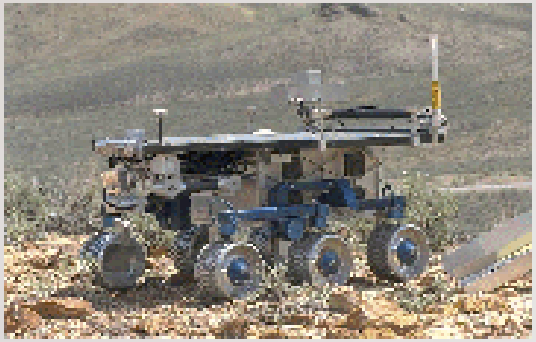
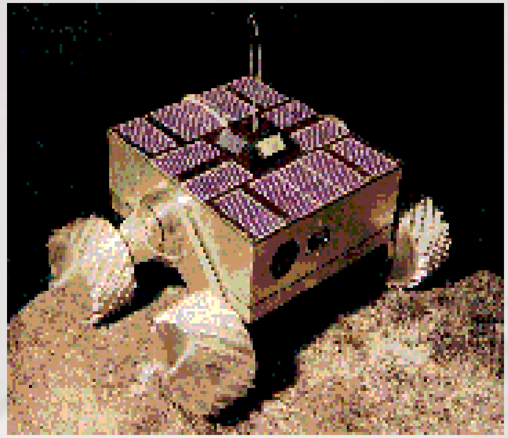
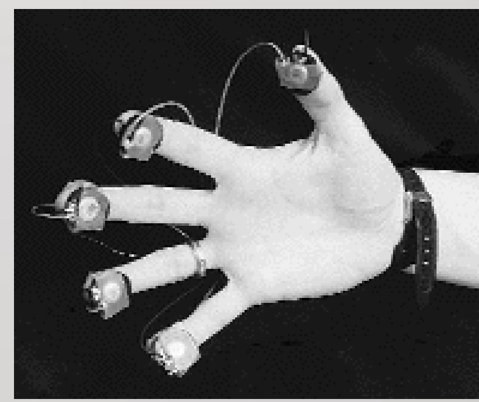
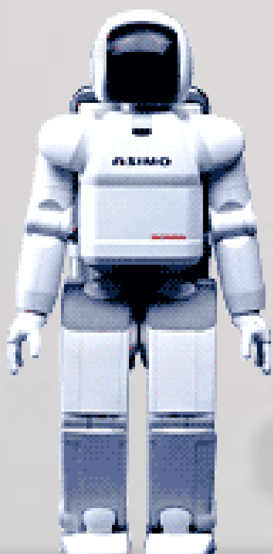




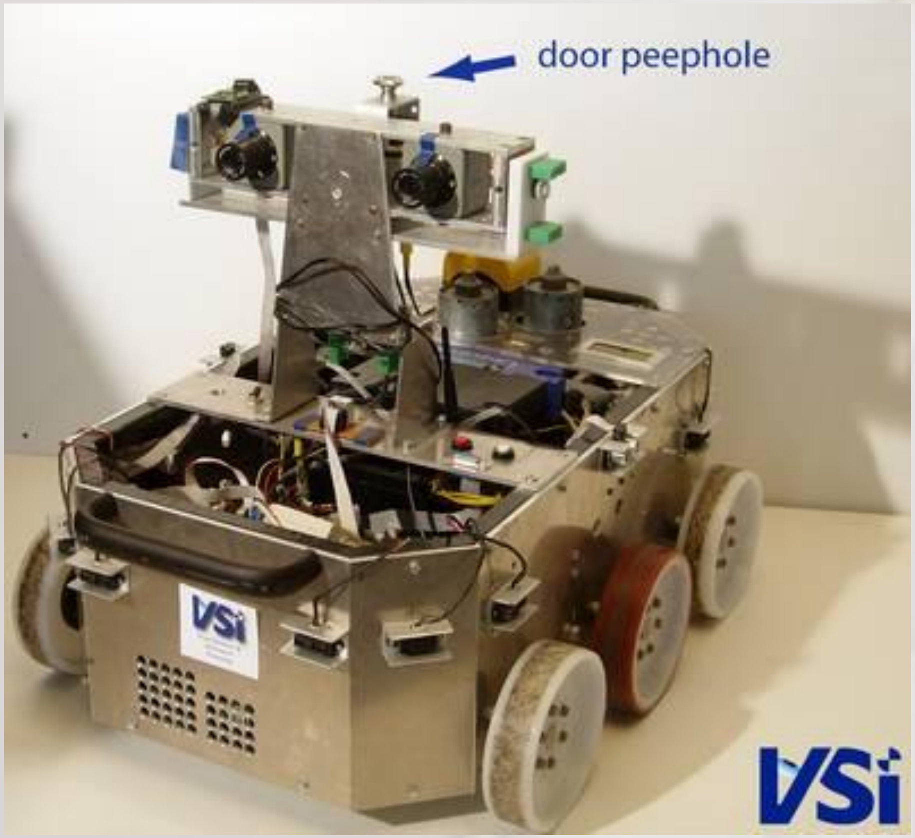
EE403
Introduction to ROBOTICS

by Dr. Ahmet Özkurt





robot: (*noun*) …



What is a robot?

