AI ROBOTICS' CONTRIBUTION TO SUSTAINABLE DEVELOPMENT[1]

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Abstract
Two different areas of engineering and technology are robotics and artificial intelligence (AI). With robotics acting as the body and artificial intelligence (AI) as the brain, the result is a robot that is artificially intelligent and capable of seeing, hearing, smelling, and walking, among other things. Therefore, robotics and artificial intelligence are two independent disciplines with different objectives and approaches. The study of robotics focuses on the mechanical components of machines, creating hardware that can carry out particular functions, such as a drone transporting items or a robotic arm constructing goods. For these systems to work, pre-programmed instructions are frequently required. In contrast, artificial intelligence (AI) encompasses software capable of learning, reasoning, and making decisions, which allows machines to respond to changing circumstances in real-time. As enterprises seek to increase operational efficiency, address labor shortages, optimize repetitive processes, and manage hazardous jobs or situations, demand for autonomous machines and AI-enabled robots is at an all-time high. AI-powered robots have the potential to make a number of industries more sustainable, including recycling, manufacturing waste reduction, pest detection and pesticide reduction in agriculture, climate change mitigation, and a variety of social applications to increase inclusivity and accessibility. AI robots will play an increasingly important role in sustainable development as technology develops, providing fresh answers to pressing global issues.
Keywords: Robotics, Artificial Intelligence (AI), AI-powered robots, Sustainable Development.

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INTRODUCTION

Technology is already altering how we work, learn, buy, socialize, entertain, and take care of our health. According to predictions, the next generation of technological advancements will be dominated by advancements in robotics, virtual reality, quantum computing, and artificial and synthetic intelligence (Safieddine & Baltezarević, 2016). With the combination of robotics and artificial intelligence (AI), a new age in automation has unquestionably begun. The emergence of intelligent machines with the ability to learn, adapt, and carry out challenging tasks on their own is evidence of this revolutionary teamwork. Machine learning algorithms, which provide the cognitive core of robotic frameworks, are essential to this paradigm shift. These algorithms use robots to analyse countless datasets, view intricate designs, and instantly optimize shapes (Sharma, 2023).

The combination of artificial intelligence and robots has resulted in what is often referred to as Industry 4.0. This change is a paradigm shift in the global industrial landscape, propelled by the astute fusion of robots, artificial intelligence, and computer advancements. Interconnected frameworks that regularly interact and work together to create a network of intelligent machines capable of making decisions on their own are what define the fourth industrial revolution. This interconnection promotes progress, adaptability, and sustainability by encouraging a more comprehensive and efficient approach to industrial operations (Wood, 2021).

The ability of humans to keep a particular system in a condition of equilibrium is known as sustainability (Osorio et al., 2005). By using modern industrial robots, production cost, performance, and sustainability challenges have been better managed. In both wealthy and developing nations, industry and research may both contribute to and gain from the fascinating challenge of robotics for sustainable development (Bugmann et al., 2011). With proven savings of 25–60% in energy consumption and carbon footprint across applications, the incorporation of energy-efficient technologies in robots has become a disruptive force in sustainable industrial practices. Industrial robots may now save 50% on operating energy while retaining payload capacity thanks to lightweight carbon fiber composites and AI-optimized control systems (Judijanto, 2025). The environment, workers, and the business that adopts green production techniques all gain from great sustainability initiatives that come with robotics. With AI's support, robots can reduce energy and material consumption, streamline supply chain operations by eliminating the need for fossil fuels, increase worker safety, and contribute to a sustainable business image (Gemeš, 2025).

LITERATURE REVIEW

Technology and sustainability are closely related ideas that are primarily examined in the context of the environment, with less attention paid to the economic and social aspects (Akbari et al., 2020). Technology and sustainability can help businesses expand their clientele, increase revenue, and enter new markets (Yang et al., 2017). Traditionally, sustainable technologies or fields that use robotic devices have been associated with the relationship between robotics and sustainability. Agriculture, waste management, marine research, logistics, and transportation are typical examples of these technologies or fields (Szilágyi et al., 2023).

