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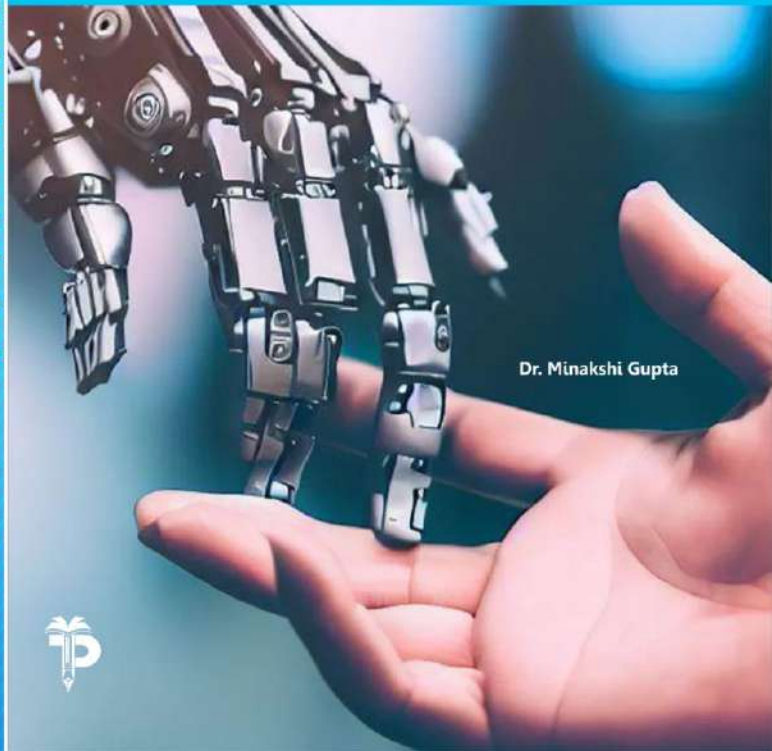
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Revitalising Global Trends in India

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CHAPTER-11

INTRODUCTION TO AI IN ROBOTICS

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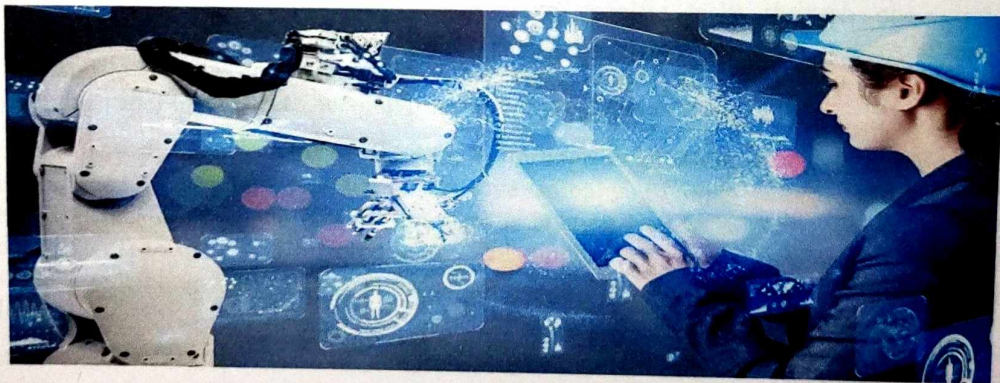
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ABSTRACT

Artificial Intelligence (AI) has played a transformative role in the field of robotics, revolutionizing the capabilities and applications of autonomous machines. This abstract explores the integration of AI into robotics, highlighting key advancements, challenges, and potential future directions. AI-driven robotics encompasses a spectrum of technologies, including machine learning, computer vision, and natural language processing, enabling robots to perceive, learn, and interact with their environments in increasingly sophisticated ways. This synergy has led to advancements in fields such as manufacturing, healthcare, and autonomous vehicles, with robots performing tasks previously deemed too complex or dangerous for humans. However, AI-powered robotics also presents challenges related to safety, ethics, and the impact on the workforce. As the field continues to evolve, addressing these issues while harnessing the full potential of AI in robotics will be crucial for its continued growth and integration into various aspects of our lives. This abstract serves as an overview of the profound impact and ongoing developments at the intersection of AI and robotics.