A Robot is:

An electromechanical device that is;

- Reprogrammable
- Multifunctional
- Sensible for environment

Classification of Robots I JIRA

- Class 1: Manual Handling Device
- Class2: Fixed-Sequence Robot
- *Class3: Variable Sequence Robot
- Class4: Playback Robot
- Class5: Numerical Control Robot
- *Class6: Intelligent Robot

JIRA:Japanise Industrial Robot Association
RIA: The Robotics Instute of America

Classification of Robots II AFR

- Type A: Handling Devices with manual control
- Type B: Automatic Handling Devices with predetermined cycles
- Type C: Programmable, servo controlled robots
- Type D: Type C with interactive with the environment

AFR: The Association Francaise de Robotique

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.

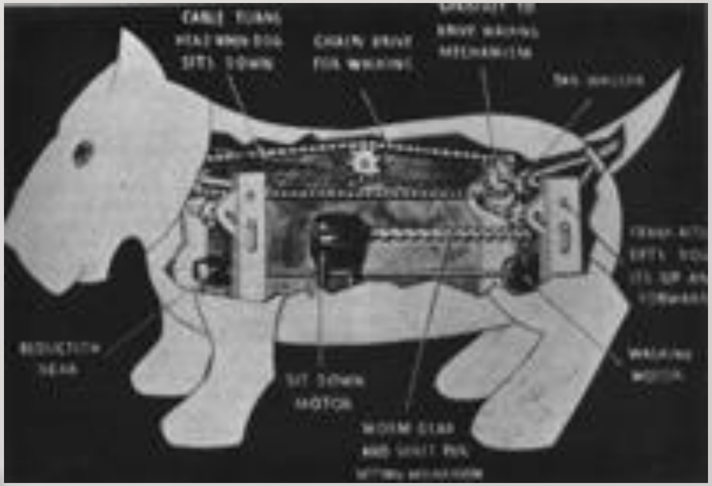
1640 — Descartes builds a female automaton which he calls “Ma fille Francine.” She accompanied Descartes on a voyage and was thrown overboard by the captain, who thought she was the work of Satan.

1738 Jacques de Vaucanson builds a mechanical duck made of more that 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.

1923 — Karel Capek coins the term *robot* in his play *Rossum's Universal Robots (R.U.R).* *Robot* comes from the Czech word *robota*, which means "servitude, forced labor."

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



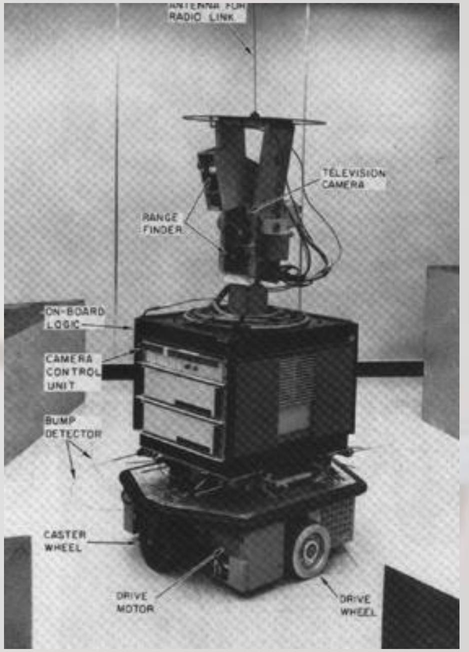
1950's -1960's

Computer technology advances and control machinery is developed. Questions Arise: Is the computer an immobile robot?

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.

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.

