
BML 300: INTRODUCTION TO HEALTHCARE ENGINEERING

Coordinator: Dr. Arnab Chanda

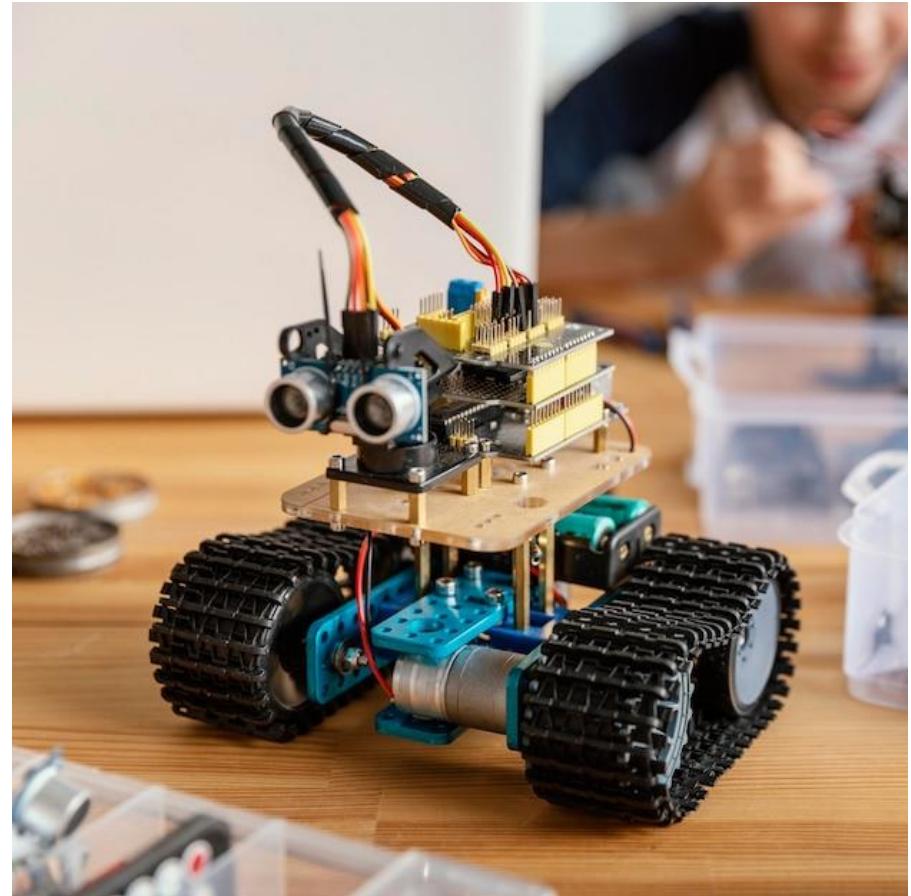
Centre for Biomedical Engineering, IIT Delhi

Department of Biomedical Engineering, AIIMS Delhi

Date: Oct 4, 2024

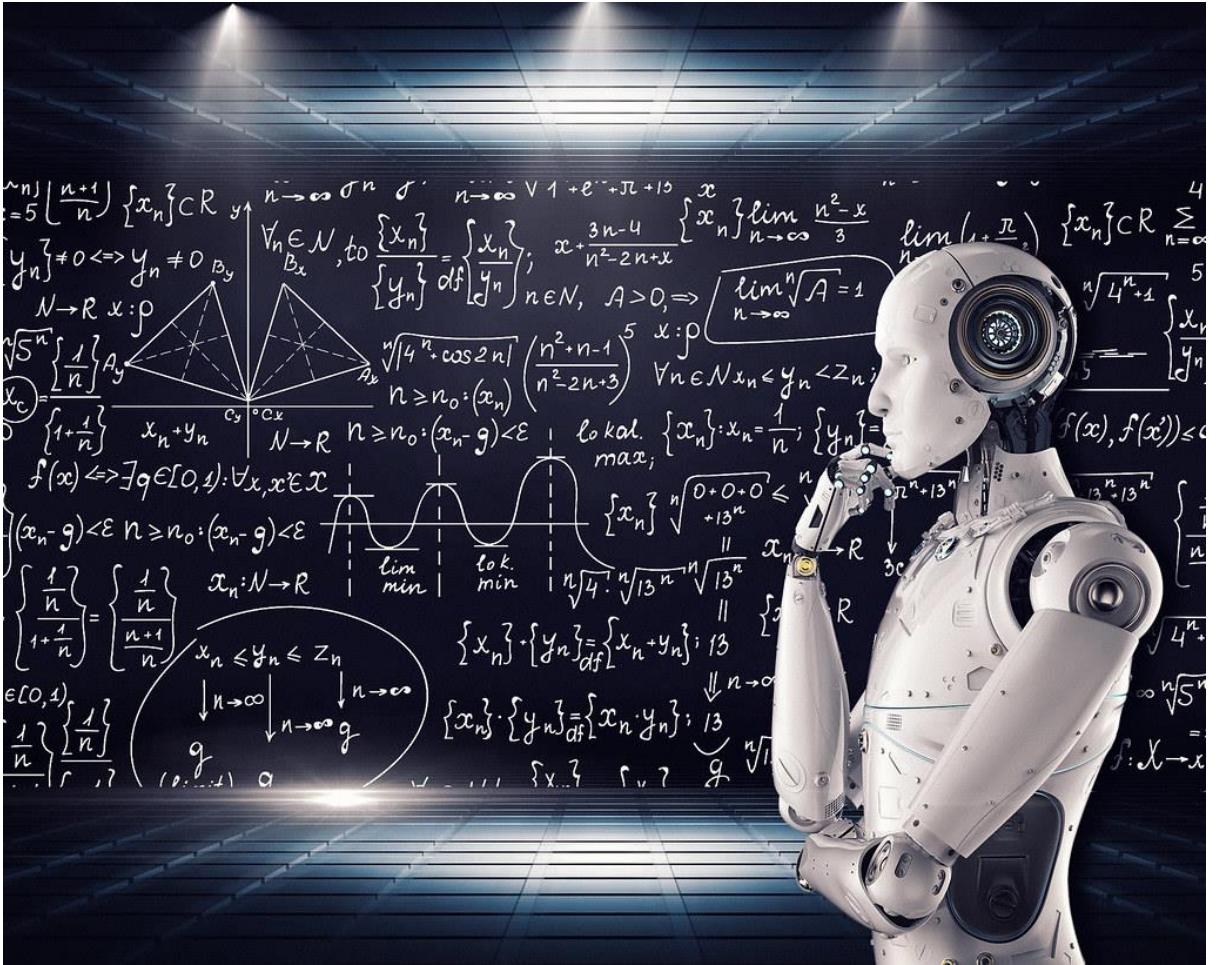
What is a Robot?

A **robot** is a machine—especially one programmable by a computer—capable of carrying out a complex series of actions automatically.^[2] A robot can be guided by an external control device, or the control may be embedded within



