AI and IoT-Based Intelligent Automation in Robotics

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Preface

It is widely believed that the current technologies are not the only factors that limits the building of an efficient human-machine intelligent processing engine. The emotions and the cognitive abilities are also playing an important role in understanding the various aspects through various intelligent technologies.

Artificial Intelligence (AI) is one of the trending technologies in the recent era. The emergence of the robotics and application of AI in it brings out a significant change in the domain. Various algorithms that emerge in AI and the computational efficiency of the systems has made it possible to address a number of applications through robotics. The Internet of Things (IoT) is the important domain that plays a major role in robotics. With the aid of IoT and AI, robotics an exponential development in providing solutions to complex technical problems have been explored.

This book aims at providing an overview of robotics and the application of AI and IoT in robotics. It contains the deep exploration of AI and IoT based intelligent automation in robotics. The various algorithms and frameworks for robotics based on AI and IoT have been presented analyzed and discussed. This book also provides insights on application of robotics in education, healthcare, defense and many other fields with the utilization of IoT and AI. It also includes the idea of smart cities using robotics.

This book contains twenty-four chapters. Chapter 1 reports the introduction about the robotics. Chapter 2 explores the techniques of robotics for automation using AI and IoT. Chapter 3 descriptively investigates the role of the defense in the same technological aspects. Chapter 4 examines the role of AI and IoT based intelligent automation of robotics in case of healthcare. Chapter 5 explores the skill transfer to robots based on semantically represented the activities of humans. Chapter 6 illustrates the healthcare robots enabled with IoT and artificial intelligence for old

aged patients. Chapter 7 explores the robotics, AI and IoT in defense system. Chapter 8 describes the techniques of robotics for automation using AI and IoT. Chapter 9 discusses an artificial intelligence based smart task responder that is android robot for human instruction using LSTM technique. Chapter 10 explores the robotics, AI and IoT in medical and healthcare. Chapter 11 scrutinizes real time mild and moderate Covid'19 human body temperature detection using AI. Chapter 12 shows the role of drones in smart cities. Chapter 13 presents UAV's in terms of agriculture prospective. Chapter 14 discussed the semi-automated parking system by using DSDV and RFID. Chapter 15 reviews on the various technologies involved in vehicle to vehicle communication. Chapter 16 explores about the smart wheelchair. Chapter 17 explores defaulters list using facial recognition. Chapter 18 introduces visitor/intruder monitoring system using machine learning. Chapter 19 provides a comparison of machine learning algorithms for air pollution monitoring system. Chapter 20 discusses a novel approach towards audio watermarking using FFT and Cordic Q-R decomposition. Chapter 21 explores the performance of DC biased optical orthogonal frequency division multiplexing in visible light communication. Chapter 22 illustrates the microcontroller based variable rate syringe pump for microfluidic application. Chapter 23 illustrates the analysis of emotion in speech signal processing and rejection of noise. Chapter 24 discusses regarding securing cloud data by using blend cryptography with AWS services.

Overall, this book is designed for exploring global technological information about the AI and IoT based intelligent automation in robotics. Armed with specific usage practices, applicability, framework and challenges readers can make informed choices about the adoption of AI and IoT based intelligent automation. It may be helpful in the development of efficient framework and models in the adoption of these techniques in different domains.

It is a great pleasure for us to acknowledge the contributions and assistance of many individuals. We would like to thank all the authors who submitted chapters for their contributions and fruitful discussion that made this book a great success. We hope the readers find value and future insights into the contributions made by the authors. This book also opens up further avenues and opportunities for the future research. We are very thankful to the team of Scrivener publishing specially to Martin Scrivener for providing the meticulous service for timely publication of this book.

We would like to express our deep sense of gratitude for the encouragement and support offered by our Institutions/Universities and colleagues. Last but not least, we gratefully acknowledge the support, encouragement and patience of our families.

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Introduction to Robotics

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Abstract

These days, automation plays a major role in all sectors of society and the technology of robotic automation is very much in demand along with other significantly trending concepts such as the Internet of Things (IoT), Machine Learning (ML), Artificial Intelligence (AI) and Cloud Computing. Many people are showing interest in purchasing things which have process automation; for example, do not increase speed once they reach a certain point and automatically turn off the water tank when it is about to overfill. Robotics is also the technology where when an instruction is given to the device it acts accordingly based on the user instruction. When we want the robot to perform based on the user instruction, we first have to train the device or robot with the instructions for the particular task we want to do. For example, if we give a data set to the robot for creation of coffee and we give an instruction to the robot to "Prepare Tea," the robot doesn't respond to the request because the request doesn't match the available datasets in the robot. In this chapter, I will focus on a basic introduction to robots, their architecture and the equipment needed for designing robots.