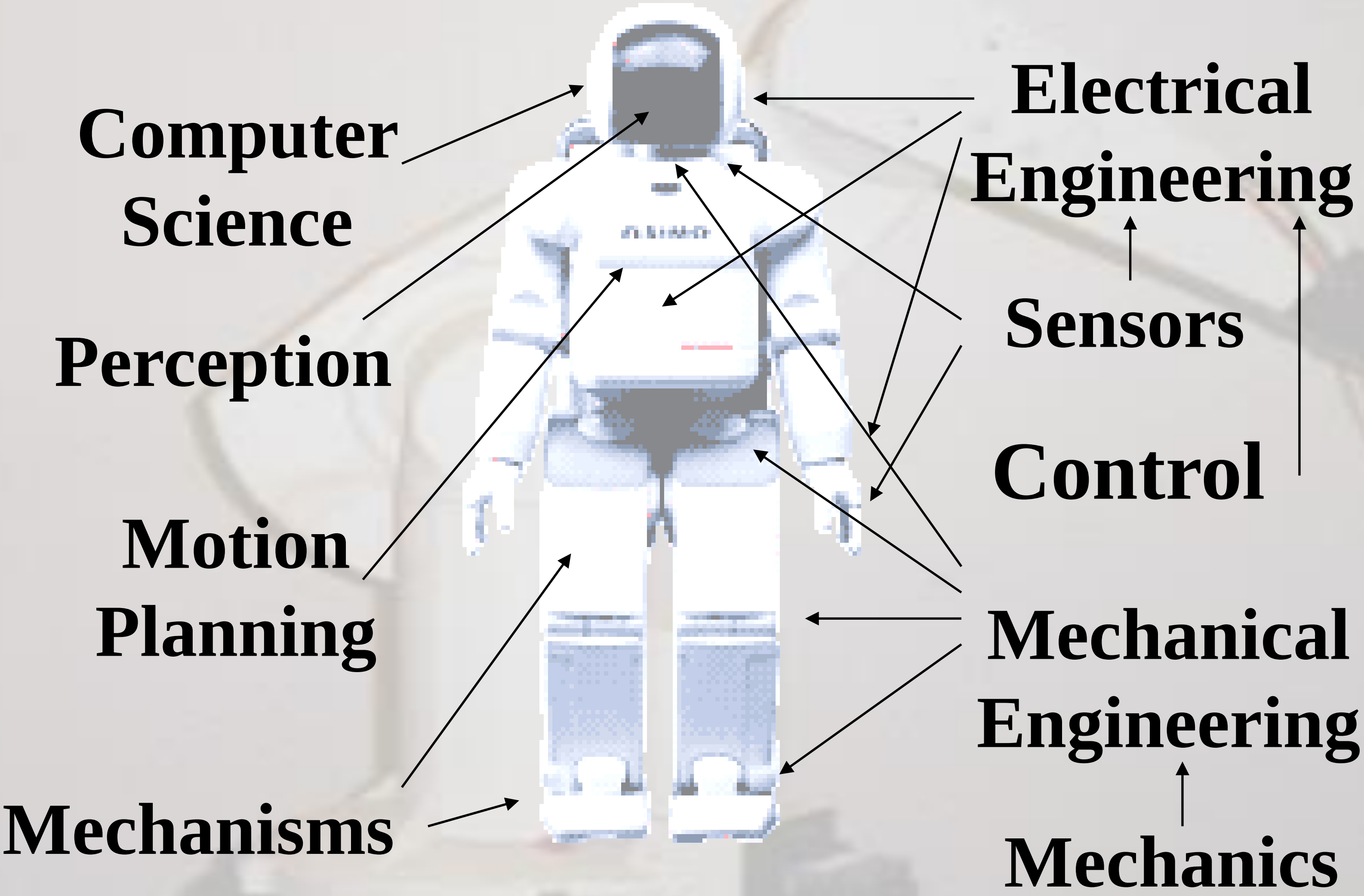
1960 — Shakey is made at Stanford Research Institute International. It contained a television camera, range finder, on-board logic, bump sensors, camera control unit, and an antenna for a radio link. Shakey was controlled by a computer in a different room.



Information and pictures from the previous five slides can be found in Isaac Asimov’s and Karen A. Frenkel’s book “Robots, Machines in Man’s Image ” © 1985

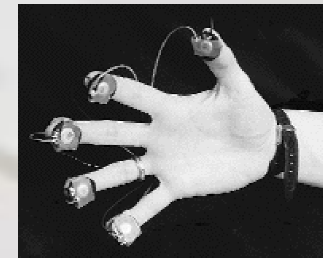

LINEAGE II

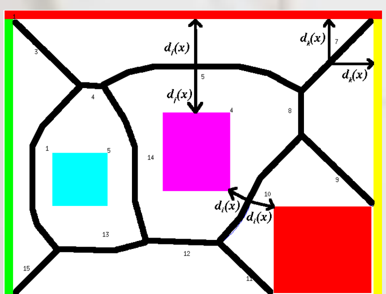
The Categories Are…..



