Write Up

Robotics

Aditya Binukumar
Srishti Sharma
Shiva Tripathi
Tanishq Tanwar

13th October, 2021

Introduction

Robotics is an interdisciplinary field that integrates computer science and engineering. Robotics involves design, construction, operation, and use of robots. The goal of robotics is to design machines that can help and assist humans. Robotics integrates fields of mechanical engineering, electrical engineering, information engineering, mechatronics, electronics, bioengineering, computer engineering, control engineering, software engineering, mathematics, among others.

Robotics develops machines that can substitute for humans and replicate human actions. Robots can be used in many situations for many purposes, but today many are used in dangerous environments (including inspection of radioactive materials, bomb detection and deactivation), manufacturing processes, or where humans cannot survive (e.g. in space, underwater, in high heat, and clean up and containment of hazardous materials and radiation). Robots can take on any form, but some are made to resemble humans in appearance. This is claimed to help in the acceptance of robots in certain replicative behaviors which are usually performed by people. Such robots attempt to replicate walking, lifting, speech, cognition, or any other human activity. Many of today's robots are inspired by nature, contributing to the field of bio-inspired robotics.

Certain robots require user input to operate while other robots function autonomously. The concept of creating robots that can operate autonomously dates back to classical times, but research into the functionality and potential uses of robots did not grow substantially until the 20th century. Throughout history, it has been frequently assumed by various scholars, inventors, engineers, and technicians that robots will one day be able to mimic human behavior and manage tasks in a human-like fashion. Today, robotics is a rapidly growing field, as technological advances continue; researching, designing, and building new robots serve various practical purposes, whether domestically, commercially, or militarily. Many robots are built to do jobs that are hazardous to people, such as defusing bombs, finding survivors in unstable ruins, and exploring mines and shipwrecks. Robotics is also used in STEM (science, technology, engineering, and mathematics) as a teaching aid.

History

One of the earliest descriptions of automata appears in the Lie Zi text, on a much earlier encounter between King Mu of Zhou (1023–957 BC) and a mechanical engineer known as Yan Shi, an 'artificer'. The latter allegedly presented the king with a life-size, human-shaped figure of his mechanical handiwork. Descriptions of more than 100 machines and automata, including a fire engine, a wind organ, a coin-operated machine, and a steam-powered engine, were made in Pneumatica and Automata by Heron of Alexandria.

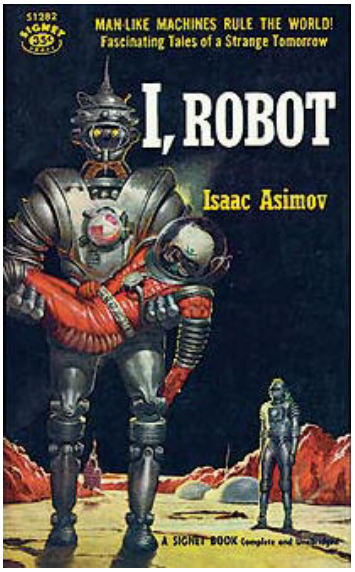
The term robotics is an extension of the word robot. One of its first uses came from Czech writer Karel Čapek, who used the word in his play, Rossum's Universal Robots, in 1920.

However, it is science fiction author Isaac Asimov who has been given credit for being the first person to use the term in the 1940s by Oxford English Dictionary.

In Asimov's story, he suggested three principles to guide the behavior of autonomous robots and smart machines. Asimov's Three Laws of Robotics have survived to the present:

1. Robots must never harm human beings.
2. Robots must follow instructions from humans without violating rule 1.
3. Robots must protect themselves without violating the other rules.

However, it wasn't until a couple of decades later in 1961 -- based on designs from the '50s -- that the first programmable robot, Unimate, was created to move scalding metal pieces from a die-cast machine.



Types of Robots

Mechanical bots come in all shapes and sizes to efficiently carry out the task for which they are designed. All robots vary in design, functionality and degree of autonomy. From the 0.2 millimeter-long “RoboBee” to the 200 meter-long robotic shipping vessel “Vindskip,” robots are emerging to carry out tasks that humans simply can’t. Generally, there are five types of robots:

Pre-Programmed Robots

Pre-programmed robots operate in a controlled environment where they do simple, monotonous tasks. An example of a pre-programmed robot would be a mechanical arm on an automotive assembly line. The arm serves one function — to weld a door on, to insert a certain part into the engine, etc. — and its job is to perform that task longer, faster and more efficiently than a human.

