hospitality, retail, and customer support. Robots are increasingly present in our daily contacts in the service sector and are instead of just seen on production floors. By evaluating the technical developments that are changing how people interact with services; this literature review intends to investigate the expanding impact of robots on the service sector.

Modern robotics involves automating a variety of human actions, from love to war, and is not just used in factories. The automotive industry, which is leading with industrial robotics and car robotization, and the military sector are the two main industries driving this technology. Robotics is also driven by artificial intelligence, which is supported by computers and the Internet. Robotics makes advantage of already-existing ICT infrastructure and presumes ongoing technical advancement [8]. Robotics has added “senses, hands, and feet” to the Internet, rendering future robots as dependent systems. It is essential to grasp that robots are frequently backed by a network of information technologies, such as the Internet, in order to comprehend the possibilities and limitations of new robotics. Service robots now outperform human service providers in areas including memory, computer power, and tackling hazardous activities. They do, however, only have a little amount of mechanical, analytical, intuitive, and sympathetic AI skills [9]. These robots are largely utilized for the first two levels of intelligence, lacking competency in high-order intelligence, despite expanded uses during the pandemic.

II. LITERATURE REVIEW

In this study investigates helicopters, under actuated multirotor, and multidirectional thrust platforms as developments in airborne robotic manipulation. In addition to discussing cooperative and networked designs, teleoperation, vision, and planning, it suggests next generations of aerial robotic manipulators. The design, control, perception, and motion planning of autonomous robots for physical interaction tasks are the main areas of interest in the quickly developing field of aerial robotic manipulation. Although earlier studies have given aerial robots very good physical contact abilities, the majority of the studies were carried out in controlled indoor settings. The goal of outdoor experimental studies is to improve accuracy and resilience by tackling problems associated with exterior environments that are unclear and disruptive. Because of these possible effects, aerial manipulation is being employed in commercial operations including contact-based inspection, building, and maintenance [10].

In this study studies cognitive robots, which are products of the development of artificial intelligence (AI) coupled with industrial robots and control methods. Robotic systems with AI capabilities are crucial for industrial operations that require flexibility and competitiveness. The study examines current advancements in learning approaches, including computer vision, deep reinforcement learning, and imitation learning, and tackles gaps, problems, restrictions, and unsolved concerns in manufacturing. Because production has to improve performance, flexibility, safety, and cost-effectiveness, traditional control systems are no longer viable. AI-based technologies facilitate intelligent industrial robot control, enabling robots to comprehend intricate manufacturing procedures and adjust to dynamic surroundings. To fully explore and harness this technology's potential, more study is needed to solve concerns like sample inefficiency and knowledge generalization [11].

In this study, parameter identification techniques for serial and parallel robots are presented, along with their benefits and drawbacks and future research directions. Industrial robots play a major role in automation; newer models emphasize great precision and intelligence. Robot parameter identification is still difficult. It would be beneficial for

future research to look at present problems with robot calibration. This study examines many calibration methods and their uses, stressing the benefits and drawbacks of each approach. Robot calibration technology is useful in the robotics sector and improves absolute pose accuracy. The research is heading toward artificial intelligence with the use of neural networks, deep learning, and big data to kinematic modeling, parameter identification, and error correction. more accuracy, improved calibration results, and more robustness in robot calibration follow from this [4].

This essay presents Industry 4.0, the fourth industrial revolution, and how it is changing communication, services, and manufacturing. In this revolution, robotics is a major technical innovation with significant industrial possibilities. It lowers expenses, improves automated systems, and accurately finishes tedious jobs. By utilizing data, cloud computing, intelligent sensors, and contemporary robotics, Industry 4.0 seeks to create intelligent factories. These factories improve workplace reliability and safety since they are sturdy, safe, and cost-effective. The growing accessibility and affordability of robotic technology is influencing how industrial manufacturing is changing to satisfy customer demand and stay competitive. The industrial sector gains from the integration of Industry 4.0 since it enhances performance, precision, dependability, and resilience to risky conditions. Production operations are automated by intelligent robots, allowing for adaptable systems and affordable product revisions [3].

This study investigates the use of robots and artificial intelligence (AI) in healthcare, aged care, and rehabilitation. It reviews the most recent advancements and looks at the difficulties hospital, care, assistive, rehabilitation, and walking aid robots have assimilating into society. Robotics integration in healthcare settings involves both flexibility and dependable performance. These robots need to work with a variety of people while maintaining security in unpredictable, unstructured environments. Robotics has a significant societal influence as it might have an impact on patient and caregiver safety and raise privacy issues that need to be addressed. The difficulties with robotic applications in business, manufacturing, logistics, and search and rescue must also be overcome to guarantee smooth integration [12].