PRIMITIVES OF ROBOTICS

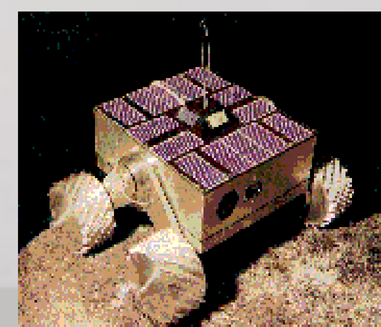
SENSE





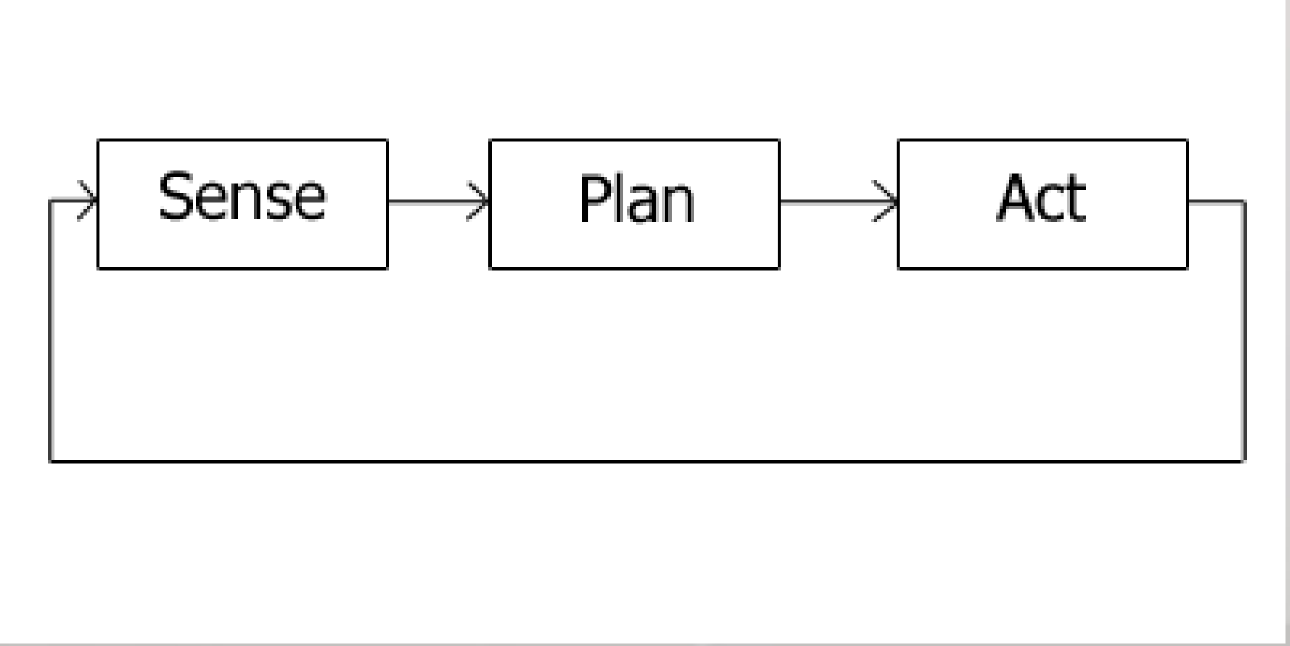
PLAN

ACT



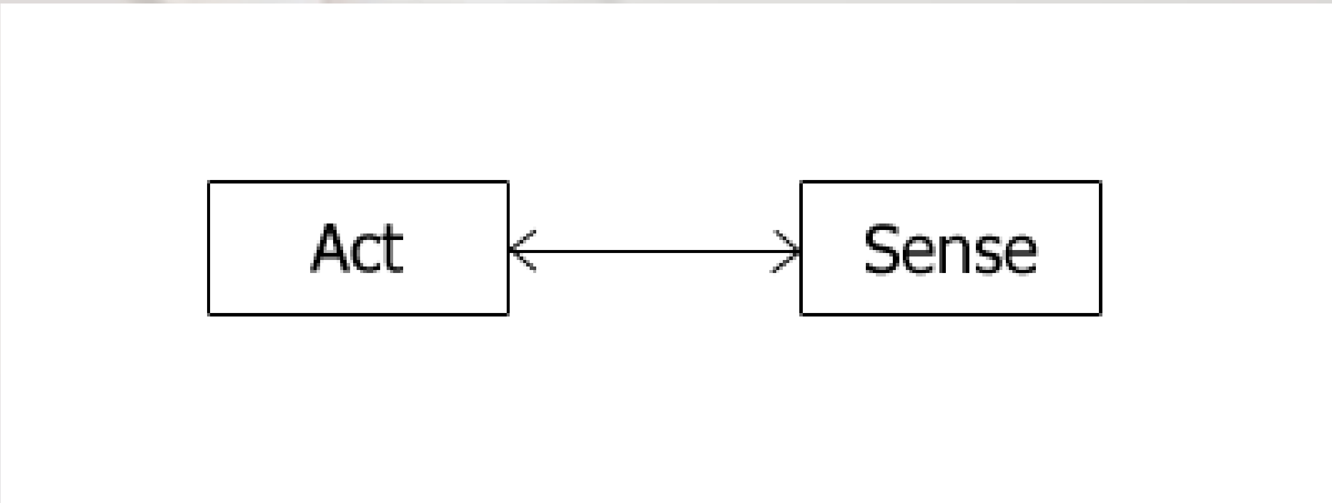
Hierarchical Paradigm

- The robot operates in a top-down fashion, heavy on planning.
- The robot senses the world, plans the next action, acts; at each step the robot explicitly plans the next move.
- All the sensing data tends to be gathered into one global world model.