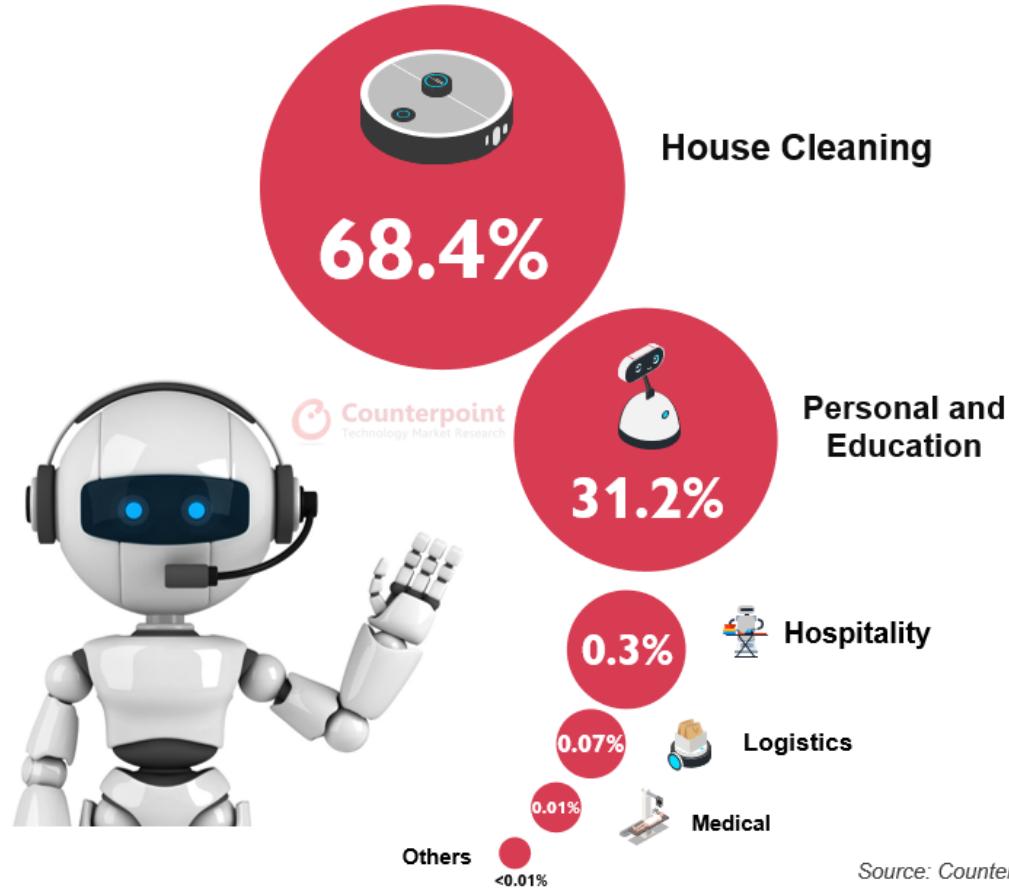
Robotics is a branch of engineering and computer science that involves the conception, design, manufacture and operation of robots.

What is Robotics?

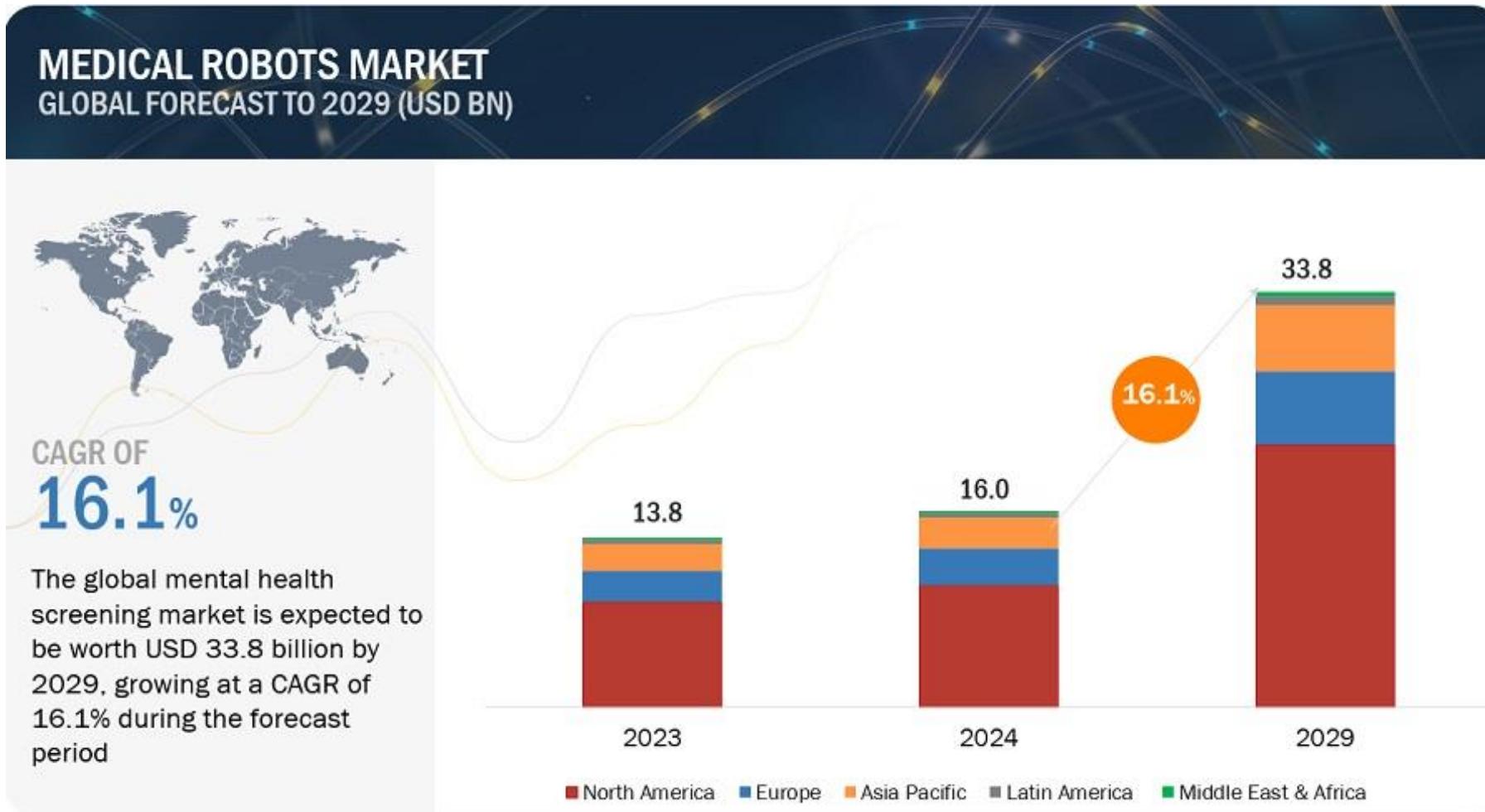


Robotics Market: Trends

Global Consumer Service Robots Shipment Market Share by Segment in 2021



Robotics Market: Trends



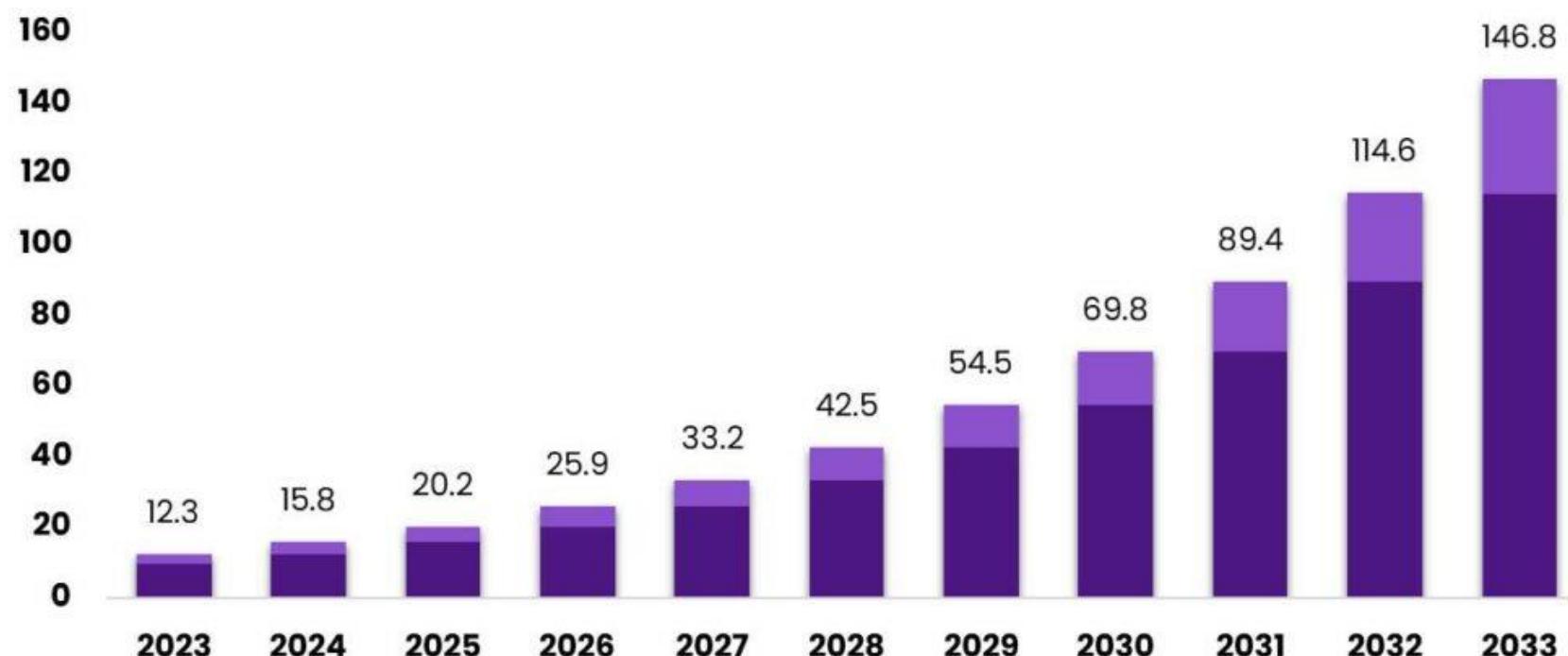
Robotics Market: Trends



Robotics Market: Trends

Global AI in Robotics Market

Size, By Robot Type, 2023-2033 (USD Billion)