However, for the entire manufacturing process to be able to reengineer goods, business models, and logistical supply networks in a sustainable manner, 4.0 technologies must be applied with a systematic approach and a holistic vision (Bai et al., 2020). In general, sustainability refers to the preservation of capital, including economic, social, human, and environmental capital (Goodland, 2002). Moreover, sustainability might be defined as the capacity to create and apply self-sustaining practices and technologies without endangering the capacity of future generations to adequately meet their own needs (Commission, 1987).

A motorized machine that can be programmed in two or more axes and has some autonomy is called a robot. It travels around its surroundings to carry out its designated tasks. There are significant automated technology application areas in the robotics market. Among these are service robotics and industrial robotics (Statista, 2024). Due to the pressing need to minimize carbon emissions and the worldwide environmental

concerns, sustainability has emerged as a key component of modern robotics. About 8% of the electricity used in production worldwide comes from industrial robots alone; thus, innovations are needed to meet sustainability targets (Liu, 2023). Commercial green innovation benefits greatly from the use of robots, which increase productivity and environmental management skills while encouraging both quality and quantity (Liang et al., 2023).

Reducing operating costs and resource waste while maintaining productivity requires energy-efficient automation systems (Firoozi et al., 2024). The advantages of employing robots in manufacturing for sustainability include satisfying safety regulations, automatically compensating for limited unpredictability, adapting to new tasks, and ease of programming by shop floor workers (Project, 2013). The impact of various agent types in fostering normative conduct was particularly examined in one study, which discovered that a robot can incite normative (sustainable) behaviour just by existing (Tussyadiah & Miller, 2019).

The majority of repetitive jobs in production processes are handled by artificial intelligence, which lessens the demand for human labor. Despite its ongoing development, this technology has the unquestionable ability to improve high-quality economic growth and optimize the industrial structure (Baltezarević, 2023)**.** Weak and strong AI are commonly used to describe the capabilities of artificial intelligence (Perez et al., 2017). The goal of weak AI, sometimes known as narrow AI, is to replicate an observed behavior as closely as feasible. It is capable of performing a task for which it has received precise training. These AI systems lack the capacity to generalize, but they can become incredibly effective in their specific field. Weak AI is exemplified by the majority of current intelligent systems that rely on machine learning, pattern recognition, data mining, or natural language processing. Recommender systems, spam filters, self-driving cars, and industrial robots are examples of intelligent systems with limited artificial intelligence. Strong AI is typically defined as an intelligent system that possesses true consciousness and is capable of thinking and reasoning similarly to a human. In addition to assimilating knowledge like a weak AI, a strong AI can also change how it operates, that is, it can independently rewire itself to carry out general intelligent tasks. Human-like cognitive capacities such as consciousness, sentience, sapience, and self-awareness control these processes (Estifanos, 2020). However, further time is required for the development of AI technology because it is still in its infancy (Baltezarević & Baltezarević, 2024)**.**

The primary goal of combining robotics and artificial intelligence is to maximize autonomy through learning. The ability to anticipate the future, plan a task, or interact (either by influencing or navigating) with the outside environment are all ways to gauge this level of intelligence. Robots that can carry out specific autonomous tasks are still a way off from developing a system with human-like intelligence (Kappassov et al., 2015). Recent market reports estimate that the AI robotics market will reach $111.9 billion by 2033, with an annual growth rate of 22.1%, from its 2023 valuation of $15.2 billion. The fact that more than 3.5 million industrial robots are in use globally demonstrates how automation and intelligent technology are revolutionizing processes (Onlinedegrees.sandiego, 2024). Numerous industries, such as recycling, manufacturing waste reduction, agriculture pesticide reduction and detection, climate change mitigation, and a range of social applications to promote accessibility and inclusion, may benefit from AI-powered robots (Timoshenko, 2023).

AI-powered robots are capable of gathering, analyzing, and acting upon environmental data in almost real-time to complete tasks, frequently on their own. Robots employ sensors such as cameras, accelerometers, vibration, proximity, and others to gather data about their surroundings. Machine learning or deep learning algorithms are then used to analyse such data, depending on the use case, employing onboard, edge, or cloud computing, or some mix of these. The robot then acts based on the insights gathered from that analysis (Intel, 2025). Robotics powered by AI is making manufacturing processes more responsive and nimbler. Under the direction of complex algorithms, intelligent machines adjust in real time to changes in production demands, maximizing flexibility and output. In addition to increasing productivity, this dynamic adaptability promotes the

steady incorporation of emerging technology into industrial processes. Similar arguments are made about the effects of AI in supply chain management, where adaptability is a crucial factor in success (Zolas et al., 2021).