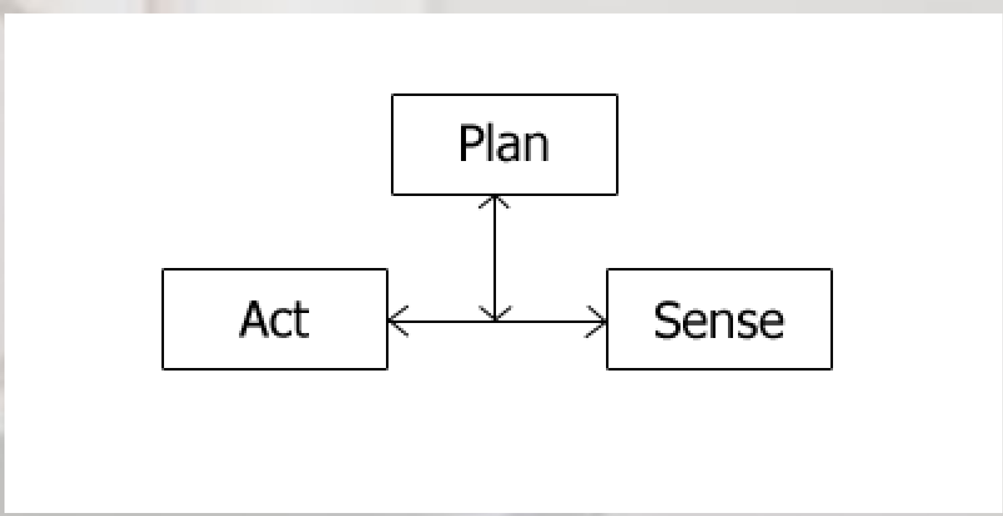
Reactive Paradigm

- Sense-act type of organization.
- The robot has multiple instances of Sense-Act couplings.
- These couplings are concurrent processes, called behaviours, which take the local sensing data and compute the best action to take independently of what the other processes are doing.
- The robot will do a combination of behaviours.

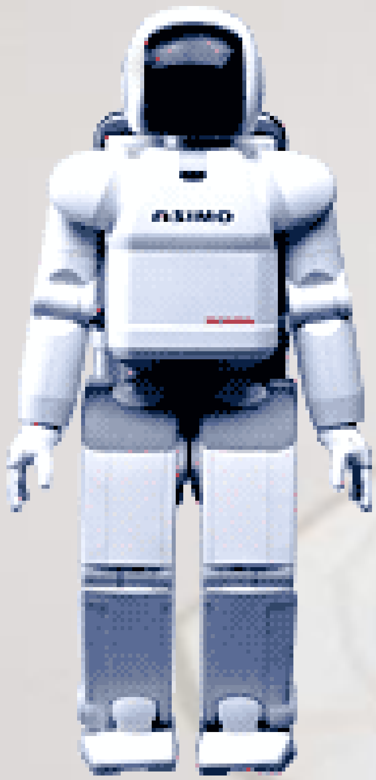


Hybrid Deliberate/Reactive Paradigm

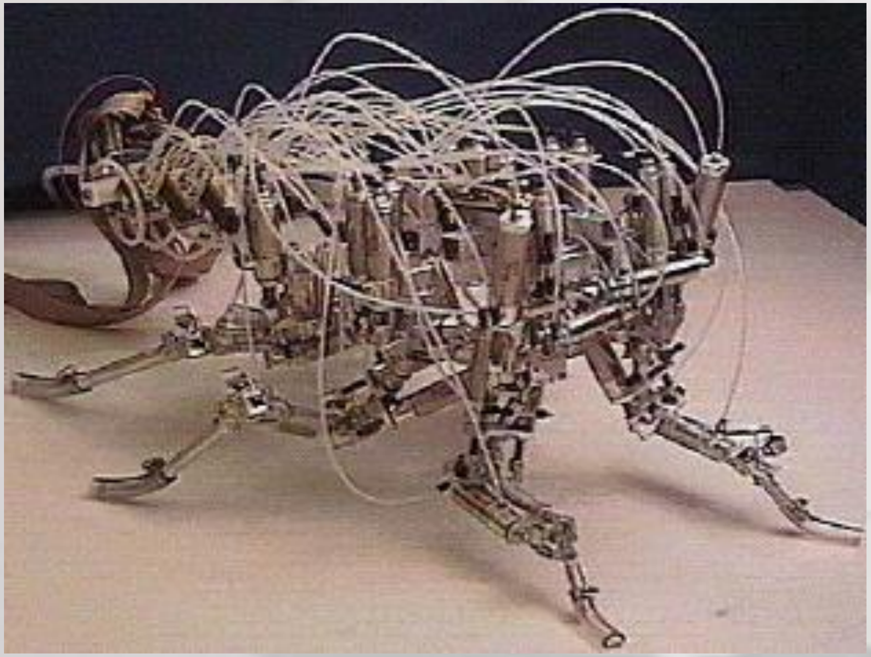
•The robot first plans (deliberates) how to best decompose a task into subtasks (also called “mission planning”) and then what are the suitable behaviours to accomplish each subtask.
•Then the behaviours starts executing as per the Reactive Paradigm.
•Sensing organization is also a mixture of Hierarchical and Reactive styles; sensor data gets routed to each behaviour that needs that sensor, but is also available to the planner for construction of a task-oriented global world model.