KEYWORDS: *Robots, Machine Learning,*

INTRODUCTION



The intersection of robotics and artificial intelligence (AI) is quickly becoming a driving force in the creation of new industries, cutting-edge technologies and increased productivity and efficiency in existing sectors. As the field of AI in robotics continues to evolve, its applications in the real world are becoming increasingly apparent.

From self-driving cars, customer service and healthcare, to industrial and service robots, AI is playing a critical role in transforming industries and improving daily life. Although there have been concerns about the potential of AI and robotics to make some aspects of human work obsolete, the World Economic Forum (WEF) predicts that this technology will create 12 million more jobs than it terminates by 2025. This growth presents an opportunity for the



retraining and reskilling of the workforce and investment in knowledge that aligns with the latest technologies.

WHAT IS ROBOTICS?

Robotics is a branch of engineering and computer sciences that includes the design, construction and operation of machines that are capable of performing programmed tasks without additional human involvement. At its core, robotics is about using technology to automate tasks while making them more efficient and safer.

Historically, robots have been used for tasks that are too difficult or dangerous for humans to perform — such as lifting heavy equipment — or for activities that are very repetitive, such as assembling automobiles. By automating these tasks, robotics solutions can enhance productivity and improve safety, freeing up human workers to focus on other more complex and creative endeavours.

It's also worth noting that robots are not subject to the same limitations as humans. For example, a human doing the same task over and over may become tired, bored or disengaged, but the robot will continue to perform the same task with an unwavering level of efficiency and precision. Robotics solutions are already making a major impact across numerous industries, from meticulously harvesting crops to making deliveries and assembling cars.

HOW AI IS USED IN ROBOTICS?

AI has made substantial progress in recent years, and its integration with robotics has proven to be a natural progression. While AI in robotics is not yet widespread, it's rapidly gaining momentum as AI systems become more advanced. The combination of AI and robotics holds tremendous potential, leading to increased productivity and efficiency, improved safety and greater flexibility for workers in a variety of professions.

One of the key ways in which AI is used in robotics is through machine learning. This technique enables robots to learn and perform specific tasks through observing and mimicking human actions. AI gives robots a computer vision that enables them to navigate, detect and determine their reactions accordingly. This helps them go beyond simply performing repetitive tasks to become true “cognitive collaborators.”

Another way that AI is used in robotics is through edge computing. AI applications in robotics require the interpretation of massive amounts of data gathered by robot-based sensors in real time, which is why this data is analyzed close to the machine, rather than being sent off to the cloud for processing. This approach provides machines with real-time awareness, enabling robots to act on decisions at a rate much quicker than human capabilities allow.

BACKGROUND INFORMATION ON AI AND ROBOTICS

Robotics:

Robotics is a multidisciplinary field that combines mechanical engineering, electronics, computer science, and AI to design, build, and operate robots. Robots are autonomous or semi-autonomous machines that can carry out tasks without direct human intervention.

Key aspects of robotics include:

- **Robot Anatomy:** Robots come in various shapes and sizes, from industrial arms used in manufacturing to humanoid robots designed to mimic human movements.



- **Sensors:** Robots use sensors like cameras, lidar, ultrasonic sensors, and tactile sensors to perceive their surroundings and make decisions based on that information.
- **Actuators:** These are the mechanical components that enable robots to move and interact with their environment. Examples include motors, servos, and pneumatic systems.
- **Control Systems:** AI and software algorithms control the movements and actions of robots based on sensor input and predefined instructions.
- **Applications:** Robotics has a wide range of applications, including manufacturing automation, medical surgery, space exploration, autonomous vehicles, and even household chores.

AI AND ROBOTICS INTEGRATION:

The integration of AI and robotics involves using artificial intelligence techniques to enhance the capabilities of robots. AI enables robots to adapt to changing environments, make decisions, and learn from their experiences. This integration has led to advancements in various industries, including autonomous cars, drone technology, industrial automation, and healthcare.

Overall, the combination of AI and robotics has the potential to revolutionize industries and improve our daily lives by creating smarter, more capable, and more adaptable machines.

APPLICATIONS OF AI IN ROBOTICS

In the world of robotics, AI has proven to be a valuable asset in a variety of applications. From customer service to manufacturing, AI has made its mark and continues to revolutionize the way we think about and interact with robots. Let's take a closer look at some of the key areas where AI is being used alongside robotics today.

