

ROBOTICS

The History of Robots

- Ancient times of over 3000 years ago in india's legend of mechanical elephants.
- The word first appeared in 1921, in Karel Capek's play *R.U.R.*, or Rossum's Universal Robots.
- "Robot" comes from the Czech for "forced labor."

A Robot is:

An electromechanical device that is:

- Reprogrammable
- Multifunctional
- Sensible for environment
- Defined by Robotics Industry Association (RIA) as
 - a re-programmable, multifunctional manipulator designed to move material, parts, tools or specialized devices through variable programmed motion for a variety of tasks



Issac Asimov

Three Laws of Robotics

- First Law

- A robot may not injure a human being or, through inaction, allow a human being to come to harm.

- Second Law

- A robot must obey the orders given it by human beings except where such orders would conflict with the First Law.

- Third Law

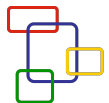
- A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

- Robotics is a multi-disciplinary field. Best robotics researchers and engineers will touch upon all disciplines:
- **Mechanical Engineering** – concerned primarily with manipulator/mobile robot design, kinematics, dynamics, compliance and actuation.
- **Electrical Engineering** – concerned primarily with robot actuation, electronic interfacing to computers and sensors, and control algorithms.
- **Computer Science** – concerned primarily with robot programming, planning, and intelligent behavior.

History of Robotics - The Origins of Robots

≈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.



Robotics Timeline

- **1922 Czech author Karel Capek wrote a story called Rossum's Universal Robots and introduced the word "Rabota" (meaning worker)**
- **1954 George Devol developed the first programmable Robot.**
- **1955 Denavit and Hartenberg developed the homogenous transformation matrices**
- **1962 Unimation was formed, first industrial Robots appeared.**
- **1973 Cincinnati Milacron introduced the T3 model robot, which became very popular in industry.**
- **1990 Cincinnati Milacron was acquired by ABB**

History of Robotics - The Origins of Robots

≈ **1250** - Bishop **Albertus Magnus** holds banquet at which guests were served by metal attendants. Upon seeing this, Saint Thomas Aquinas smashed the attendants to bits and called the bishop a sorcerer.



1640 - **Descartes** builds a female automaton which he calls “Ma fille Francine.” She accompanied Descartes on a voyage and was thrown overboard by the captain, who thought she was the work of Satan.

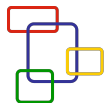


History of Robotics - The Origins of Robots

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.

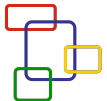


History of Robotics - The Origins of Robots

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 *robota*, which means "servitude, forced labor."

Robotics™



History of Robotics - The Origins of Robots

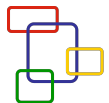
Robotics was first introduced into our vocabulary by Czech playwright Karel Capek in his 1920's play **Rossum's Universal Robots**.

The word “robota” in Czech means simply work. Robots as machines that resemble people, work tirelessly, and revolt against their creators. .



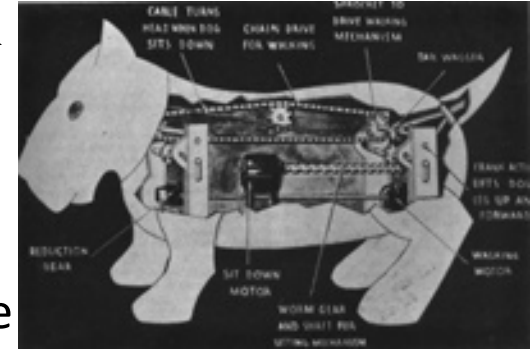
Karel Capek

The same myth/concept is found in many books/movies today:
“Terminator”, “Star-Wars” series.
Mary Shelley’s 1818 Frankenstein.
Frankenstein & The Borg are examples of “**cybernetic organisms**”.



History of Robotics

1940 - Sparko, the [Westinghouse](#) dog, uses both mechanical and electrical components.

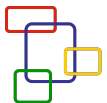


1941 - Isaac Asimov introduced the word 'Robotics' in the science fiction short story 'Liar!'

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.



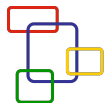
History of Robotics

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

Questions Arise: Is the computer an immobile robot?

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

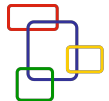
1954 – **George Devol** replaced the slave manipulator in a teleoperator with the programmability of the CNC controller, thus creating the first “industrial robot”, called the “Programmable Article Transfer Device”.