So What IS a Robot?



This semester we will study many aspects of robotics.



General Robot Structures

General Definitions

Sensors and Sensor Planning

Actuators

Vision

Artificial Intelligence

Motion Planning

Mobile Robot Platforms

Forward Kinematics

Inverse Kinematics

Trends in Robotics

Classical Robotics (mid-70's)
- exact models
- no sensing necessary

Reactive Paradigm (mid-80's)
- no models
- relies heavily on good sensing

Hybrids (since 90's)
- model-based at higher levels
- reactive at lower levels

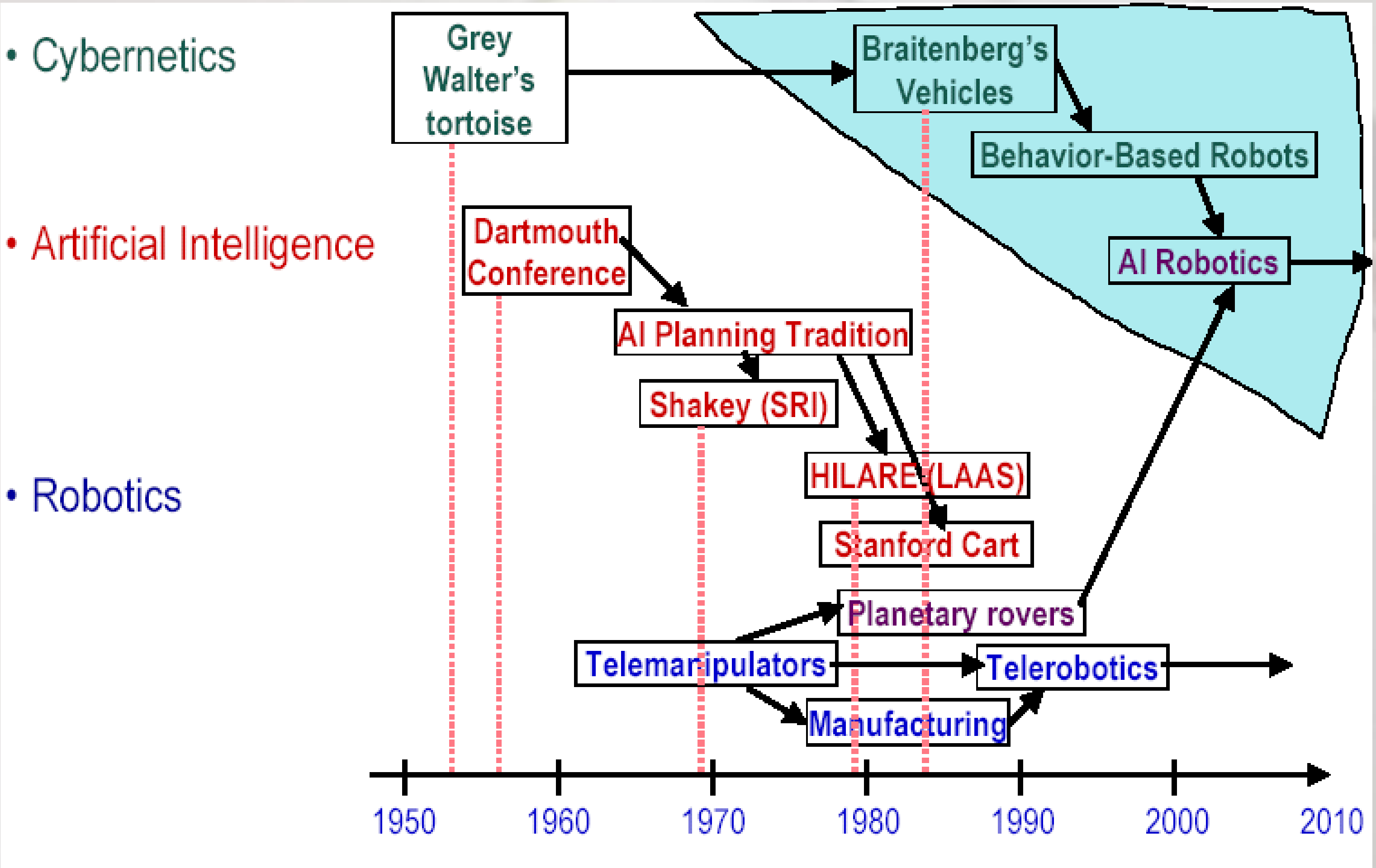
Probabilistic Robotics (since mid-90's)
- seamless integration of models and sensing
- inaccurate models, inaccurate sensors

What do we mean by “Intelligence”?

- Open question:where intelligence begins and ends
- Intelligence (our working definition):

  the ability to improve an animal or human’s likelihood of survival within the real world, and, whereappropriate, to compete or cooperate successfully with other agents to do so.