Humanoid Robots

Humanoid robots are robots that look like and/or mimic human behavior. These robots usually perform human-like activities (like running, jumping and carrying objects), and are sometimes designed to look like us, even having human faces and expressions. Two of the most prominent examples of humanoid robots are Hanson Robotics’ Sophia (in the video above) and Boston Dynamics’ Atlas.

Autonomous Robots

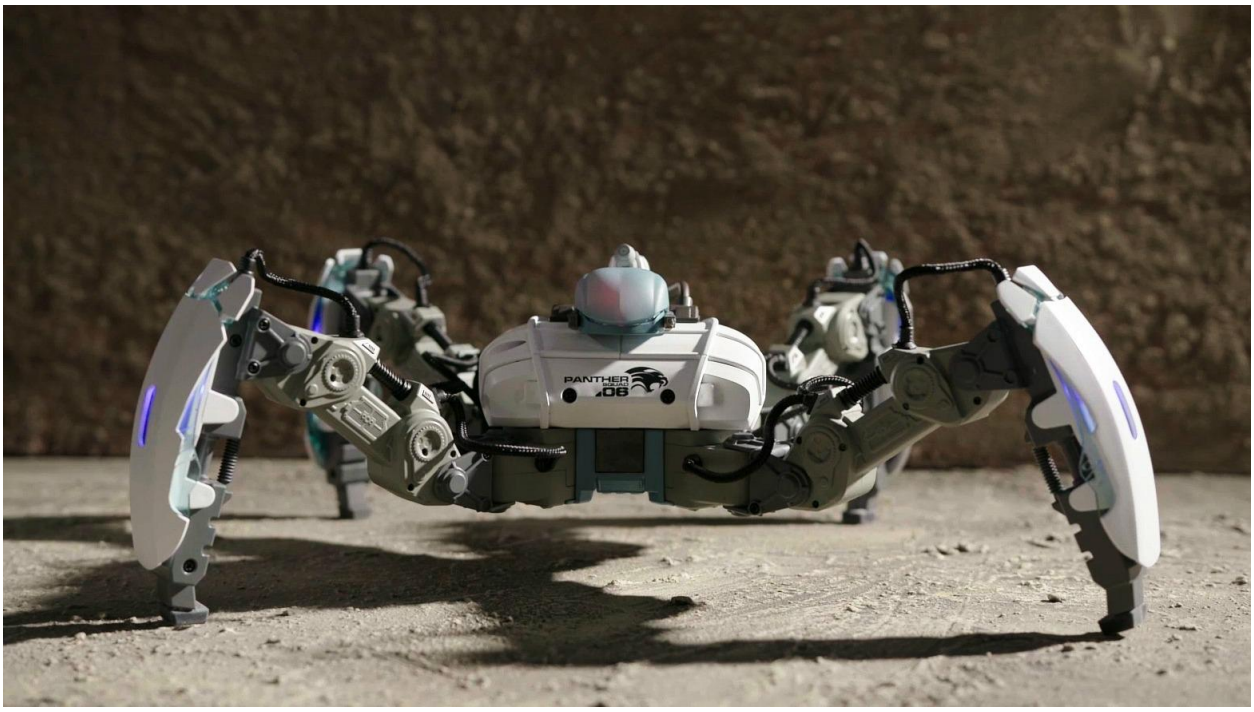
Autonomous robots operate independently of human operators. These robots are usually designed to carry out tasks in open environments that do not require human supervision. They are quite unique because they use sensors to perceive the world around them, and then employ decision-making structures (usually a computer) to take the optimal next step based on their data and mission. An example of an autonomous robot would be the Roomba vacuum cleaner, which uses sensors to roam freely throughout a home.

Teleoperated Robots

Teleoperated robots are semi-autonomous bots that use a wireless network to enable human control from a safe distance. These robots usually work in extreme geographical conditions, weather, circumstances, etc. Examples of teleoperated robots are the human-controlled submarines used to fix underwater pipe leaks during the BP oil spill or drones used to detect landmines on a battlefield.

Augmenting Robots

Augmenting robots either enhance current human capabilities or replace the capabilities a human may have lost. The field of robotics for human augmentation is a field where science fiction could become reality very soon, with bots that have the ability to redefine the definition of humanity by making humans faster and stronger. Some examples of current augmenting robots are robotic prosthetic limbs or exoskeletons used to lift hefty weights. From Diffusing Bombs to Performing Surgery, VR Robots Have Some Amazing Uses.