Customer Service: AI-powered chatbots are becoming increasingly common in customer service applications. These automated service agents can handle simple, repetitive requests without the need for human involvement. The more these systems interact with humans, the more they learn. And as AI systems become more sophisticated, we can expect to see more and more robots being used in customer service in both online and brick-and-mortar environments.

Assembly: AI has proven to be an invaluable tool in robotic assembly applications, especially in complex manufacturing industries such as aerospace. With the help of advanced vision systems, AI can enable real-time course correction and can be used to help a robot automatically learn the best paths for certain processes while in operation.

Packaging: AI is used in the packaging industry to improve efficiency, accuracy and cost-effectiveness. By continuously refining and saving certain motions made by robotic systems, AI helps make installing and moving robotic equipment easier for everyone.

Imaging: Across many industries — including assembly and logistics — accurate imaging is crucial. With the assistance of AI, robots can achieve enhanced visual acuity and image recognition competencies, enabling greater accuracy in even the smallest of details.

Machine Learning: Machine learning is a powerful tool for robots. By exploring their surroundings, robots can learn more about their environment, find ways around obstacles and

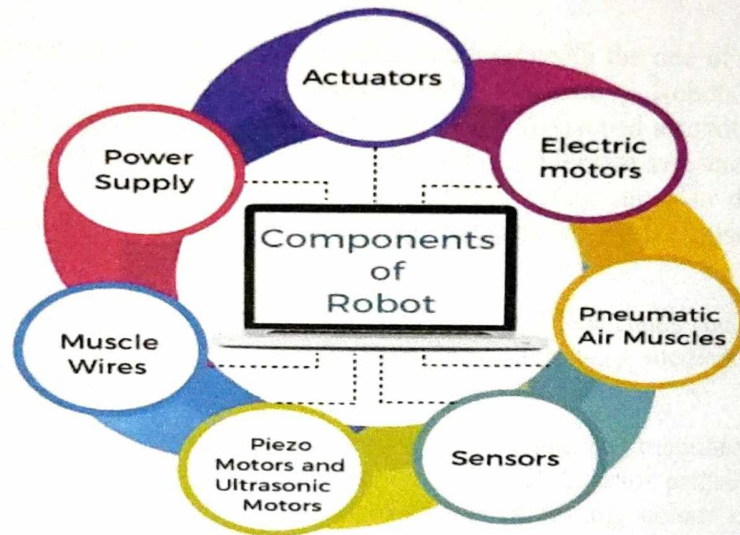


solve problems to complete tasks more efficiently. From home robots like vacuum cleaners to manufacturing robots in factories, machine learning is helping robots become more intelligent and adaptable in their work.

These are just a few of the many applications of AI in robotics today. As these technologies continue to expand and grow in sophistication, it is likely that we will see even more innovative applications in the near future.

COMPONENTS OF ROBOT

Several components construct a robot, these components are as follows:



Actuators: Actuators are the devices that are responsible for moving and controlling a system or machine. It helps to achieve physical movements by converting energy like electrical, hydraulic and air, etc. Actuators can create linear as well as rotary motion.

Power Supply: It is an electrical device that supplies electrical power to an electrical load. The primary function of the power supply is to convert electrical current to power the load.

Electric Motors: These are the devices that convert electrical energy into mechanical energy and are required for the rotational motion of the machines.

Pneumatic Air Muscles: Air Muscles are soft pneumatic devices that are ideally best fitted for robotics. They can contract and extend and operate by pressurized air filling a pneumatic bladder. Whenever air is introduced, it can contract up to 40%.

Muscles wire: These are made up of nickel-titanium alloy called Nitinol and are very thin in shape. It can also extend and contract when a specific amount of heat and electric current is supplied into it. Also, it can be formed and bent into different shapes when it is in its martensitic form. They can contract by 5% when electrical current passes through them.

Piezo Motors and Ultrasonic Motors: Piezoelectric motors or Piezo motors are the electrical devices that receive an electric signal and apply a directional force to an opposing ceramic plate. It helps a robot to move in the desired direction. These are the best suited electrical motors for industrial robots.



Sensor: They provide the ability like see, hear, touch and movement like humans. Sensors are the devices or machines which help to detect the events or changes in the environment and send data to the computer processor. These devices are usually equipped with other electronic devices. Similar to human organs, the electrical sensor also plays a crucial role in Artificial Intelligence & robotics. AI algorithms control robots by sensing the environment, and it provides real-time information to computer processors.