History of today's Intelligent Robots



Summary of Robot Behavior

- •Robotic behaviors generate a motor response from a given perceptual stimulus
- •Purely reactive systems avoid the use of explicit representational knowledge
- •Three design paradigms:
  - –Ethologically guided/constrained
  - –Situated activity
  - –Experimentally driven
- •Expression of behaviors can be accomplished in several ways:
  - –SR diagrams
  - –Functional notation
  - –FSA diagrams
- •Behaviors can be represented as triples (S, R, β)

- **Summary of Robot Behavior (con’t.)**

- •Presence of stimulus is necessary, but not sufficient, to evoke a motor response. Only when stimulus exceeds a threshold does it produce a response.
- •A strength multiplier, or gain *g*, can be used to turn off behaviors or alter the response’s relative strength.
- •Responses are encoded in two forms:
  - –Discrete encoding: Rule-based methods often used
  - –Continuous functional encoding: inverse square law often used

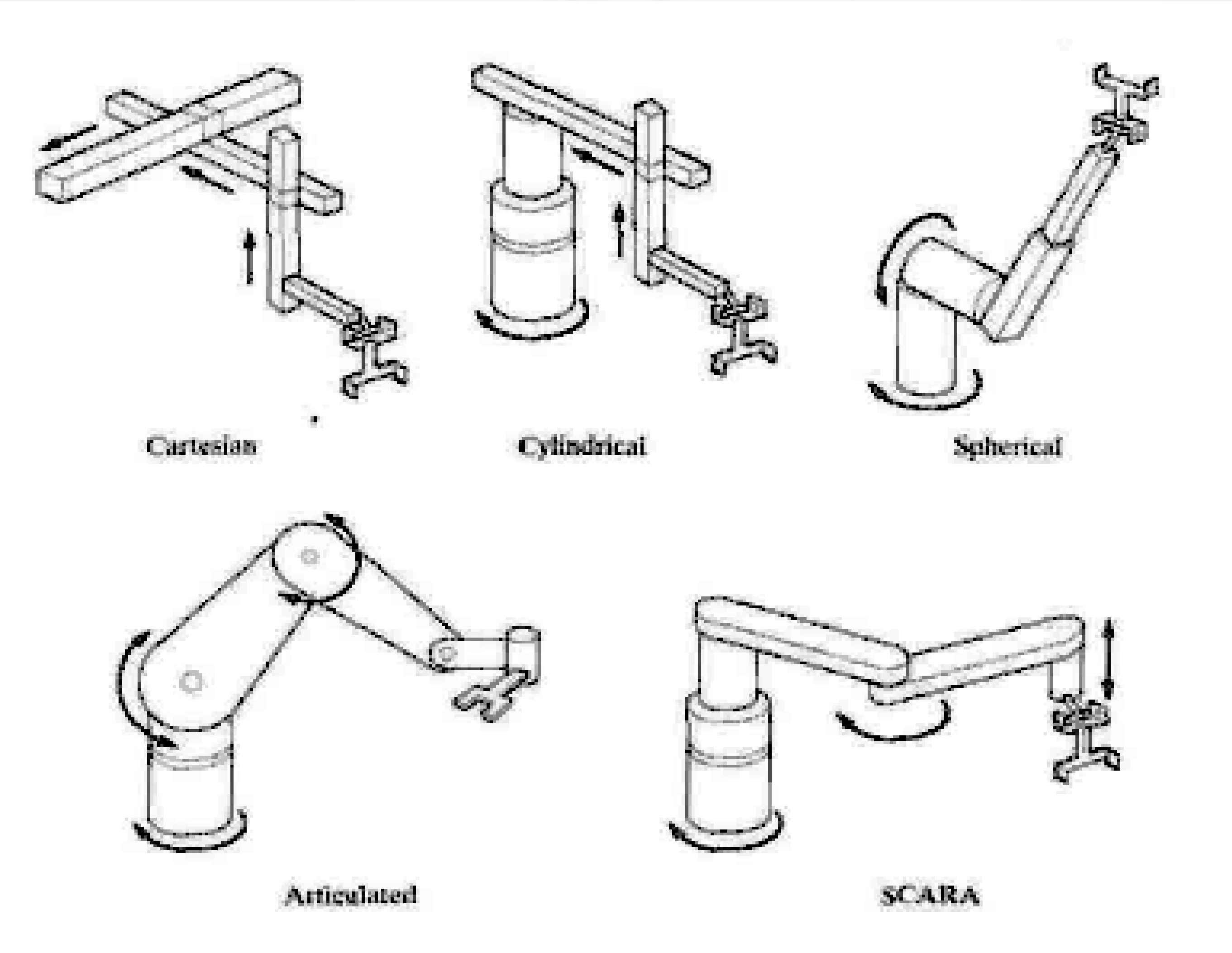
Advantages of Robots

- Robotics and automation can, in many situation, increase productivity, safety, efficiency, quality, and consistency of products
- Robots can work in hazardous environments
- Robots need no environmental comfort
- Robots work continuously without any humanity needs and illnesses
- Robots have repetable precision at all times
- Robots can be much more accurate than humans, they may have mili or micro inch accuracy.
- Robots and their sensors can have capabilities beyond that of humans
- Robots can process multiple stimuli or tasks simultaneously, humans can only one.
- Robots replace human workers who can create economic problems