Functioning of Robots

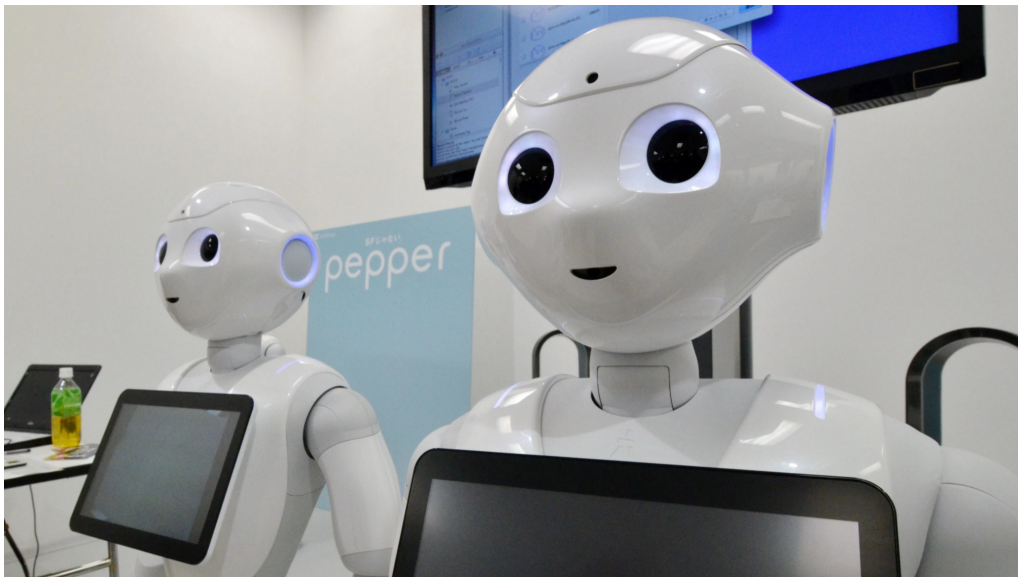
Independent robots

Independent robots are capable of functioning completely autonomously and independent of human operator control. These typically require more intense programming but allow robots to take the place of humans when undertaking dangerous, mundane or otherwise impossible tasks, from bomb diffusion and deep-sea travel to factory automation. Independent robots have proven to be the most disruptive to society, eliminating low-wage jobs but presenting new possibilities for growth.

Dependent robots

Dependent robots are non-autonomous robots that interact with humans to enhance and supplement their already existing actions. This is a relatively new form of technology and is being constantly expanded into new applications, but one form of dependent robots that has been realized is advanced prosthetics that are controlled by the human mind.

A famous example of a dependent robot was created by Johns Hopkins APL in 2018 for a patient named Johnny Matheny, a man whose arm was amputated above the elbow. Matheny was fitted with a Modular Prosthetic Limb (MPL) so researchers could study its use over a sustained period. The MPL is controlled via electromyography, or signals sent from his amputated limb that controls the prosthesis. Over time, Matheny became more efficient in controlling the MPL and the signals sent from his amputated limb became smaller and less variable, leading to more accuracy in its movements and allowing Matheny to perform tasks as delicate as playing the piano.



Components of a Robot

Robots are built to present solutions to a variety of needs and fulfill several different purposes, and therefore, require a variety of specialized components to complete these tasks. However, there are several components that are central to every robot's construction, like a power source or a central processing unit. Generally speaking, robotics components fall into these five categories:

Control system

Computation includes all of the components that make up a robot's central processing unit, often referred to as its control system. Control systems are programmed to tell a robot how to utilize its specific components, similar in some ways to how the human brain sends signals throughout the body, in order to complete a specific task. These robotic tasks could comprise anything from minimally invasive surgery to assembly line packing.

Sensors

Sensors provide a robot with stimuli in the form of electrical signals that are processed by the controller and allow the robot to interact with the outside world. Common sensors found within robots include video cameras that function as eyes, photoresistors that react to light and microphones that operate like ears. These sensors allow the robot to capture its surroundings and process the most logical conclusion based on the current moment and allows the controller to relay commands to the additional components.

