An overview of emerging trends in robotics and automation

Tole Sutikno[1,2]
[1]Master Program of Electrical Engineering, Faculty of Industrial Technology, Universitas Ahmad Dahlan, Yogyakarta, Indonesia
[2]Embedded Systems and Power Electronics Research Group, Yogyakarta, Indonesia

Article Info

ABSTRACT

Robotics has experienced significant growth and development over the past few decades, with the first industrial robots introduced in the 1950s. As technology advances, robotics has become more intelligent, smart, and flexible, with the introduction of artificial intelligence (AI) and machine learning (ML). Robots are now being integrated into various fields, including healthcare, agriculture, transportation, and space exploration. Robots are set to revolutionize our daily lives, transforming interactions and work processes as technology advances. Emerging trends in robotics, such as AI and ML, soft robotics, and swarm robotics, can transform industries and improve efficiency. The future of robotics and automation promises safer workplaces, improved healthcare, and enhanced environmental sustainability. Society must adapt to this changing landscape, requiring continuous learning and upskilling to remain relevant in the workforce.
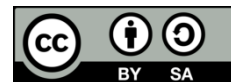
Corresponding Author:

Tole Sutikno
Master Program of Electrical Engineering, Faculty of Industrial Technology, Universitas Ahmad Dahlan
Ahmad Yani Street (South of Ring Road), Tamanan, Yogyakarta 55166, Indonesia
Email: tole@te.uad.ac.id

1. INTRODUCTION

Robotics is a discipline that has had amazing growth and development over the past few decades, and this growth and development is continuing at a rapid pace. With new ideas being generated on a consistent basis, it may be challenging to keep up with the most recent developments and trends in the industry. The term "robotics technology" refers to a subfield of engineering and computer science that focuses on the creation, development, and implementation of computer-controlled machines. One definition of a robot is a machine that is capable of doing a variety of tasks on its own, typically by interacting with its environment and making decisions based on the information it receives from its senses [1]–[4].

Artificial intelligence (AI), computer science, electrical engineering, and mechanical engineering are some of the fields that have contributed to the development of robotic technology. In the twenty-first century, significant advancements in robotics technology have been made possible by the introduction of AI, machine learning (ML), and other cutting-edge technologies. There are already numerous industries that are beginning to include robots into their operations, such as the medical industry, agriculture, transportation, and even space exploration. They are able to manage a wide variety of activities, ranging from simple repetition to complex decision-making and problem-solving, and they work in a variety of contexts, including hospitals and factories. We will see a rise in the incorporation of robots into our everyday lives as technology continues to improve, which will result in a transformation of how we live, interact, and work [3], [5]–[14].

The objective of robotic technology is to create machines that are capable of performing tasks in a manner that is more proficient, secure, and efficient than any other equipment or person. Robotics has a wide range of applications, some of which include medical robots, autonomous vehicles, drones, self-driving cars, and space exploration. Some recent developments in the field of robotics will be presented in this paper.

2. EVOLUTION AND EMERGING TRENDS OF ROBOTICS AND AUTOMATION

The origins of the concept of robotics may be traced back to ancient civilizations. The first examples of automata can be found in Greek mythology and Chinese culture. On the other hand, the first industrial robots did not come into existence until after the 1950s, which marked the beginning of a new era in the field of robotics. These early robots were enormous and heavy, and their primary application was in manufacturing environments, where they were utilized for operations, such as welding and painting. As time has progressed, robots have undergone major advancements, becoming more intelligent, sophisticated, and flexible. Additionally, the development of microprocessors and sensors has enabled them to carry out jobs that are more difficult [11], [15]–[17].

2.1. Artificial Intelligence and Machine Learning

Two of the most fascinating and prospective developments in the field of robotics are AI and ML. In contrast to ML, AI enables robots to learn from their experiences and develop over time. This enables robots to undertake jobs that would otherwise be too difficult for them to manage. Within the next several years, it is anticipated that this technology will become even more prevalent, as it is already being utilized in applications such as autonomous vehicles, industrial robots, and drones [1], [3], [10], [18]–[20].

The sparkling stars of technical growth are AI and ML, which are at the forefront of technological advancement. These technologies are being utilized by businesses operating in a wide range of sectors in order to improve decision-making, automate processes, and obtain actionable insights from massive databases. When it comes to e-commerce recommendations and content curation on social media platforms, AI-driven personalization is radically altering the user experience. AI is helping to speed up the process of medication discovery in the healthcare industry by making it possible to make more precise diagnoses. Additionally, AI and ML are helping to make automated vehicles and smart homes more widespread. It is clear that AI and ML are here to stay, as evidenced by the fact that there is a growing demand for AI professionals and that research and development in the field is expanding [10], [21]–[25].