***Keywords*:** Machine learning, IoT, AI, energy, drones, nano tubes, energy, actuation

1.1 Introduction

"Robotics" or "robots" is a very popular term which we are increasingly hearing day by day. The word "robotics" was derived from the word "robot,"

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which comes from the Slavic word "robota," meaning slave/servant. Robots were introduced to society by George C. Devol, who generally referred to them as artificial people. Generally, robots consist of different components such as sensors, controlling devices, manipulators, power supply as well as software to perform the defined action. A combination of these characteristics forms the robot. For preparing the perfect robot we have to proceed with designing, building, programming as well as testing the robot using a combination of physics, mathematics, computational techniques, mechanical engineering, electrical engineering and structural engineering. In some of the particular scenarios the concepts of biology, chemistry and medicine are also involved based on the requirements. Generally, robot technology is used [1] in environments where a human cannot perform the action.

Many people treat robots as machines but in many of the real-time applications robots replace the person and also act as a person, such as the androids in the movies *Star Wars*, *Terminator* and *Star Trek: The Next Generation*. The robots capture human faces and activities and perform tasks as a person does. Even though developers are implementing many advancements in robots and using them in many applications, they are not able to develop enough common sense in them because robots perform the task based on the user's instructions but can't predict future actions by doing tasks in a dynamic manner. So, regarding this topic, many of the researchers are working in this domain under the research domain named "humanoid robots."

Most of the robots which were created till now are very dangerous, boring, onerous and just plain nasty. We can find these types of robots in the medical, automobile, manufacturing, and industrial industries among others, as well as the space industry. Robots, such as the Mars rover Sojourner and the upcoming Mars Exploration rover or the underwater robotic vehicle Caribou, were designed and sent to places where humans cannot go, such as volcanoes, mars, etc., for the purpose of helping to conduct research in those particular places. On the other hand, other types of robots were designed for the purpose of entertaining small children and others. A few of them are Techno, Polly and AIBO ERS-220, which often arrive at the stores around Christmas time.

Robots are very efficient, fun and easy to design. In his book *Being Digital*, Nicholas Negroponte relates an excellent story that took place about eight years ago at the time of the televised premier of the Media Lab's LEGO/Logo work at the Hennigan School. When the robot was first introduced to the children in school, they didn't show interest in adopting it. However, in a third attempt, the children talked, played and had fun with the robot. The children asked the robot questions and the robot started

giving responses to the children. The children in the class felt very excited and had fun with the robot.

Finally, what exactly does robot mean?

Many authors gave definitions based on their understanding. There is really no standard definition of robotics. When designing the robot, every designer needs to have the following properties and features, if not it is not considered a robot [2].

The robot should have following characteristics:

- Sensing
  First, robots have to recognize the surroundings and respond according to them. The robots will not behave in all the environments. We have to imbue robots with sensitivity to light (eyes), touch, pressure (like hands), chemicals (nose), sound (ears) and taste (tongue) among others. By combining all these we will get the correct working robot for the environment.
- Movement
  The robot should be capable of identifying surroundings/environment in order to perform actions such as moving its body all around the surroundings.
- Energy
  Robots should be capable of identifying the power in their battery and should charge by themselves.
- Intelligence
  Robots need to become smarter than humans. Those who make robots smart are called programmers. Robots should require a minimum amount of knowledge to understand and perform the task that the user instructed.

So, the definition of the term robot encompasses a sensor, controlling device, physical device, manipulator, and a programming testing device, with mechanical engineering, electrical engineering, mathematics, and a small portion of chemistry also being involved.

1.2 History and Evolution of Robots

Table 1.1 shows the origins of robotics along with detailed information of when the robots came into existence, the developer's name, etc. Presently, there are various types of robots which are used for various environments

Table 1.1 History of the earliest robots.

Date	Significance	Robot name	Inventor
3rd century BC and earlier	First humanoid automata based on an earlier description		Yan Shi
1st century AD and earlier	Descriptions of more than 100 machines and automata which include a fire engine, a wind organ, a coin-operated machine, and a steam-powered engine		Ctesibius, Philo of Byzantium, Heron of Alexandria, and others
c. 420 BC	Robot designed like a bird, which will fly	Flying Pigeon	Archytas of Tarentum
1206	First humanoid robot with automata mechanism	Robot band, hand-washing automaton [11], automated moving peacocks [12]	Al-Jazari
1495	Humanoid robot	Mechanical Knight	Leonardo da Vinci
1738	Mechanical duck which can eat, flap its wings, and excrete	Digesting Duck	Jacques de Vaucanson
1898	First radio-controlled device	Teleautomaton	Nikola Tesla
1921	First fictional automatons called robots	Rossum's Universal Robots	Karel Čapek
1930s	Humanoid robot exhibited at the 1939 and 1940 New York World's Fair	Elektro	Westinghouse Electric Corporation
1946	First general-purpose digital computer	Whirlwind	Multiple people

(*Continued*)

Table 1.1 History of the earliest robots. (*Continued*)

Date	Significance	Robot name	Inventor
1948	Simple robots exhibiting biological behaviors	Elsie and Elmer	William Grey Walter
1956	First commercial robot from the Unimation company	Unimate	George Devol
1961	First installed industrial robot	Unimate	George Devol
1967 to 1972	First full-scale humanoid intelligent robot	WABOT-1	Waseda University
1973	First industrial robot with six electromechanically driven axes	Famulus	KUKA Robot Group
1974	First microcomputer controlled electric industrial robot, IRB 6 from ASEA, which was already patented in 1972.	IRB 6	ABB Robotics
1975	Programmable universal manipulation arm, a Unimation product	PUMA	Victor Scheinman
1978	First object-level robot programming language, which allows robots to handle variations in object position, shape, and sensor noise	Freddy I and II, RAPT robot programming language	Patricia Ambler and Robin Popplestone
1983	First multitasking, parallel programming language used for a robot control	ADRIEL I	Stevo Bozinovski and Mihail Sestakov

for various users. Moreover, the robots were classified into mechanical construction, electrical components and computer programming mechanism.