Actuators

As previously stated, a device can only be considered to be a robot if it has a movable frame or body. Actuators are the components that are responsible for this movement. These components are made up of motors that receive signals from the control system and move in tandem to carry out the movement necessary to complete the assigned task. Actuators can be made of a variety of materials, such as metal or elastic, and are commonly operated by use of compressed air (pneumatic actuators) or oil (hydraulic actuators,) but come in a variety of formats to best fulfill their specialized roles.

Power Supply

Like the human body requires food in order to function, robots require power. Stationary robots, such as those found in a factory, may run on AC power through a wall outlet but more commonly, robots operate via an internal battery. Most robots utilize lead-acid batteries for their safe

qualities and long shelf life while others may utilize the more compact but also more expensive silver-cadmium variety. Safety, weight, replaceability and lifecycle are all important factors to consider when designing a robot's power supply.

Some potential power sources for future robotic development also include pneumatic power from compressed gasses, solar power, hydraulic power, flywheel energy storage organic garbage through anaerobic digestion and nuclear power.

End Effectors

End effectors are the physical, typically external components that allow robots to finish carrying out their tasks. Robots in factories often have interchangeable tools like paint sprayers and drills, surgical robots may be equipped with scalpels and other kinds of robots can be built with gripping claws or even hands for tasks like deliveries, packing, bomb diffusion and much more.

Uses of Robots

Robots have a wide variety of use cases that make them the ideal technology for the future. Soon, we will see robots almost everywhere. We'll see them in our hospitals, in our hotels and even on our roads.

Manufacturing

The manufacturing industry is probably the oldest and most well-known user of robots. These robots and co-bots (bots that work alongside humans) work to efficiently test and assemble products, like cars and industrial equipment. It's estimated that there are more than three million industrial robots in use right now.

Logistics

Shipping, handling and quality control robots are becoming a must-have for most retailers and logistics companies. Because we now expect our packages to arrive at blazing speeds, logistics companies employ robots in warehouses, and even on the road, to help maximize time efficiency. Right now, there are robots taking your items off the shelves, transporting them across the warehouse floor and packaging them. Additionally, a rise in last-mile robots (robots that will autonomously deliver your package to your door) ensure that you'll have a face-to-metal-face encounter with a logistics bot in the near future.

Home

It's not science fiction anymore. Robots can be seen all over our homes, helping with chores, reminding us of our schedules and even entertaining our kids. The most well-known example of home robots is the autonomous vacuum cleaner Roomba. Additionally, robots have now evolved to do everything from autonomously mowing grass to cleaning pools.

Travel

Is there anything more science fiction-like than autonomous vehicles? These self-driving cars are no longer just imagination. A combination of data science and robotics, self-driving vehicles are taking the world by storm. Automakers, like Tesla, Ford, Waymo, Volkswagen and BMW are all working on the next wave of travel that will let us sit back, relax and enjoy the ride. Rideshare companies Uber and Lyft are also developing autonomous rideshare vehicles that don't require humans to operate the vehicle.

Healthcare

Robots have made enormous strides in the healthcare industry. These mechanical marvels have use in just about every aspect of healthcare, from robot-assisted surgeries to bots that help humans recover from injury in physical therapy. Examples of robots at work in healthcare are Toyota's healthcare assistants, which help people regain the ability to walk, and "TUG," a robot designed to autonomously stroll throughout a hospital and deliver everything from medicines to clean linens.

Recently, robots have been employed by pharmaceutical companies to help speed up the fight against COVID-19. These bots are now being used to fill and seal COVID-19 testing swabs, and are also being used by some manufacturers to produce PPE and respirators.

Other applications of Robotics

-
- Helping fight forest fires
- Working alongside humans in manufacturing plants (known as co-bots)
- Robots that offer companionship to elderly individuals
- Surgical assistants
- Last-mile package and food order delivery
- Autonomous household robots that carry out tasks like vacuuming and mowing the grass
- Assisting with finding items and carrying them throughout warehouses
- Used during search-and-rescue missions after natural disasters
- Landmine detectors in war zones.

Robotics at Work: Boston Dynamics

Boston Dynamics is an American engineering and robotics design company founded in 1992 as a spin-off from the Massachusetts Institute of Technology. Headquartered in Waltham, Massachusetts, Boston Dynamics has been owned by the Hyundai Motor Group since December 2020.

Boston Dynamics is best known for the development of a series of dynamic highly-mobile robots, including BigDog, Spot, Atlas, and Handle. Since 2019, Spot has been made commercially available, making it the first commercially available robot from Boston Dynamics, while the company stated its intent to commercialize other robots as well, including Handle.