The Market will Grow
At the CAGR of:

28.12%

The Forecasted Market
Size for 2033 in USD:

\$146.8 B

market.us

ONE STOP SHOP FOR THE REPORTS

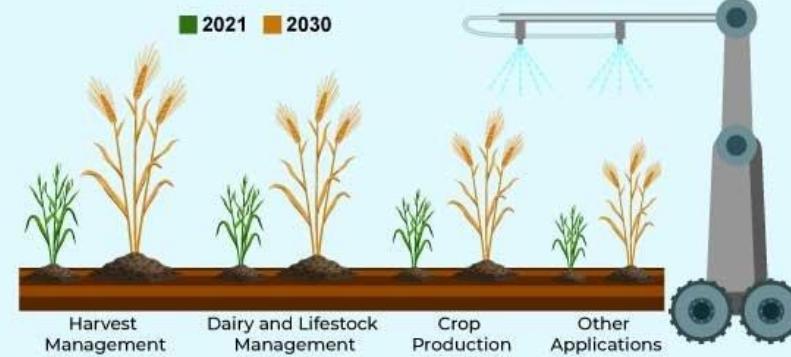
Robotics Market: Trends

GLOBAL AGRICULTURAL ROBOTS MARKET FORECAST 2022-2030

MARKET BY REGION

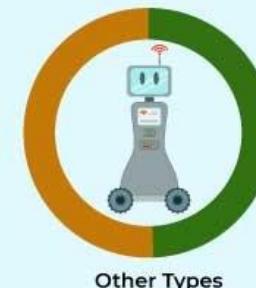
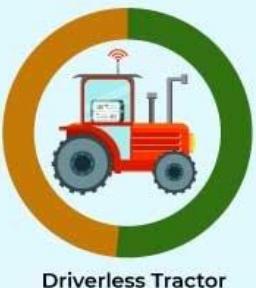
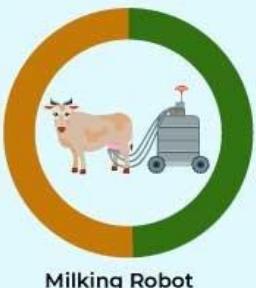


MARKET BY APPLICATION



MARKET BY TYPE

■ 2021
■ 2030



TOP COMPANIES

• AGCO CORPORATION AUTONOMOUS SOLUTIONS INC CNH INDUSTRIAL DEERE & COMPANY

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Robotics Market: Trends

GLOBAL HOSPITALITY ROBOTS MARKET 2022-2026

Market growth will **ACCELERATE** at a **CAGR** of

11.6%



Incremental growth (\$M)