By combining comparable experiences, getting feedback from their surroundings (a process known as reinforcement learning), and using simulations to solve issues without using their hands, AI-enabled robots will probably have the ability to learn on their own. Networked robots might quickly share and expand upon collective knowledge, with advances to one system benefiting all others, in contrast to people who learn gradually (Intel, 2025). The creation of autonomous drones that employ AI to track crop health and maximize resource utilization was recently documented in an article published in the journal Artificial Intelligence in Agriculture. By identifying plant illnesses early and administering focused treatments, these drones potentially lessen the need for extensive pesticide use and support environmentally friendly farming methods. By maximizing resource use and reducing chemical inputs, artificial intelligence (AI) in agriculture improves productivity and promotes environmental sustainability (Subeesh & Mehta, 2021)**.**

AI and robotics provide long-term, sustainable production that benefits the community, the environment, and the business. Manufacturing operations are completed by robots far more quickly than by hand. Simultaneously, industrial robots optimize time and cost by freeing up trained workers to complete more difficult jobs. Industrial robots can do a wider range of activities than manual laborers because of their superior capabilities and perceptions, which are made possible by their software and sensor technology. Consequently, we may automate a robot for multiple jobs in a single setup, reducing the space, training, and changeover time (Gemeš, 2025). The transition to AI-enabled, electric-powered robots promotes reduced emissions and a smaller carbon footprint, which is consistent with the renewable energy industry's dedication to environmental sustainability (Horn, 2023). One of the most significant sustainability changes made possible by robots is the switch from fossil fuel-powered transportation, logistics, and agricultural equipment to battery electric vehicle, or BEV, technology. In addition to drastically cutting emissions, the use of smaller autonomous electric vehicles for the first, last, and middle miles can alter the overall number of trips made and lessen the need for larger, partially loaded vehicles to do longer trips (Keay, 2023).

Significant lighting energy is also saved since robots can complete their tasks without intense lighting. Since manufacturing floors that use industrial robots rather than humans don't require heating, we can save even more energy throughout the winter (Gemeš, 2025). Autonomous robots with artificial intelligence can quickly and precisely repair damaged ecosystems, clean up the oceans, and restore forests. By doing this, years of environmental harm can be undone and biodiversity preserved for coming generations (Adventairobotics, 2025).

CONCLUSION

The idea of AI-powered robots has fascinated and aroused interest for decades. Nowadays, a lot of businesses are using robotics concepts that were previously limited to science fiction. Finally, robots can see, walk, talk, smell, and move more and more like humans thanks to machine learning and artificial intelligence. Businesses are using AI-powered robots to fill gaps between humans and technology, solve problems, and modify their business models in response to changing demands. Robotics is the design, construction, and operation of machines that can carry out tasks either fully or partially on their own. These devices, which are frequently employed to perform hazardous or repetitive activities, improve efficiency, productivity, and safety in a variety of contexts. The goal of AI is to build systems that mimic human intellect so that machines can evaluate information, spot trends, and reach conclusions. AI is the driving force behind technologies like autonomous navigation, speech recognition, and predictive analytics. AI and robotics work together to create intelligent devices that can change their surroundings, revolutionizing sectors including logistics, healthcare, and agriculture.

Robotics and artificial intelligence (AI) are becoming effective instruments to address environmental issues and create a sustainable future. From reinventing agriculture to enhancing energy networks, these innovations are changing industries and accelerating the transition to a greener society. Robotics powered by AI holds great promise for creating an environmentally friendly tomorrow. To invest in the appropriate development and application of these technologies, governments, corporations, and research institutions must collaborate. Public-private sector collaborations can foster innovation and speed up the adoption of AI-powered solutions for environmental issues. By leveraging AI and robots, we can pave the way for future generations to live in a more sustainable and cleaner world.

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