History of Robotics

1955 – The Darmouth 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.](#)

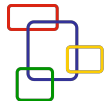


History of Robotics

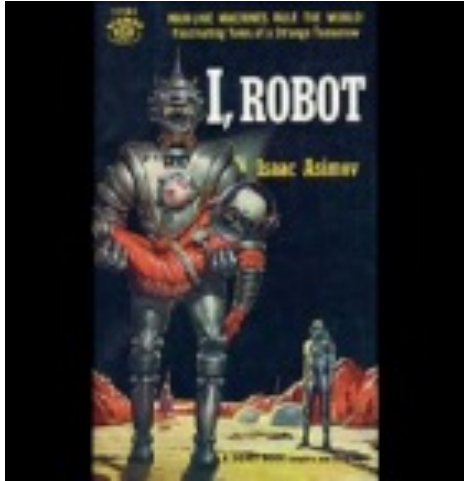
1956 - [Joseph Engleberger](#), a Columbia physics student buys the rights to Devol's robot and founds the Unimation Company.

1956 - [George Devol](#) applied for a patent for the first programmable robot, later named 'Unimate'.

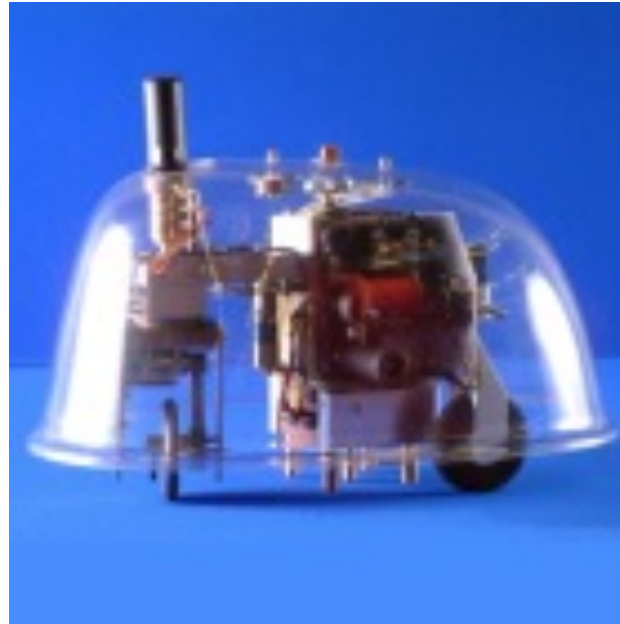
1957 - Launch of the first artificial satellite, [Sputnik 1](#).



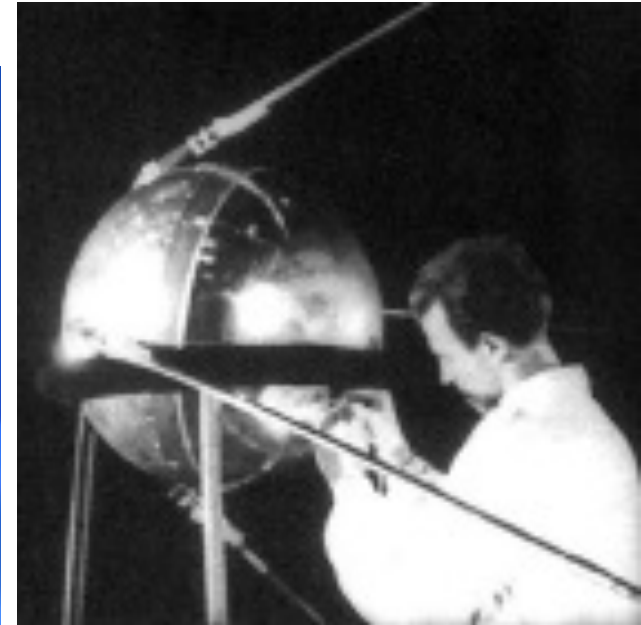
History of Robotics



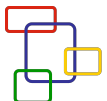
I, Robot



Turtle robot



Sputnik I

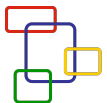


History of Robotics

- **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*”.