APPLICATIONS OF ROBOTICS

Robotics have different application areas. Some of the important applications domains of robotics are as follows:

Robotics in defence sectors: The defence sector is undoubtedly the one of the main parts of any country. Each country wants their defence system to be strong. Robots help to approach inaccessible and dangerous zone during war. DRDO has developed a robot named Daksh to destroy life-threatening objects safely. They help soldiers to remain safe and deployed by the military in combat scenarios. Besides combat support, robots are also deployed in anti-submarine operations, fire support, battle damage management, strike missions, and laying machines.

Robotics in Medical sectors: Robots also help in various medical fields such as laparoscopy, neurosurgery, orthopaedic surgery, disinfecting rooms, dispensing medication, and various other medical domains.

Robotics in Industrial Sector: Robots are used in various industrial manufacturing industries such as cutting, welding, assembly, disassembly, pick and place for printed circuit boards, packaging & labelling, palletizing, product inspection & testing, colour coating, drilling, polishing and handling the materials.

Moreover, Robotics technology increases productivity and profitability and reduces human efforts, resulting from lower physical strain and injury. The industrial robot has some important advantages, which are as follows:

- Accuracy
- Flexibility
- Reduced labour charge
- Low noise operation
- Fewer production damages
- Increased productivity rate.

Robotics in Entertainment: Over the last decade, use of robots is continuously getting increased in entertainment areas. Robots are being employed in entertainment sector, such as movies, animation, games and cartoons. Robots are very helpful where repetitive actions are required. A camera-wielding robot helps shoot a movie scene as many times as needed without getting tired and frustrated. A big-name Disney has launched hundreds of robots for the film industry.

Robots in the mining industry: Robotics is very helpful for various mining applications such as robotic dozing, excavation and haulage, robotic mapping & surveying, robotic drilling and explosive handling, etc. A mining robot can solely navigate flooded passages and use cameras and other sensors to detect valuable minerals. Further, robots also help in excavation



to detect gases and other materials and keep humans safe from harm and injuries. The robot rock climbers are used for space exploration, and underwater drones are used for ocean exploration.

AI TECHNOLOGY USED IN ROBOTICS

Computer Vision

Robots can also see, and this is possible by one of the popular Artificial Intelligence technologies named Computer vision. Computer Vision plays a crucial role in all industries like health, entertainment, medical, military, mining, etc.

Computer Vision is an important domain of Artificial Intelligence that helps in extracting meaningful information from images, videos and visual inputs and take action accordingly.

Natural Language Processing

NLP (Natural Languages Processing) can be used to give voice commands to AI robots. It creates a strong human-robot interaction. NLP is a specific area of Artificial Intelligence that enables the communication between humans and robots. Through the NLP technique, the robot can understand and reproduce human language. Some robots are equipped with NLP so that we can't differentiate between humans and robots.

Similarly, in the health care sector, robots powered by Natural Language Processing may help physicians to observe the disease details and automatically fill in EHR. Besides recognizing human language, it can learn common uses, such as learn the accent, and predict how humans speak.

Edge Computing

Edge computing in robots is defined as a service provider of robot integration, testing, design and simulation. Edge computing in robotics provides better data management, lower connectivity cost, better security practices, more reliable and uninterrupted connection.

Complex Event Process

Complex event processing (CEP) is a concept that helps us to understand the processing of multiple events in real time. An event is described as a Change of State, and one or more events combine to define a Complex event. The complex event process is most widely used term in various industries such as healthcare, finance, security, marketing, etc. It is primarily used in credit card fraud detection and also in stock marketing field.

For example, the deployment of an airbag in a car is a complex event based on the data from multiple sensors in real-time. This idea is used in Robotics, for example, Event-Processing in Autonomous Robot Programming.

Transfer Learning and AI

This is the technique used to solve a problem with the help of another problem that is already solved. In Transfer learning technique, knowledge gained from solving one problem can be implement to solve related problem. We can understand it with an example such as the model used for identifying a circle shape can also be used to identify a square shape.

Transfer learning reuses the pre-trained model for a related problem, and only the last layer of the model is trained, which is relatively less time consuming and cheaper. In robotics, transfer learning can be used to train one machine with the help of other machines.