This study explores the moral implications of AI and robotics in healthcare, emphasizing the ambiguity that exists between expectations and worries. It suggests activities based on the ethics of care, particularly for socially helpful robots in a children's hospital, in place of ideal or dystopian situations. The paper looks at how AI may be used in healthcare and offers a study strategy that takes into account the ambiguity, variety, and moral dilemmas that surround these technologies. The ethical-political thesis “Caring in the In-Between” of the REN method seeks to advance responsible robots and AI. In the process of developing and applying technology in healthcare settings, this approach promotes public health practices and care networks. In order to lead responsible AI and robots, the study draws on the STS idea of measured action and the ethics of care [13].

While stressing that their usage in clinical settings is still in its infancy, this research investigates robotic assistance systems for the physical rehabilitation of individuals with neurological impairments. Robot-based systems for upper extremity rehabilitation are reviewed methodically in this study, with characteristics like device type, data analysis capabilities, therapeutic techniques, human-robot interfaces, safety precautions, and treatment emphasis examined. It concludes that more widespread use of robot-aided systems in clinical practice may depend on factors including improving patient-robot interaction, permitting self-adaptation, and integrating lifelike surroundings in completely immersive virtual reality. Since neurological problems are the main cause of disability and the second greatest cause of mortality globally, there is a growing need for support services, rehabilitation programs, and therapy. Robotic rehabilitation systems are becoming more and more popular, yet clinical adoption of these systems is still lower than expected [7].

This study investigates the nature of knowledge embodiment and the effects of AI robotic systems on interpersonal interactions. Using a case study at Anhui Provincial Hospital, it investigates the ways in which these technologies affect interpersonal interactions and people, defining four categories of knowledge embodiment in AI robots. The nature of knowledge, the connection between embodiment and human cognition, and the evolution of knowledge labor are the main topics of each kind. The study draws attention to the institutional and social aspects of these connections, which go beyond technological determinism and call for cautious handling. Similar to competitors, AI robotic systems may take on more socially active responsibilities in knowledge work. The study highlights the significance of comprehending institutional and social interactions with AI technology and offers insights into the possibilities of AI robotic systems in healthcare. It implies that cutting-edge technology may develop into an independent social actor, obfuscating the distinction between technology and people. The results also provide information scientists fresh research questions about how human-technology connections are reshaped by knowledge embodiment [14].

This study looks at how advances in robotics, artificial intelligence, smart sensors, big data analytics, and robotics have led to the introduction of robots for a variety of jobs in the service industry. Although the deployment of robots has always been driven by the desire for improved productivity, the COVID-19 epidemic has raised the need for contactless services as a means of reducing social isolation. The study uses information from a survey of 201 hotel customers to examine the quality of service given by robots by evaluating their expectations and real experiences. Important performance analysis (IPA) and the Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS)

were used to examine this relationship. The report emphasizes how important reliability and certainty are to raising the standard of service in the robotic services sector [9].

In order to construct immersive environments for training, simulation, and robot control, this article leverages commercial gaming technology to examine the synergies between virtual reality and robotics. This engaging encounter increases output and provides a useful solution. Cyber-physical systems and intelligent automation—including robotics—are key components of Industry 4.0's productivity and safety gains. Efficient human-robot cooperation is necessary to guarantee robot security and boost output. The study presents an immersive virtual reality framework with safe and affordable robot control capabilities through training, integration in productive work settings, and simulation. The system is intended for human-robot cooperation [11].

III. CONCLUSION

The significant effects of automation and robotics on the industrial, healthcare, and service sectors are highlighted by this overview of the literature. Robots have evolved from basic devices to intricate systems that are essential to modern operations. They enhance productivity and accuracy in the workplace, driving the advancements of Industry 4.0. In healthcare, robots improve patient care by employing cutting-edge technology for surgery and rehabilitation. In the service industry, they are redefining client relations and operational efficiency. Despite tremendous progress, challenges such as high-order intellect and empathy constraints, as well as ethical issues, still pose problems. Industry 4.0 and technological developments are driving the continuous advancement of robotics, which has the potential to completely transform these industries by increasing productivity and altering the way work and services are delivered. To fully realize the promise of robotics, future research should focus on addressing these ethical concerns, exploring novel applications, and continually pushing the boundaries of robotic capabilities.

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