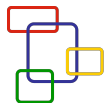


Robot Institute of America, 1979



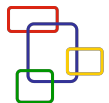
History of Robotics

- **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



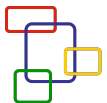
Unimate 1



Moon Walk

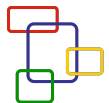


Shakey



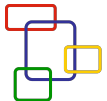
History of Robotics

- **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

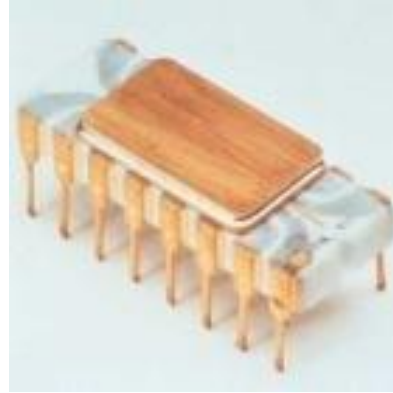
- 2000's – Military applications - Robotic assistants for dangerous environments and reconnaissance, AUV's and UUV's, etc.
- 2000's – Intuitive Surgical introduces the Da Vinci surgical robot.
- 2000's – Robotic Deployment of Sensor Networks



History of Robotics



Lunokhod 1



Intel 4004



R2-D2 and C-3PO



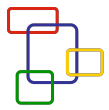
Asimo



Sojourner



Lego Mindstorms



History of Robotics



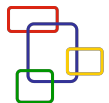
Sony AIBO



Sony QRIO

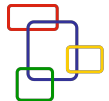


MQ-1 Predator



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



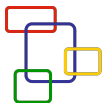
Actroid



Mars Exploration Rover



Robonaut-2



History of Robotics

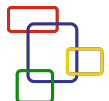
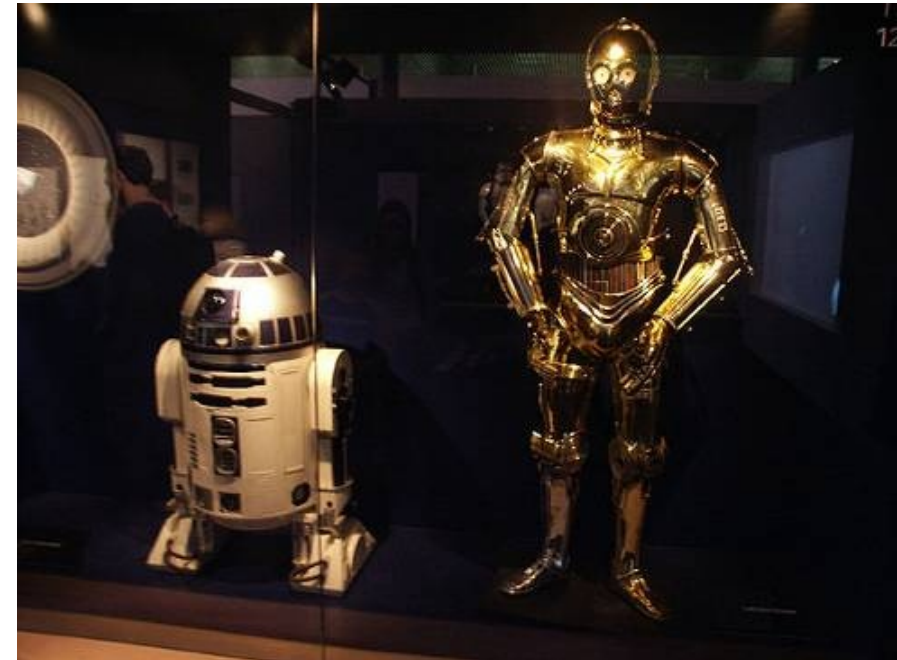
Should robots look like humans?

“anthropomorphic or humanoid robots”.

Need for these machines to also be intelligent - link to **“Artificial Intelligence (AI)”**.

Need for humans to create machines similar to them is rooted in religious beliefs, recommended reading **“God in the Machine” by Anne Foerst**

It is not the appearance of the robot that most connects it to humans: HAL in “Space Odyssey 2001”, Lt. Data in “Star Trek-TNG”, R2D2 and C3PO in “Star Wars”. Which one is more “likeable” and why?

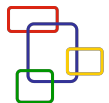


History of Robotics

Robots need not look like humanoids, but they make use of:

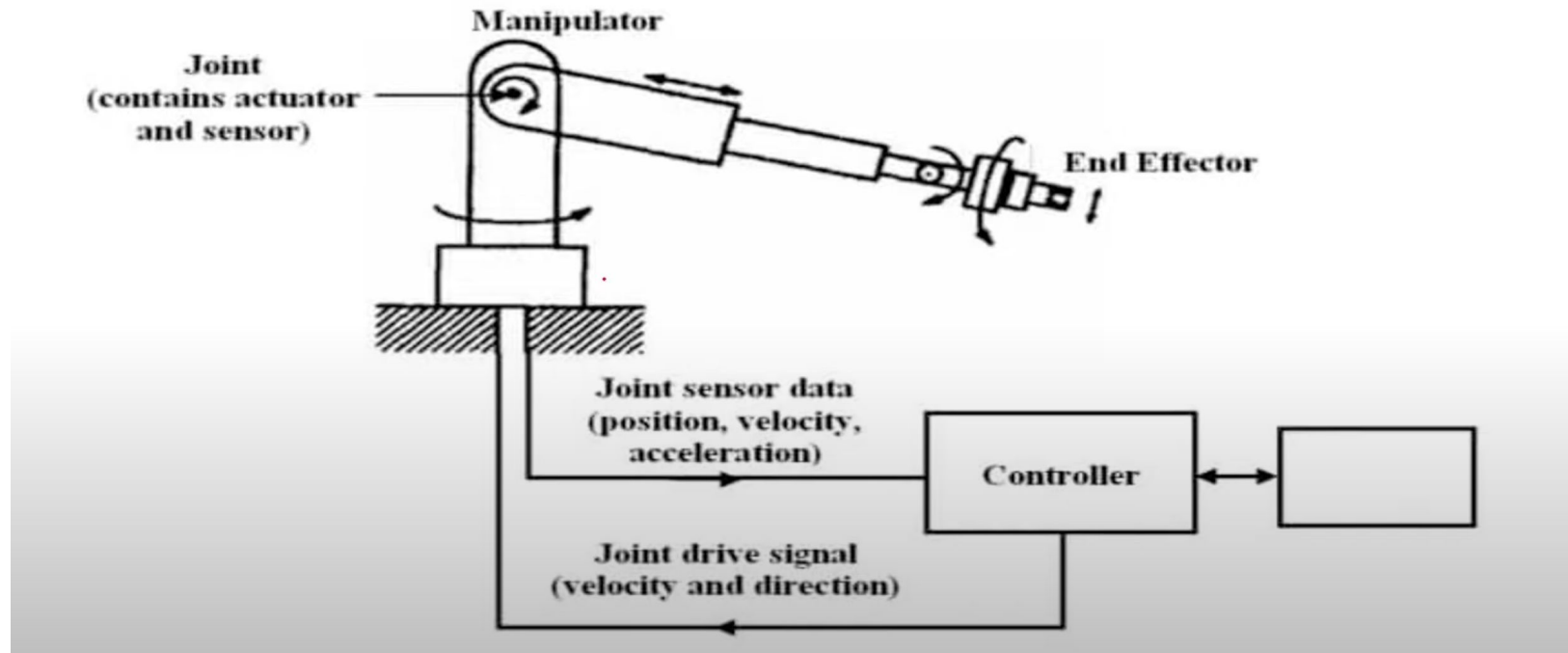
Strong & precise articulated arms to accomplish tasks that were performed by humans – **“articulated robots”, or “manipulators”**. **Fear that they will replace human laborers.**

Use of mobility to reposition the robot from one location to another, **“mobile robots”**. **This can be done by locomotion like humans do (“legged robots”), but most likely it will use other means such as wheels (“wheeled robots”).**



Robot Components

Basic Components..



- 1. Manipulator or Rover: Main body of robot (Links, Joints, other structural element of the robot)
- 2. End Effector: The part that is connected to the last joint hand of a manipulator.
- 3. Actuators: Muscles of the manipulators (servomotor, stepper motor, pneumatic and hydraulic cylinder).
- 4. Sensors: To collect information about the internal state of the robot or To communicate with the outside environment.

- 5. Controller: Similar to cerebellum. It controls and coordinates the motion of the actuators.
- 6. Processor: The brain of the robot. It calculates the motions and the velocity of the robot's joints, etc.
- 7. Software: Operating system, robotic software and the collection of routines.

SENSORS

- Sensors provide awareness of the environment by sensing things. Sensors are the core of robots. It is the system that alerts the robots.
- Sensing can be in different forms like-
 - Light
 - Sound
 - Heat
 - Chemicals
 - Force
 - Object proximity
 - Physical orientation/position
 - Magnetic & Electric Fields

End Effectors

- In robotics, an end effector is the device at the end of a robotic arm, designed to interact with the environment.
- End effectors may consist of a gripper or a tool. The gripper can be of two fingers, three fingers or even five fingers.

Actuators

- Locomotion
- Manipulation
- Locomotion-
 - Legs
 - Wheels
 - Other exotic means

- Manipulations-

- Degrees of freedom

- independently controllable components of motion

- Arms

- convenient method to allow full movement in 3D

- more often used in fixed robots due to power & weight

- even more difficult to control!

- due to extra degrees of freedom

- Grippers

- may be very simple (two rigid arms) to pick up objects

- may be complex device with fingers on end of an arm

- probably need feedback to control grip force