2.2. Collaborative Robots (Cobots)

The term "cobot" refers to collaborative robots, which are specially intended to operate with humans in a variety of environments. However, in contrast to typical industrial robots, which are frequently kept at a safe distance from human workers by means of safety barriers, cobots are able to function safely in close proximity to human workers. The jobs that demand both speed and precision, such as assembly, packaging, and quality control, are perfect for these robots because they are suitable for those tasks [26]–[29].

A burgeoning trend in the landscape of automation is the use of cobots. The relevance of these robots is still being revealed. They are intended to collaborate with humans in order to improve the efficiency, safety, and adaptability of industrial operations. Cobots are enjoying a spike in their application, particularly among small and medium-sized businesses, for a number of reasons, one of which is that they are becoming more cost-effective and easier to integrate. One of the primary motivating factors behind this trend is the broad industrial demand for flexible and responsive automation systems that can work in tandem with human workers on a variety of activities, ranging from assembly to quality control. The emergence of collaborative robots as a wonderful opportunity to shape the future of work across numerous industries at a time when businesses are striving to optimize their operations and preserve a competitive edge is of great significance [26]–[29].

2.3. Service Robotics for Healthcare

The healthcare industry is undergoing a change as a result of the roles that robots are taking on. These tasks include providing companionship for elderly patients and supporting surgeons during sensitive procedures. Robotic exoskeletons are helpful in the process of physical rehabilitation, while telemedicine robots make it possible to conduct medical consultations remotely [10], [14], [19], [27], [30].

2.4. Agricultural and Environmental Robotics

With the world's growing population, robotics is finding its place in agriculture to improve efficiency and reduce the environmental impact of farming. Autonomous drones and robots equipped with sensors and cameras are used for precision planting, monitoring crop health, and even harvesting [5], [7], [19].

2.5. Soft Robotics and Bioinspired Designs

Among the many growing fields, soft robotics is one that focuses on the creation of robots that are created from materials that are soft and flexible, such as silicone and elastomers. While classic inflexible robots are able to swiftly adapt to their surroundings, these robots are able to interact with objects in a

manner that is more natural. The field of soft robotics has the potential to transform a wide variety of industries, including agriculture, manufacturing, and healthcare, among others [31].

In the field of robotics, soft robotics is a burgeoning movement that focuses on the creation of robots that are made of materials that are flexible and pliable and that mirror natural organisms. The utilization of this cutting-edge methodology enables robots to carry out activities with a human-like touch and adaptability, which makes them suitable for use in a variety of industries, including healthcare, manufacturing, and others. The requirement for robots that are able to interact with humans in a secure manner and handle delicate things in places where typical stiff robots might not be suited is the driving force behind this development. In addition to the development of materials and manufacturing techniques, soft robotics is also finding applications in a variety of industries, which promises a future of automation solutions that are more versatile and adaptable than those that have been available in the past. Taking its cues from the natural world, soft robotics attempts to replicate the adaptability and flexibility of living beings. In situations where standard stiff robots would struggle, these robots, which are frequently constructed from materials that are soft and flexible, perform exceptionally well. There are a variety of applications for surgical robots, including soft grippers used in manufacturing and surgical robots that simulate the dexterity of human hands [18], [27], [30], [32]–[34].

2.6. Swarm Robotics

The field of study known as swarm robotics investigates how huge sets of basic robots can collaborate to complete difficult tasks. The majority of these robots are low-powered and straightforward, yet when they collaborate in vast numbers, they are capable of producing remarkable outcomes. Search and rescue, environmental monitoring, and agricultural uses are all examples of applications for swarm robotics [35]–[39].

Swarm robotics is a field that is gaining major interest in the robotics and automation sector. This field was inspired by the collective behavior of social insects. In order to accomplish difficult tasks, it requires a number of robots, which are often quite simple, to collaborate and work in a coordinated manner. One of the primary reasons for its widespread adoption is the fact that it has the potential to revolutionize a wide range of applications, including environmental monitoring, agriculture, and logistics. Swarm robotics is a system that is thought to be a solution to difficulties such as disaster response and precision agriculture. It offers advantages such as redundancy, adaptability, and resilience. With further developments in coordination algorithms and communication technologies, it is possible that it will become a significant role in the landscape of automation going forward [35]–[39].