291.74



The market is **FRAGMENTED** with several players occupying the market

Growth Contributed by **NORTH AMERICA**

37%



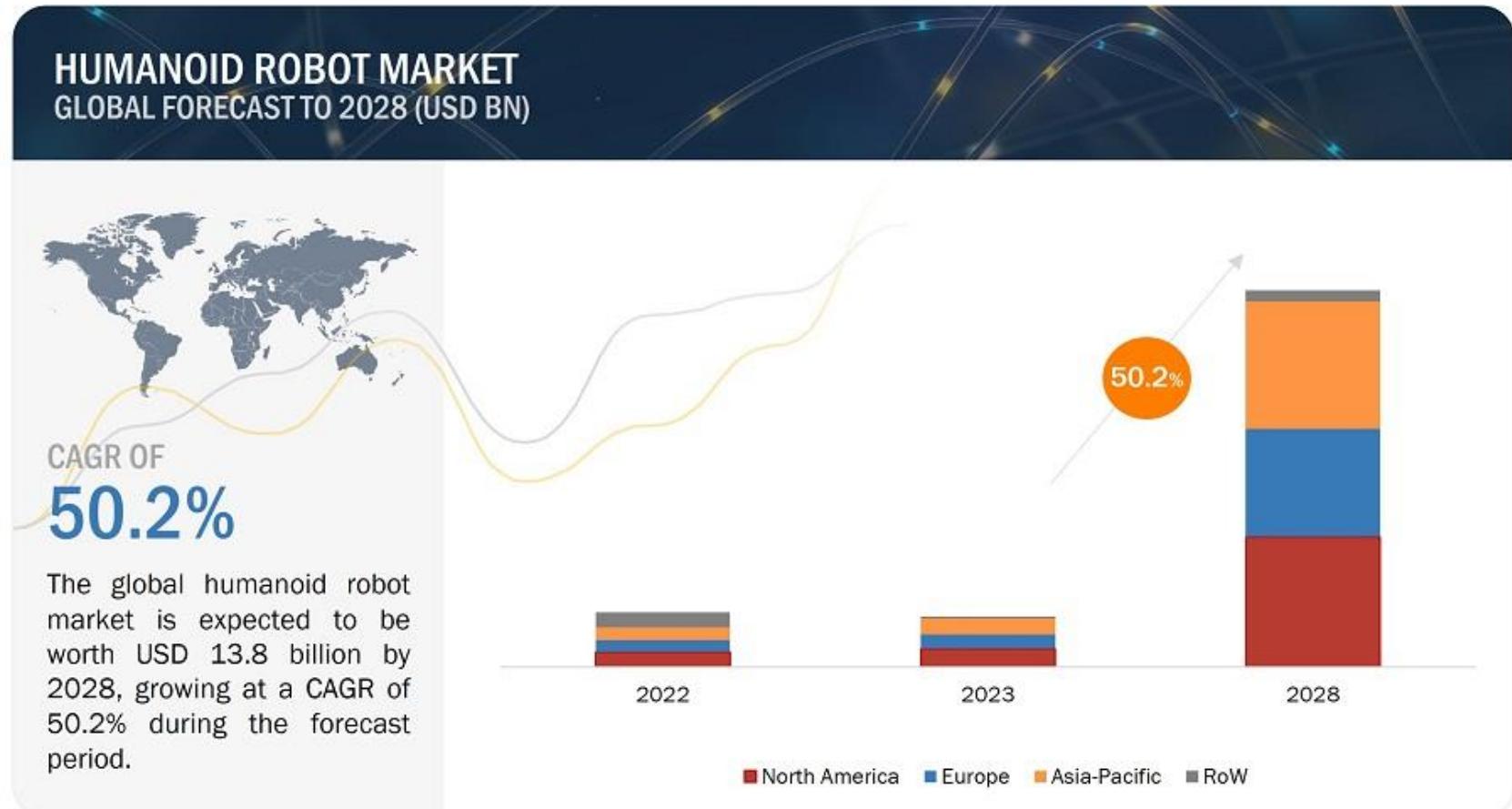
Growth for **2022**



11.0%

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Robotics Market: Trends

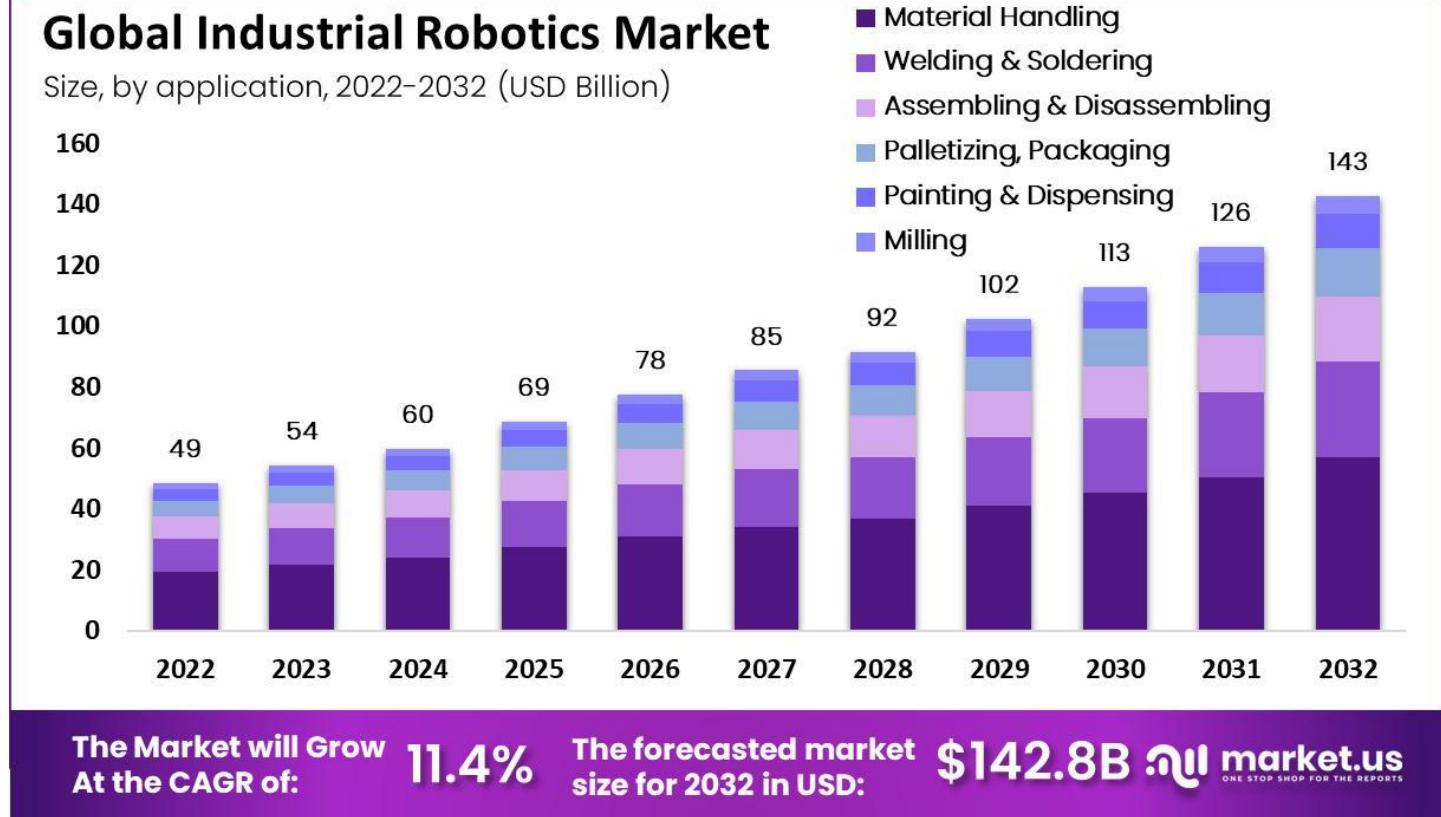
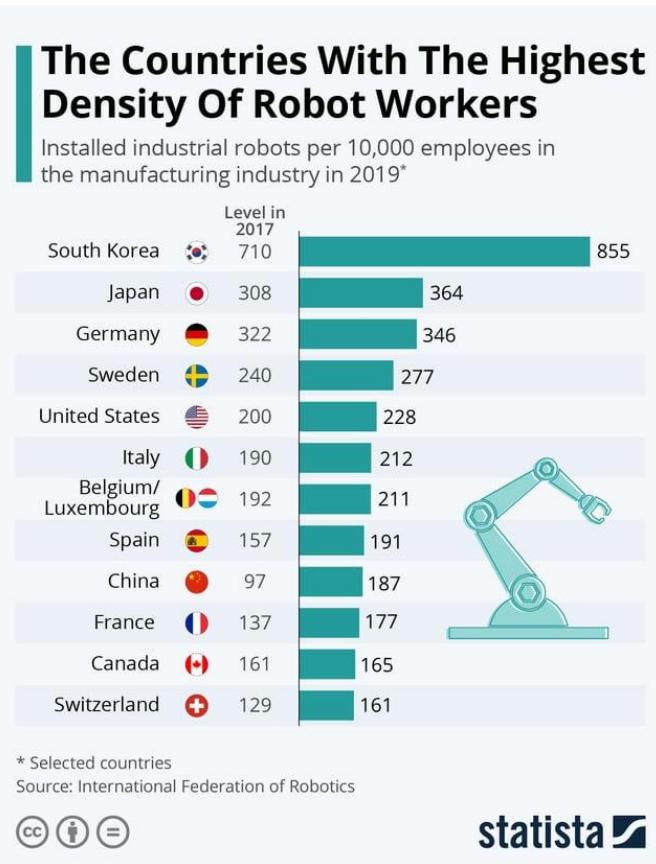


Robotics in Industry

Industrial robots are heavy-duty machines designed to automate the manufacturing process. They are equipped with at least one robotic arm, and often complete repetitive or dangerous tasks in warehouses and factories.



Robotics in Industry



Robotics in Industry

Five Main Types of Industrial Robots

There are more than five types of industrial robots, but the most common ones can be (and should be) classified by their mechanical structure, according to the International Federation of Robotics.

Cartesian Robots

These work on three linear axes using the Cartesian Coordinate system (X, Y and Z), meaning they use three sliding joints to move up and down, in and out and side to side. The cartesian robot is the [most commonly used industrial robot](#), typically for CNC machines or 3D printing.



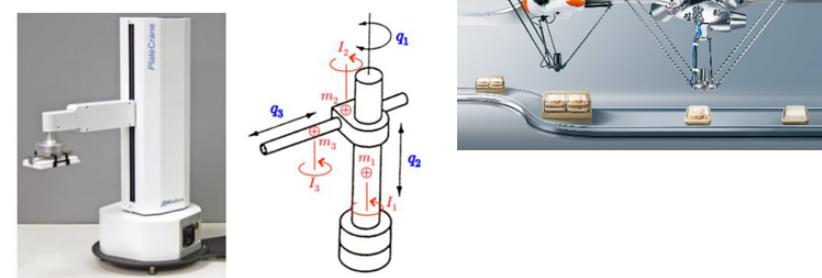
SCARA Robots

Selective Compliance Articulated Robot Arm (SCARA) robots have two parallel rotary joints that provide compliance in a plane. The SCARA robot is commonly used for assembly applications and specializes in lateral movements.



Articulated Robot

With anywhere from two to 10 (or more) joints, articulated robots are connected to the base with a twisting joint. Resembling a human arm, they are commonly used in packaging, painting, metal casting and other industrial applications.



Delta Robots

Heavily used for manufacturing in the food, pharmaceutical and electronic industries, these spider-like robots are connected with a common base. The delta robot is typically used for fast pick and place applications due its precision at high speed.