The mechanical part of the robot is designed for mechanical purposes such as designing the particular shape and processing of the particular task. With the mechanical components it also follows the physics friction mechanism for processing of the task.

The robots have the electrical power capable of handling the mechanical products because the electricity is capable of handling the machine [3]. Even though there are petrol-based robots, they still require electrical energy in order to function, just as a car works with a battery.

1.3 Applications

Because the lives of people were becoming busier, robots were designed to help meet the needs of their users. Initially we assigned the task or multiple tasks as per the instructions of humans and the robots performed the task if the particular task was programmed and vice versa. Later on, the robots were designed in such a way that specific robots or customized robots were designed for specific tasks. The main theme in designing customized robots was to make them work more efficiently. Generally, the robots were designed in an assembly manner for making them more adaptive as well as making the tasks speedier. Such types of robots were categorized as "assembly robots." Now robots were also used in the automobile industry for procedures such as welding, tightening, etc., and the robots were the products called "integrated units" because they were designed in such a way that they were integrated with different fields like mechanical and electrical engineering and computers. For example, robots that performed welding tasks were called "welding robots." Any type of robot had the capability of performing various types of tasks [4]. Some robots were exclusively designed for making the heavy load changes and such type of robots were treated as "heavy duty robots." Finally, "humanoid robots" were designed for addressing all the emergencies that a human does.

The robots described above are just some of the various robots and their applications in specific fields. Some of the various types of robots and various places where they are being used include:

- Military robots
- Industrial robots
- Collaborative robots

- Construction robots
- Agricultural robots
- Medical robots
- Robots for kitchen automation
- Spot robot for combat
- Robots for cleaning up contaminated areas
- such as toxic sites or nuclear facilities
- Domestic robots
- Nanorobots
- Swarm robots
- Autonomous drones
- Robots for sports field line marking

1.4 Components Needed for a Robot

Electricity, mechanical power and programming are the main things needed to successfully design a robot. First, when designing the robot, the planning and outlook of how it should be viewed after implementation are the main things to keep in mind [5]. Below are the requirements for designing a full-fledged robot:

1) Power Source
   For the power source the main thing which we use is batteries. The power taken from electricity will convert to the thermal energy stored in the batteries. All robots need a battery in order to work. The robot will work up to a certain number of hours when it is fully charged. The batteries, such as silicon batteries and acid batteries, are used because batteries, such as silver-cadmium batteries, are too expensive. While designing the required battery for a particular robot, initially we only have to think about the power consumption of the robot based on its working capacity. If the robot work capacity is less and if we give more power the electricity inside the robot may short circuit and total loss or damage to the robot may ensue. We also have to consider the weight of the robot while designing because if the robot is heavier it will consume more power when performing the user requests [6]. If the robot is heavier there are many disadvantages such as not cost-effective, difficult to manage the tasks, higher power consumption, inefficient, etc. Apart

from electric power there are a few other alternatives which are beneficial, such as

- Pneumatic power
- Solar power
- Hydraulic power
- Flywheel energy storage
- Anaerobic digestion
- Nuclear power

2) Actuation
   In human terminology, the actuator is like muscles for the robot. Here the overall thing depends on the momentum of the device. Most of the devices work in an electrical and mechanical manner. These robots help in controlling, managing and monitoring the works. After designing the particular robot for a particular manner in the customized way, many of the alterations were performed on the robot and many of the software updates and alterations were made either in terms of hardware or software or battery or capacity, etc., based on the load and capacity of the robot.
3) Electric Motors
   A large number of robots use electrical and mechanical power for performing tasks. The robots use mechanical power as well as electrical power for performing tasks. The robots use DC motors and AC motors for industrial purposes for performing the heavy loaded type of tasks. There will be motors which perform the heavy loaded as well as light loaded tasks. Here, when performing the heavy loaded and light loaded tasks the capacity of battery as well as the usage of the battery varies from time to time.
4) Linear Actuators
   There are various types of actuators which have faster speed as well as direction. Here, when the speed changes the direction also changes and vice versa. There are various types of robots which have more pneumatic and hydraulic actuators. There is an actuator called a "linear actuator" which has a motor as well as a lead screw. Another type of actuator which is powered by hand is the rack and pinion actuator commonly found in cars.
5) Series Elastic Actuator
   This part is designed in a flexible and elastic manner and works in a more robust manner in controlling things like