On June 23, 2016, Boston Dynamics revealed the four-legged canine-inspired Spot which only weighs 25 kg (55 pounds) and is lighter than their other products. In November 2017, a promotional video of the Spot using its forward claw to open a door for another robot reached #1 on YouTube, with over 2 million views. A later video the same month showed Spot persisting in attempting to open the door in the face of human interference. Viewers perceived the robot as "creepy" and "reminiscent of all kinds of sci-fi robots that wouldn't give up in their missions to seek and destroy".

On May 11, 2018, CEO of Boston Dynamics Marc Raibert at TechCrunch Robotics Session 2018 announced that the Spot robot was in pre-production and preparing for commercial availability in 2019. On its website, Boston Dynamics highlights that Spot is the "quietest robot [they] have built." The company says it has plans with contract manufacturers to build the first 100 Spots later that year for commercial purposes, with them starting to scale production with the goal of selling Spot in 2019. However, in September 2019, journalists were informed that the robots will not be sold, but they will be given on lease to selected business partners. In November 2019 Massachusetts State Police became the first law enforcement agency to use Spot mini as robot cop as well as in the unit's bomb squad.

Since January 23, 2020, Spot's SDK is available for anyone via GitHub. It will allow programmers to develop custom applications for Spot to do various actions that could be used across different industries. On June 16, 2020 Boston Dynamics made Spot available for the general public to purchase at a price of US$74,500. On June 23, 2020, a lone Spot named 'Zeus' was used by SpaceX at their Boca Chica Starship Test Site to help contain sub-cooled liquid nitrogen and to inspect 'Potentially Dangerous' sites at and around the Launchpad. On July 9, 2020, a team of Spot robots performed as cheerleaders in the stands at a baseball match between the Fukuoka SoftBank Hawks and the Rakuten Eagles, backed by a team of SoftBank Pepper Robots. Spot

performed inspection tasks on the Skarv floating production storage and offloading vessel in November 2020. In October 2021, it was announced that Boston Dynamics would collaborate with Zepth (a construction industry solution provider) to combine Spot's data collection capabilities with Zepth's technology that offers insights into the captured data, which can be used to enhance efficiency, productivity, and collaboration throughout each phase of a project lifecycle.

Future of Robotics

Increasingly sophisticated machines may populate our world, but for robots to be really useful, they'll have to become more self-sufficient. After all, it would be impossible to program a home robot with the instructions for gripping each and every object it ever might encounter. You want it to learn on its own, and that is where advances in artificial intelligence come in.

Take Brett. In a UC Berkeley lab, the humanoid robot has taught itself to conquer one of those children's puzzles where you cram pegs into different shaped holes. It did so by trial and error through a process called reinforcement learning. No one told it how to get a square peg into a square hole, just that it needed to. So by making random movements and getting a digital reward (basically, yes, do that kind of thing again) each time it got closer to success, Brett learned something new on its own. The process is super slow, sure, but with time roboticists will hone the machines' ability to teach themselves novel skills in novel environments, which is pivotal if we don't want to get stuck babysitting them.

Another tack here is to have a digital version of a robot train first in simulation, then port what it has learned to the physical robot in a lab. Over at Google, researchers used motion-capture videos of dogs to program a simulated dog, then used reinforcement learning to get a simulated four-legged robot to teach itself to make the same movements. That is, even though both have four legs, the robot's body is mechanically distinct from a dog's, so they move in distinct ways. But after many random movements, the simulated robot got enough rewards to match the simulated dog. Then the researchers transferred that knowledge to the real robot in the lab, and sure enough, the thing could walk—in fact, it walked even faster than the robot manufacturer's default gait, though in fairness it was less stable.

Conclusion

Unprecedented advances in sensor technology, computing power, and edge processing can provide robots with robust AI capabilities, but this is predicated on secure, but flexible connectivity and interoperability among all ecosystem participants. Robots must be able to connect readily to other robots, and also with a full range of IoT, edge, cloud, and analytical tools and other devices.

To date, the robotics and IoT communities have been driven by varying, yet highly related objectives. IoT focuses on services for pervasive sensing, monitoring, and tracking, while the robotics community focuses on production action, interaction, and autonomous behavior. Fusing both fields leads to better robotics task execution.The robots have more data for analysis and AI enabled decision-making. In this way, edge computing opens the door for even closer collaboration between man and machine.