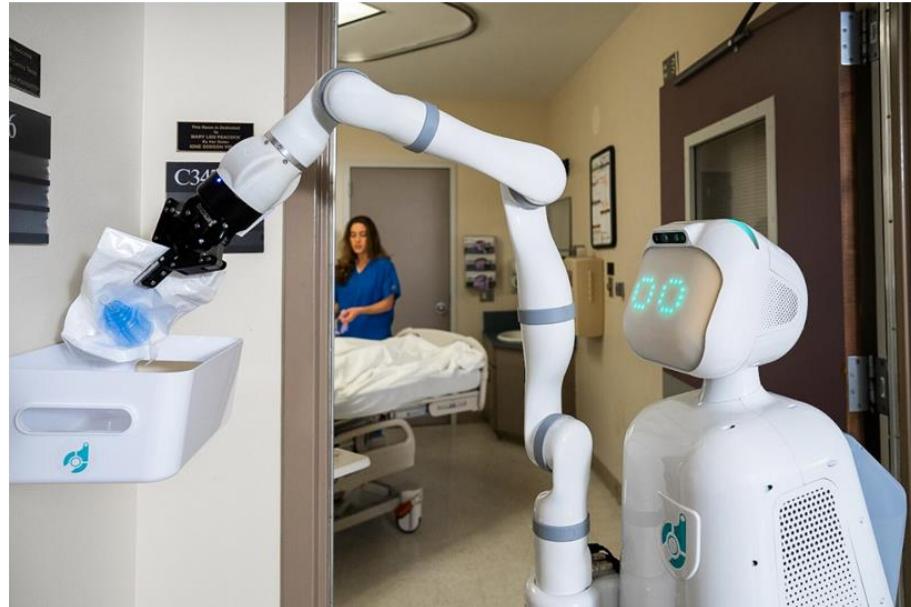
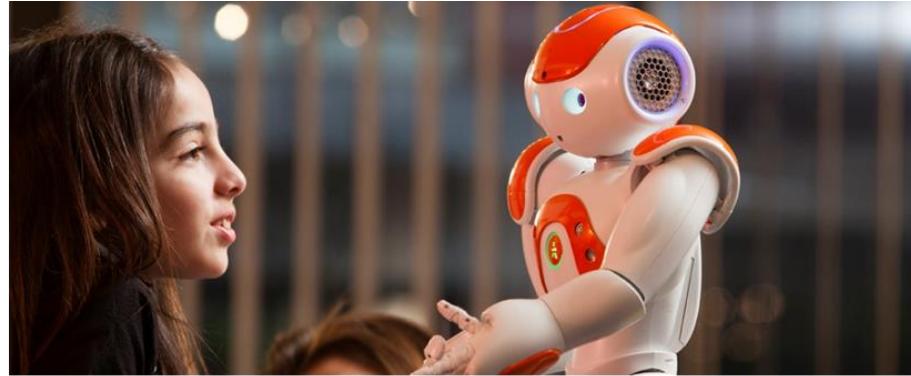
Cylindrical Robots

Considered a good fit for tight spaces, this compact robot features at least one rotary joint for rotational movement and a prismatic joint for linear motion. Common cylindrical robot applications include simple assembly, die-casting and machine loading and unloading.

Robotics in Society

Robots are used in society in various ways, ranging from healthcare and transportation to entertainment. Robots, such as bomb disposal can also be used in a military setting.

- Healthcare Industry
- Transportation and Logistics
- Construction and Infrastructure
- Entertainment and Hospitality
- Robots in society: Mining Industry
- Robots in society: Military

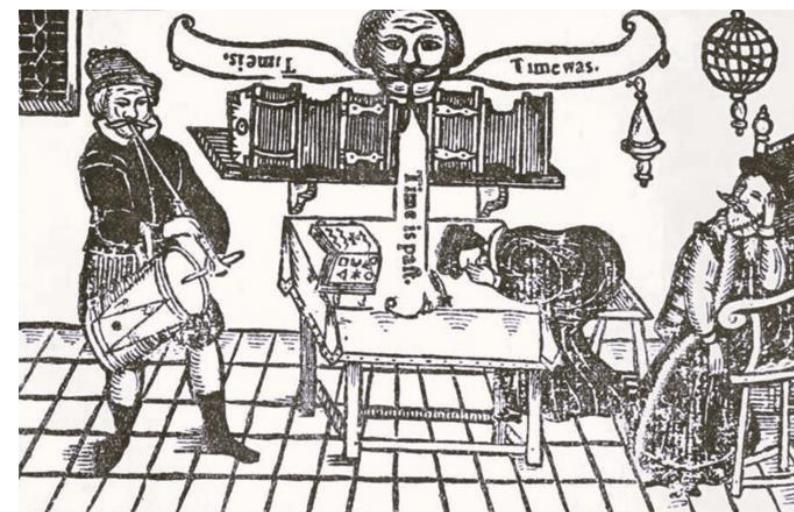


History of Robotics

250 B.C. - Ctesibius, an ancient Greek engineer and mathematician, invented a water clock which was the most accurate for nearly 2000 years.



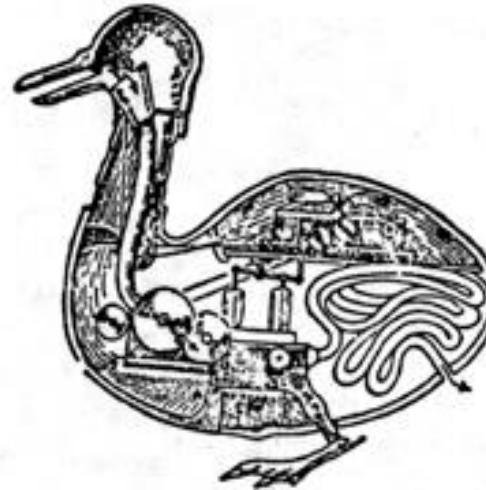
60 A.D. – Hero of Alexandria designs the first automated programmable machine. These 'Automata' were made from a container of gradually releasing sand connected to a spindle via a string. By using different configurations of these pulleys, it was possible to repeatably move a statue on a pre-defined path.



History of Robotics

1738 - Jacques de Vaucanson builds a mechanical duck made of more than 4,000 parts. The duck could quack, bathe, drink water, eat grain, digest it and void it. Whereabouts of the duck are unknown today.

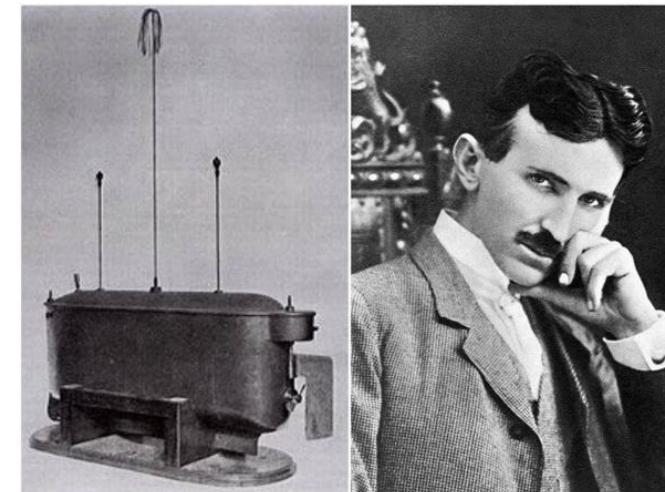
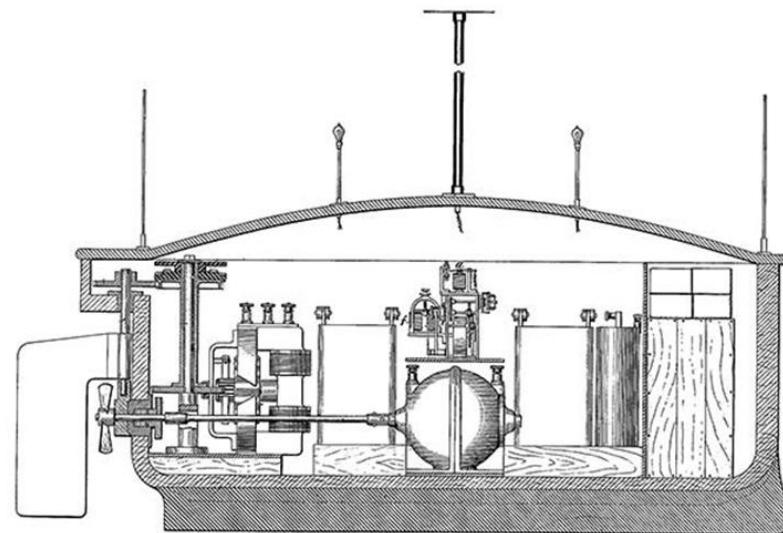
1805 - Doll, made by Maillardet, that wrote in either French or English and could draw landscapes.



History of Robotics

1898 - The first radio-controlled submersible boat was invented by Nikola Tesla.

1921 - The term "**robot**" was first used in 1920 in a play called "R.U.R." Or "*Rossum's universal robots*" by the Czech writer Karel Capek. The plot was simple: man makes robot then robot kills man! Many movies that followed continued to show robots as harmful, menacing machines. *Robot* comes from the Czech word *robo*, which means "servitude, forced labor."