Reinforcement Learning

Reinforcement learning is a feedback-based learning method in machine learning that enables an AI agent to learn and explore the environment, perform actions and learn automatically from experience or feedback for each action. Further, it is also having feature of autonomously learn to behave optimally through hit-and-trial action while interacting with the environment. It is primarily used to develop the sequence of decisions and achieve the goals in uncertain and potentially complex environment. In robotics, robots explore the environment and learn about it through hit and trial. For each action, he gets rewarded (positive or negative). Reinforcement learning provides Robotics with a framework to design and simulate sophisticated and hard-to-engineer behaviours.

Affective computing

Affective computing is a field of study that deals with developing systems that can identify, interpret, process, and simulate human emotions. Affective computing aims to endow robots with emotional intelligence to hope that robots can be endowed with human-like capabilities of observation, interpretation, and emotion expression.

Mixed Reality

Mixed Reality is also an emerging domain. It is mainly used in the field of programming by demonstration (PbD). PbD creates a prototyping mechanism for algorithms using a combination of physical and virtual objects.

What are Artificially Intelligent Robots?

Artificial intelligent robots connect AI with robotics. AI robots are controlled by AI programs and use different AI technologies, such as Machine learning, computer vision, RL learning, etc. Usually, most robots are not AI robots, these robots are programmed to perform repetitive series of movements, and they don't need any AI to perform their task. However, these robots are limited in functionality.

AI algorithms are necessary when you want to allow the robot to perform more complex tasks.

A warehousing robot might use a path-finding algorithm to navigate around the warehouse. A drone might use autonomous navigation to return home when it is about to run out of battery. A self-driving car might use a combination of AI algorithms to detect and avoid potential hazards on the road. All these are the examples of artificially intelligent robots.

What are the advantages of integrating Artificial Intelligence into robotics?

The major advantages of artificially intelligent robots are social care. They can guide people, especially come to aid for older people, with chatbot like social skills and advanced processors.

Robotics also helps in Agricultural industry with the help of developing AI based robots. These robots reduce the farmer's workload.

In Military industry, Military bots can spy through speech and vision detectors, along with saving lives by replacing infantry

Robotics also employed in volcanoes, deep oceans, extremely cold places, or even in space where normally humans can't survive.



Robotics is also used in medical and healthcare industry as it can also perform complex surgeries that have a higher risk of a mistake by humans, but with a pre-set of instructions and added Intelligence. AI integrated robotics could reduce the number of casualties greatly.

Difference in Robot System and AI Programs

Here is the difference between Artificial Intelligence and Robots:

1. AI Programs

Usually, we use to operate them in computer-simulated worlds.

Generally, input is given in the form of symbols and rules.

To operate this, we need general-purpose/Special-purpose computers.

2. Robots

Generally, we use robots to operate in the real physical world.

Inputs are given in the form of the analogue signal or in the form of the speech waveform.

Also, to operate this, special hardware with sensors and effectors are needed.

FUTURE OF AI IN ROBOTICS

The future of AI in robotics is vast and exciting. The next stage of AI, known as AGI or Artificial General Intelligence, holds the potential to reach levels of true human understanding. The key to this is integrating the computational system of AI with a robot. The robot must possess mobility, senses (such as touch, vision and hearing) and the ability to interact with physical objects, which will enable the system to experience immediate sensory feedback from every action it takes. This feedback loop enables the system to learn and comprehend, bringing it closer to achieving true AGI.

The current focus on AI in robotics is shifting from the question of what tasks robots can perform for people, to what type of input a robot can provide the AI's "mind." By allowing AI to explore and experiment with real objects, it will be possible for it to approach a deeper understanding, much like a human child. With this integration of AI and robotics, we can expect to see significant advancements in a wide range of industries, from manufacturing and healthcare to security and space exploration.

The future of AI in robotics is bright and holds the potential for tremendous progress in how we understand and interact with the world. By combining the computational power of AI with the physical capabilities of robots, we are opening up new doors for exploration and innovation, and the potential for true AGI is within reach.

CONCLUSION

AI in robotics has revolutionized various industries, offering benefits such as increased efficiency, precision, and automation. It has enabled robots to perform tasks with greater autonomy and adaptability. However, challenges remain, including ethical concerns, the need for robust safety measures, and the potential impact on employment. The future of AI in robotics holds promise for further advancements and integration into our daily lives, but it also requires careful consideration of its societal and ethical implications.



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