2.7. Autonomous Vehicles

One of the applications of robotics that has received the most attention and discussion is autonomous automobiles. Sensors, global positioning systems (GPS), and artificial intelligence are often utilized by these vehicles in order to traverse their surroundings and make judgments. Motor vehicles that drive themselves and other autonomous vehicles have the potential to revolutionize transportation by lowering the number of accidents, enhancing the flow of traffic, and lowering the need for parking places [3], [4], [37], [40], [41].

Continuously reshaping the urban landscape is the result of the proliferation of autonomous vehicles. Self-driving cars and drones are gaining popularity as a result of developments in artificial intelligence, sensor technology, and communication. These innovations have contributed to such developments. Taking into consideration the important urban needs of today, which include enhancing safety, reducing traffic congestion, and increasing transportation efficiency, the trend appears to be virtually innate. Several major technology companies and automobile manufacturers are making significant investments in the development of autonomous vehicles, which is leading to improvements in ride-sharing services and solutions for last-mile delivery. The way in which we carry both people and things is going to be fundamentally altered by autonomous cars as regulations continue to develop to accommodate new technology [3], [4], [25], [37], [40], [41].

As a result of the advent of autonomous vehicles and drones, the transportation industry is undergoing a transformation that is currently having an effect. The arrival of self-driving cars, which have the potential to make roads safer and more efficient, as well as delivery drones, is causing a significant shift in the landscape of the logistics industry. When it comes to shipping parcels, they provide services that are not only efficient but also economical.

2.8. Medical Robotics

Healthcare delivery is being revolutionized by the fast-expanding field of medical robotics, which is one of the fields that is undergoing tremendous growth. Robots are currently being utilized in a variety of contexts to carry out surgical procedures, provide assistance with rehabilitation, and provide medical care to

patients. In comparison to human surgeons, medical robots are able to carry out activities with a higher degree of precision and accuracy, and they even have the ability to work for longer periods of time without becoming fatigued [18], [27]

Healthcare and surgical procedures are two of the most important areas that are being rapidly transformed by medical robotics as a result of the advancements that it provides. Surgeons are increasing their use of robots to assist them in performing complex procedures, such as minimally invasive surgeries and diagnostics, with the intention of achieving greater precision and better outcomes for patients. Research and development in the medical industry are pushed ahead as a result of their ability to permit less invasive treatments and more accurate diagnosis. With the help of telemedicine and remote monitoring, robots are also improving access to medical care. They are going to transform the way that we approach medical treatment and the procedures that are involved in healthcare as a result of on-going technology improvements [19], [27], [30].

2.9. Humanoid Robots

Humanoid robots are intentionally intended to look and move in a manner that is similar to that of humans. The fact that these robots are still in the preliminary stages of development does not change the fact that they have the potential to alter a considerable number of different industries. Humanoid robots have a variety of applications, including teaching, providing entertainment, and providing personal help [42].

In the area of science fiction conception of robotics, the humanoid is perhaps the most interesting and closely aligned example of a robot. Such robots are currently gaining traction as a key trend in the robotics and automation sector. They are designed to resemble human look and actions, and they are currently gaining popularity. For a variety of purposes, including customer service, education, and providing companionship to old people, robots like Sophia and ASIMO are becoming increasingly popular. As a result of the growing interest in social robotics and the goal to develop machines that are capable of interacting in a manner similar to that of humans, this concept is gaining momentum. In addition to their usefulness in the aforementioned industries, they also present significant concerns over the future of communication between humans and robots [18], [42], [43].

2.10. Augmented Reality

Through the use of augmented reality (AR), it is possible to superimpose digital information on top of the physical world. Within the realm of robotics, AR has the potential to offer operators real-time information regarding the surroundings of the robot, hence simplifying the process of controlling and monitoring the robot. In a variety of contexts, including gaming and entertainment, as well as teaching and training, this technology is applicable [13], [18].

Augmented reality, often known as AR, is another developing concept that is gaining speed in its application and is transforming the way in which we engage with technology. The layering of digital information onto our physical surroundings is how AR improves our experience of the real world. A wide variety of industries, including gaming, education, training, navigation, and others, can all benefit from the implementation of this technology. This allows for a seamless transition between the virtual and physical worlds, which in turn improves the quality of human encounters and boosts overall productivity. As AR technology, such as smart glasses, become more widely available and advanced, the number of people using them continues to increase. The possibility for more immersive and intuitive human-machine interactions is the driving force behind this trend, which is generating a dynamic and bright future for augmented reality within the context of the robotics and automation technology [13], [18], [44], [45].