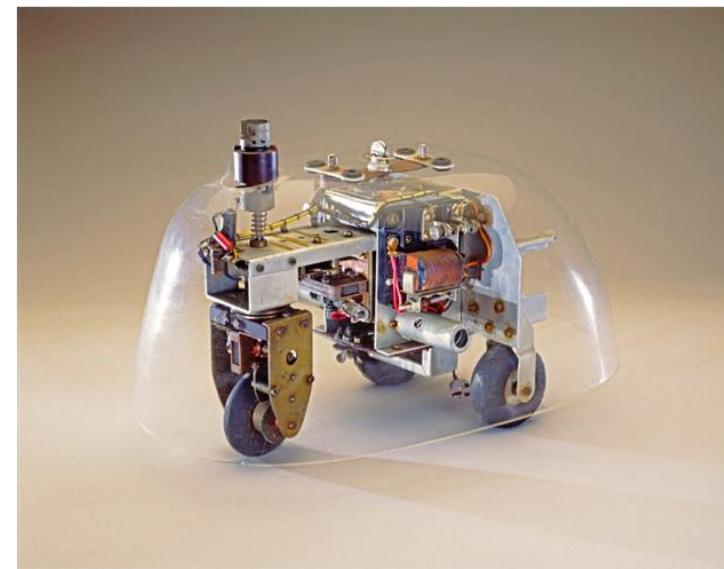
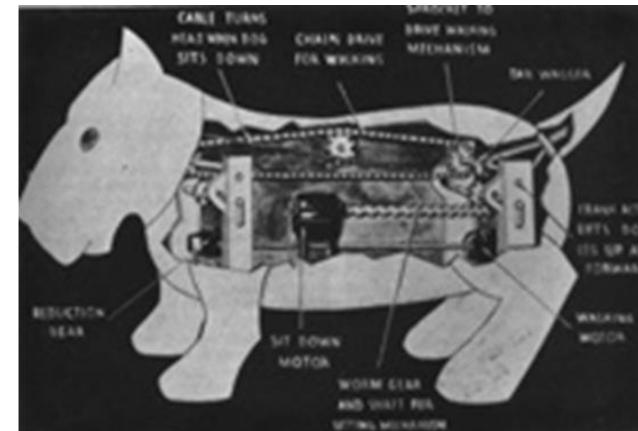
History of Robotics

1940 - Sparko, the Westinghouse dog, uses both mechanical and electrical components.

1941 - Isaac Asimov introduced the word 'Robotics' in the science fiction short story 'Liar!'

1948 - William Grey Walter builds Elmer and Elsie, two of the earliest autonomous robots with the appearance of turtles. The robots used simple rules to produce complex behaviors.

Cybernetics is a discipline that was created in the late 1940's by Norbert Wiener, combining feedback control theory, information sciences and biology to try to explain the common principles of control and communications in both animals and machines.

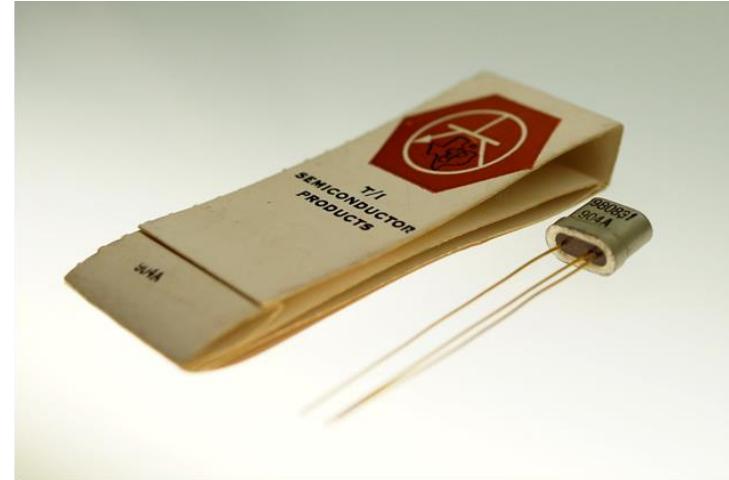


History of Robotics

1950's - Computer technology advances and control machinery is developed.

1954 - The first silicon transistor was produced by Texas Instruments.

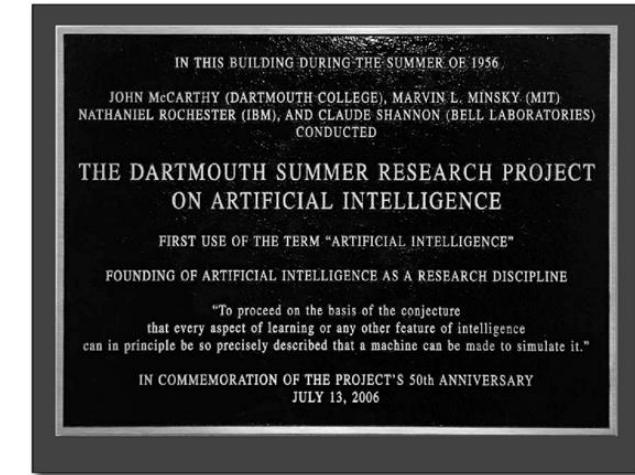
1954 – George Devol replaced the slave manipulator in a teleoperator with the programmability of the CNC controller, thus creating the first “industrial robot”, called the “Programmable Article Transfer Device”.



History of Robotics

1955 – The Dartmouth Summer Research Conference marks the birth of AI. Marvin Minsky, from the AI lab at MIT defines an intelligent machine as one that would tend to “build up within itself an abstract model of the environment in which it is placed. If it were given a problem, it could first explore solutions within the internal abstract model of the environment and then attempt external experiments”. This approach dominated robotics research for the next 30 years.

1956 - Researchers aim to combine “perceptual and problem-solving capabilities,” using computers, cameras, and touch sensors. The idea is to study the types of intelligent actions these robots are capable of. A new discipline is born: [A.I.](#)

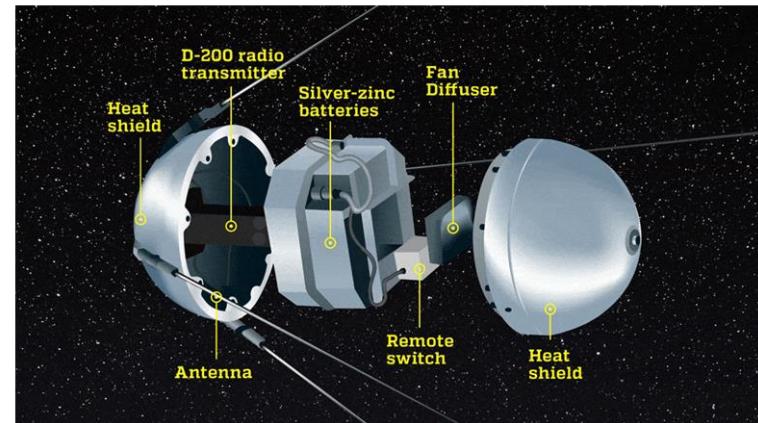


History of Robotics

1956 - Joseph Engleberger, a Columbia physics student buys the rights to Devol's robot and founds the Unimation Company.

1956 - George Devol applied for a patent for the first programmable robot, later named 'Unimate'.

1957 - Launch of the first artificial satellite, Sputnik 1.



History of Robotics

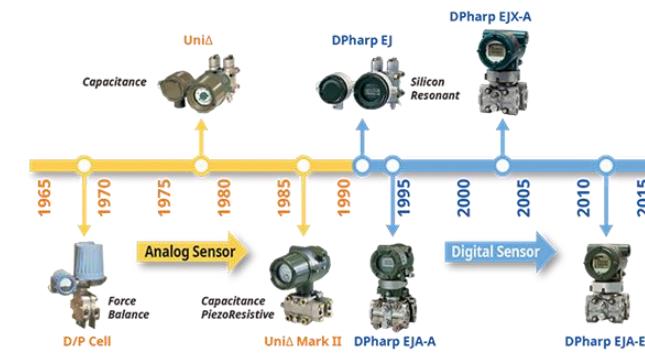
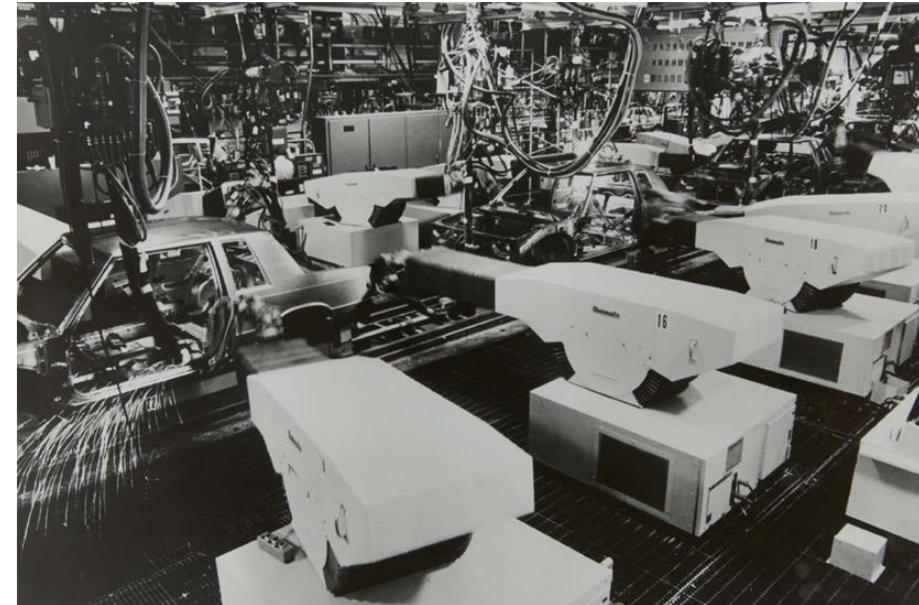
1960`s - Industrial Robots created.** Robotic Industries Association states that an “industrial robot is a re-programmable, multifunctional manipulator designed to move materials, parts, tools, or specialized devices through variable programmed motions to perform a variety of tasks”.**



History of Robotics

1961 - The first Unimate robot is installed in a Trenton, NJ General Motors plant to tend a die casting machine. The key was the reprogrammability and retooling of the machine to perform different tasks. The Unimate robot was an innovative mechanical design based on a multi-degree of freedom cantilever beam. The beam flexibility presented challenges for control. Hydraulic actuation was eventually used to alleviate precision problems.

1962 – 1963 – The introduction of **sensors** is seen as a way to enhance the operation of robots. This includes force sensing for stacking blocks (Ernst, 1961), vision system for binary decision for presence of obstacles in the environment (McCarthy 1963), pressure sensors for grasping (Tomovic and Boni, 1962). Robot interaction with an unstructured environment at MIT's AI lab (Man and Computer – MAC project).



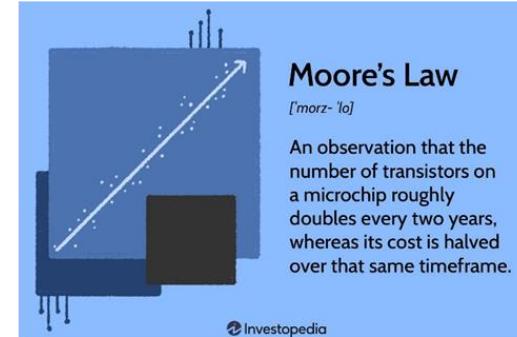
History of Robotics

1965 - Gordon E. Moore introduces the concept 'Moore's law', which predicts the number of components on a single chip would double every two years.

1966 – 1968 'Shakey', a mobile robot is developed by **SRI (Stanford Research Institute)**. 'Shakey' was capable of planning, route-finding and moving objects. It was placed in a special room with specially colored objects. A vision system would recognize objects and pushed objects according to a plan. This planning software was **STRIPS**, and it maintained and updated a world model. The robot had pan/tilt and focus for the camera, and bump sensors.

1968 – Kawasaki Heavy Industries in Japan acquires a license for **Unimate**.

1969 - The Apollo 11 mission, puts the first man on the moon. Landing was made inside the Lunar Module 'Eagle'.



History of Robotics

1970 - Luna 17 lands on the moon, carrying the roving remote-controlled robot, Lunokhod 1.

1971 - Intel introduce the first commercially available microprocessor, the 4004.

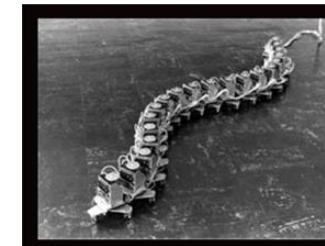
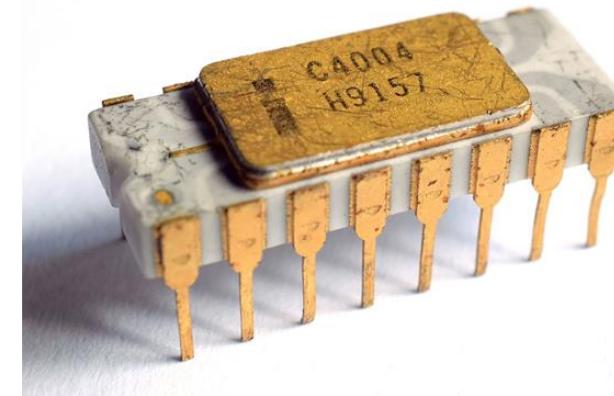
1971 -1973 – The Stanford Arm is developed, along with the first language for programming robots - WAVE.

1972 – First snake-like robot – ACM III – Hirose – Tokyo Inst. Of Tech.

1970's – JPL develops its first planetary exploration Rover using a TV camera, laser range finder and tactile sensors.

1975 - The space probes Viking 1 and 2 were launched each with an articulated robot arm.

1976 - The film Star Wars is released introducing R2-D2 and C-3PO.



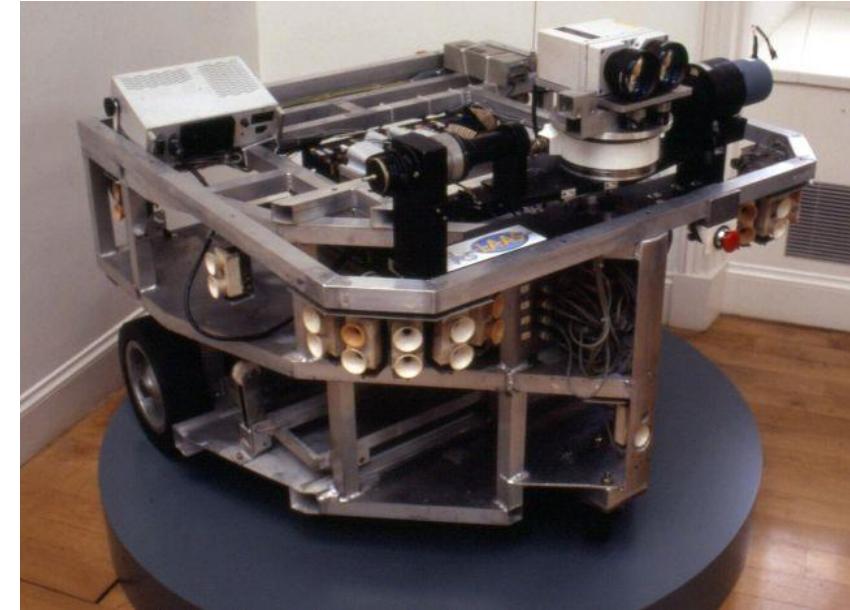
History of Robotics

1977 – Development of mobile robot Hilaire at Laboratoire d'Automatique et d'Analyse des Systèmes (LAAS) in Toulouse, France. This mobile robot had three wheels and it is still in use.

Two famous robots:

1978- Puma (Programmable Universal Machine for Assembly), by Unimation.

1979 - SCARA (Selective Compliant Articulated Robot for Assembly) introduced in Japan and the US (by Adept Technologies).



History of Robotics

1980's – Innovation in improving the performance of robot arms – feedback control to improve accuracy, program compliance, the introduction of personal computers as controllers, and commercialization of robots by a large number of companies: KUKA (Germany), IBM 7535, Adept Robot (USA), Hitachi, Seiko (Japan).



Early 1980's – Multi-fingered hands developed, Utah-MIT arm (16 DOF) developed by Steve Jacobsen, Salisbury's hand (9 dof).



1977-1983 – Stanford cart/CMU rover developed by Hans Moravec, later on became the Nomad mobile robot.



History of Robotics

1980's – Legged and hopping robots
(BIPER – Shimoyama) and Raibert 1986.



1984 -1991 – V. Braitenberg revived the tortoise mobile robots of W. Grey Walter creating autonomous robots exhibiting behaviors. Hogg, Martin and Resnick at MIT create mobile robots using LEGO blocks (precursor to LEGO Mindstorms). Rodney Brooks at MIT creates first insect robots at MIT AI Lab – birth of behavioral robotics.



History of Robotics

1986 - Honda starts work on its first humanoid, robot named 'E0' (later to become ASIMO).