2.11. Industry 4.0 and Smart Manufacturing

The internet of things (IoT), big data, and sophisticated automation are the means by which Industry 4.0, also referred to as the fourth industrial revolution, is altering production and automation. The IoT devices capture real-time data, which is then evaluated using big data analytics. This concept anticipates networked systems and data-driven decision-making for efficient and flexible supply chain management. A significant consequence of this is the development of smart manufacturing, which involves the utilization of IoT-connected robots by firms such as BMW and Volkswagen to achieve real-time flexibility, hence increasing efficiency and decreasing downtime [15], [16], [19], [46].

The web-based software solutions and low-cost robotic arms are helping to democratize modern manufacturing and make automation accessible to businesses of all sizes. This is one of the reasons why smaller enterprises should adopt Industry 4.0. This wish to stimulate industrial automation for all organizations by giving a low-price range and simple programming, without sacrificing the robots' power and efficiency [15], [16], [19], [46].

2.12. Ethical and Societal Implications

Concerns of an ethical nature are brought to the forefront as the use of robotics becomes more widespread in society. There are a number of challenges that need to be carefully examined, including employment displacement, worries around privacy, and the possibility of biased AI algorithms. Creating a balance between the advancement of technology and the welfare of society is a significant challenge that must be overcome [47].

2.13. The Path Ahead

The current trends in robotics indicate to a future in which machines will become indispensable collaborators, thereby expanding our capacities and improving the quality of life. The convergence of AI, sensors, and robotics will continue to drive innovation across all sectors, allowing for the resolution of difficulties and the creation of opportunities in ways that were previously unimaginable [17].

3.   CONCLUSION

There are a lot of intriguing trends and innovations that you should keep an eye on, and the world of robotics is continuously undergoing rapid change. Emerging technologies such as artificial intelligence and machine learning, as well as soft robotics and swarm robotics, have the potential to revolutionize a wide variety of manufacturing sectors. We may anticipate that in the future, there will be even more applications that are both inventive and interesting as robots continues to improve. As new developments in robotics emerge, they are ushering in a new era of automation that is altering industries as well as our everyday lives. Robots are becoming increasingly important in a variety of fields, including healthcare, agriculture, transportation, and others, as they help solve difficult problems and become more efficient. Despite the fact that there are still obstacles to overcome, the trajectory of robotics is extremely exciting since it holds the promise of safer workplaces, greater healthcare, and enhanced environmental sustainability.

It is exciting to think about the transformative technological advancement that is on the horizon, and the future of robotics and automation is a source of excitement for this. As a result of the ongoing integration of artificial intelligence, the internet of things, and automation, we can predict an unprecedented boost in productivity as well as a consistently developing attitude to work. In order to maintain one's relevance in the labor field, it will be essential to engage in ongoing education and skill enhancement. This will be necessary for society as a whole to adjust to the shifting environment. It would be necessary for businesses and educational institutions to collaborate in order to successfully train the next coming generation to work alongside automation, thereby fostering their potential and inventiveness. There is a tremendous amount of potential for humans in the future of robotics and automation, provided that the need to learn, adapt, and innovate is not ignored.

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BIOGRAPHY OF AUTHOR

Tole Sutikno 🆔 🔍 �ꜱᴄ ᴄ is a lecturer and the head of the Master Program of Electrical Engineering at the Faculty of Industrial Technology at Universitas Ahmad Dahlan (UAD) in Yogyakarta, Indonesia. He received his Bachelor of Engineering from Universitas Diponegoro in 1999, Master of Engineering from Universitas Gadjah Mada in 2004, and Doctor of Philosophy in Electrical Engineering from Universiti Teknologi Malaysia in 2016. All three degrees are in electrical engineering. He has been a Professor at UAD in Yogyakarta, Indonesia, since July 2023, following his tenure as an Associate Professor in June 2008. He is the current Editor-in-Chief of TELKOMNIKA and Head of the Embedded Systems and Power Electronics Research Group (ESPERG). He is one of the top 2% of researchers worldwide, according to Stanford University and Elsevier BV's list of the most influential scientists from 2021 to the present. His research interests cover digital design, industrial applications, industrial electronics, industrial informatics, power electronics, motor drives, renewable energy, FPGA applications, embedded systems, artificial intelligence, intelligent control, digital libraries, and information technology. He can be reached via email at tole@te.uad.ac.id.