1988 - SCAMP designed as the first robot pet with emotions.

1989 - Mark Tilden introduces BEAM robotics, beam being an acronym for Biology, Electronics, Aesthetics, and Mechanics.

'90: modifiable robots for assembly. Mobile autonomous robots. Vision controlled robots. Walking robots.

1991 - First HelpMate mobile autonomous robot used in hospitals.



History of Robotics

1990's – Humanoid robots – Cog, Kismet (MIT), Wasubot, WHL-I – Japan, Honda P2 (1.82m, 210kg), and P3 (1.6m, 130kg), ASIMO.

1990's – Entertainment and Education Robots – SARCOS ("Jurassic Park"), Sony AIBO, LEGO Mindstorms, Khepera, Parallax.

ROBOCUP, the competition simulating the game of soccer played by two teams of robots having been held around the world since 1997 (Osaka) .



History of Robotics

1997 - Sojourner becomes the first rover to land on Mars as part of the Mars Pathfinder mission.

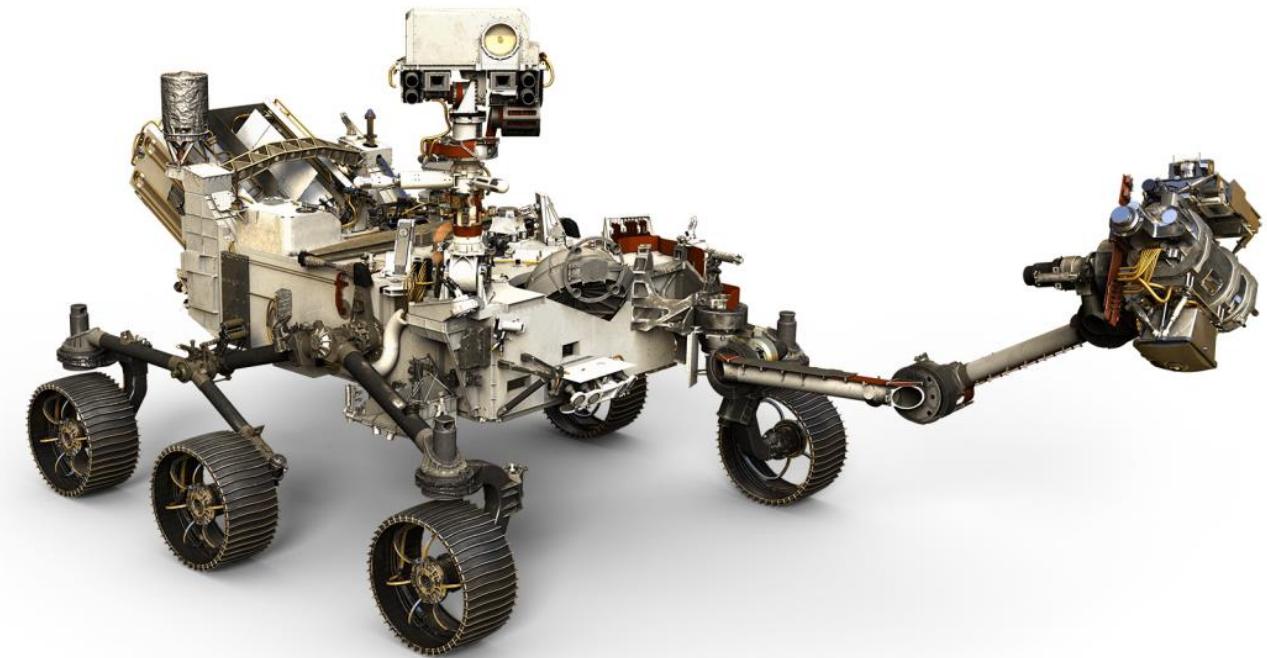
1998 - Lego enters the robotics market with its first version of Lego Mindstorms.

1999 - Sony introduces AIBO, an autonomous robotic dog capable of seeing, walking and interacting with its environment. This was followed a year later by the SDR-3X humanoid robot later known as QRIQ (both discontinued in 2006).



History of Robotics

1990's – Introduction of space robots (manipulators as well as rovers – the MARS rover 1996), parallel manipulators (Stewart-Gough Platforms), multiple manipulators, precision robots ("Robotworld"), surgical robots ("RoboDoc"), first service robots (as couriers in hospitals, etc)



History of Robotics

2000 - Honda unveils ASIMO, the first non-prototype release of its humanoid robot.

2001 - US Air force test the MQ-1 Predator, the first armed unmanned aerial vehicle (UAV) fitted with two Hellfire missiles.

2000's – iRobot introduces the first autonomous vacuum – “Roomba”.

2000's – Mini and micro robots, “Smart Dust” – Pister @ Berkeley, UTA, EPFL/Lausanne, microfactories.

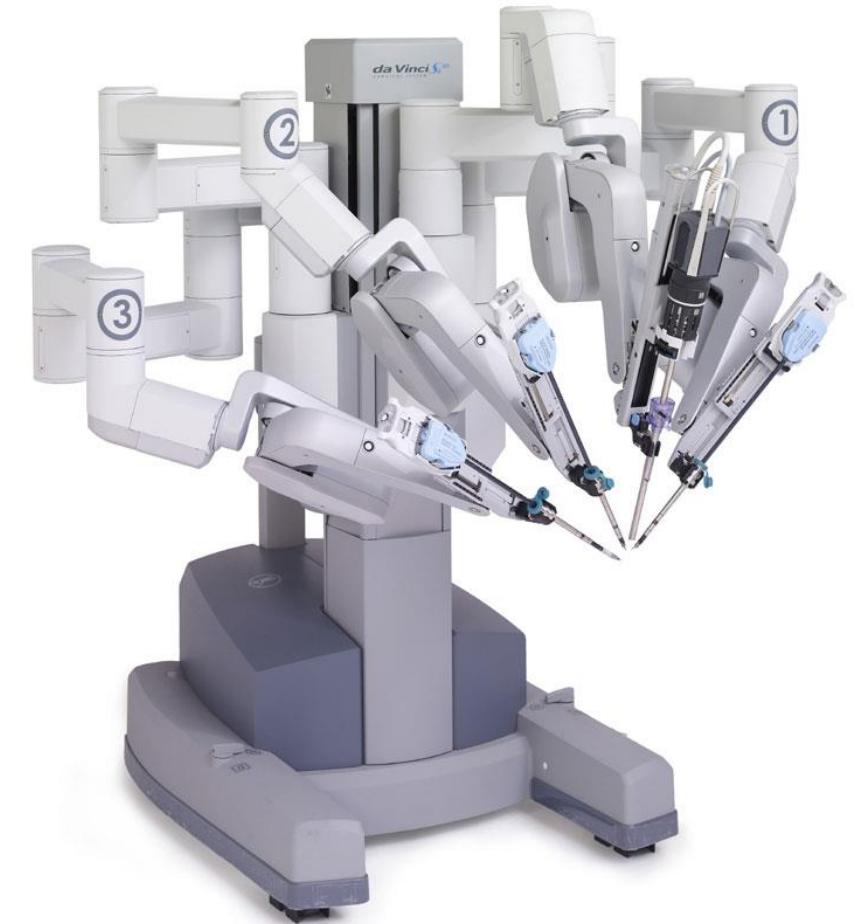


History of Robotics

2000's – Military applications - Robotic assistants for dangerous environments and reconnaissance, AUV's and UUV's, etc.

2000's – Intuitive Surgical introduces the Da Vinci surgical robot.

2000's – Robotic Deployment of Sensor Networks



History of Robotics

2002 - iRobot introduces Roomba, a personal robotic vacuum cleaner.

2003 - Osaka University unveils their first 'Actroid', the term given for a humanoid robot with strong visual human characteristics.

2004 - The first DARPA Grand challenge is held. Sponsored by the US department of defence, the challenge is designed to create autonomous vehicles for warfare.

2004 - The Mars rovers Spirit and Opportunity land on Mars. As of November 25th 2009 The rover Spirit has completed 2150 days of its 92 day (90 sol) mission.

2010 - NASA and General Motors join forces to develop Robonaut-2, the new version of NASA's humanoid robot astronaut.



History of Robotics

2011-2024

Focus on Robotics and Automation

Applications and AI/ML

Humanoid Development

Surgical Robot Manufacturing