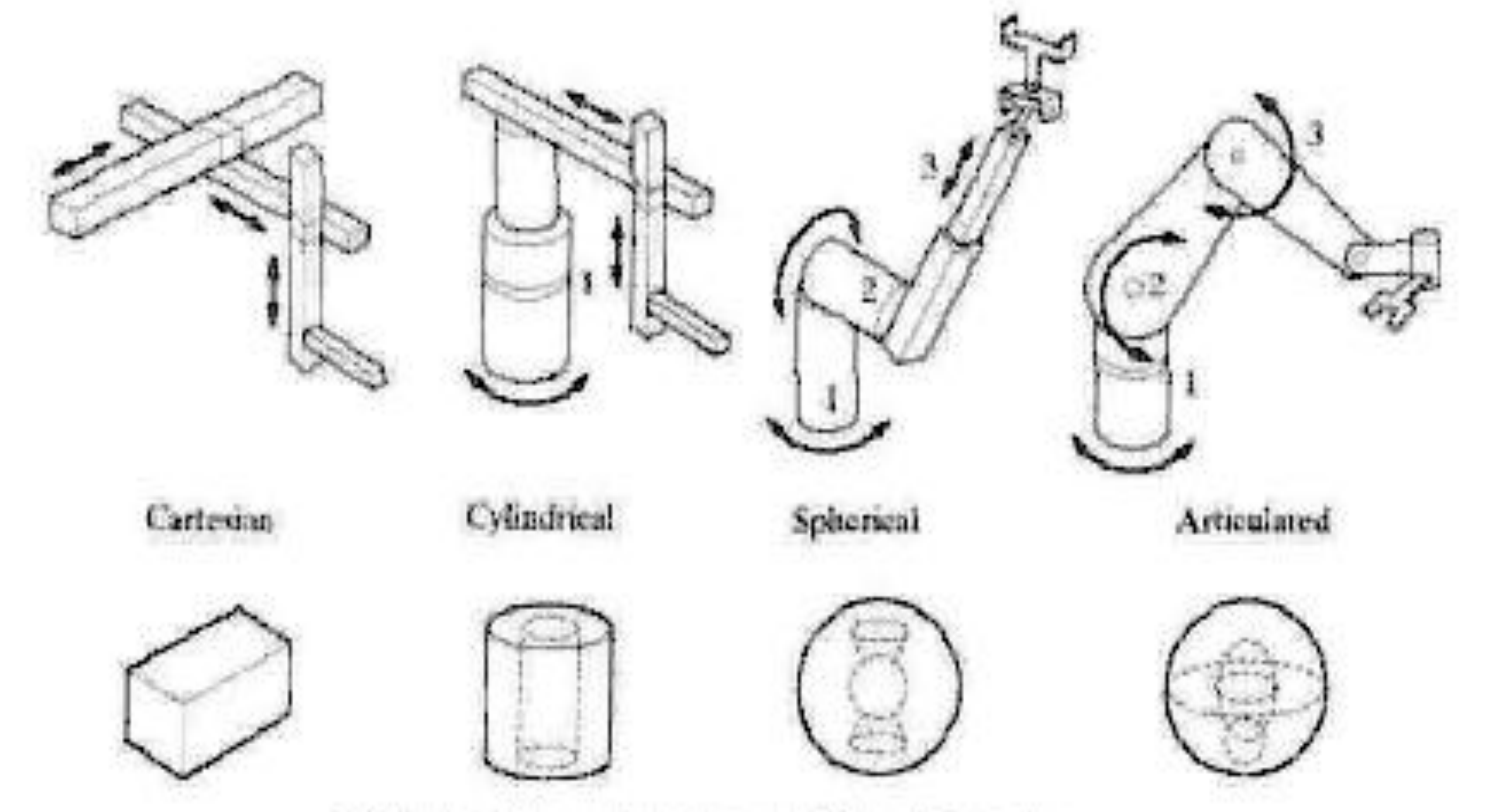
Disadvantages of Robots

- Robots lack capability to respond in emergencies, this can cause:
  - Inappropriate and wrong responses
  - A lack of decision-making power
  - A loss of power
  - Damage to the robot and other devices
  - Human injuries
- Robots may have limited capabilities in
  - Degrees of Freedom
  - Dexterity
  - Sensors
  - Vision systems
  - Real-time Response
- Robots are costly, due to
  - Initial cost of equipment
  - Installation Costs
  - Need for peripherals
  - Need for training
  - Need for Programming

Possible Robot Coordinate Frames

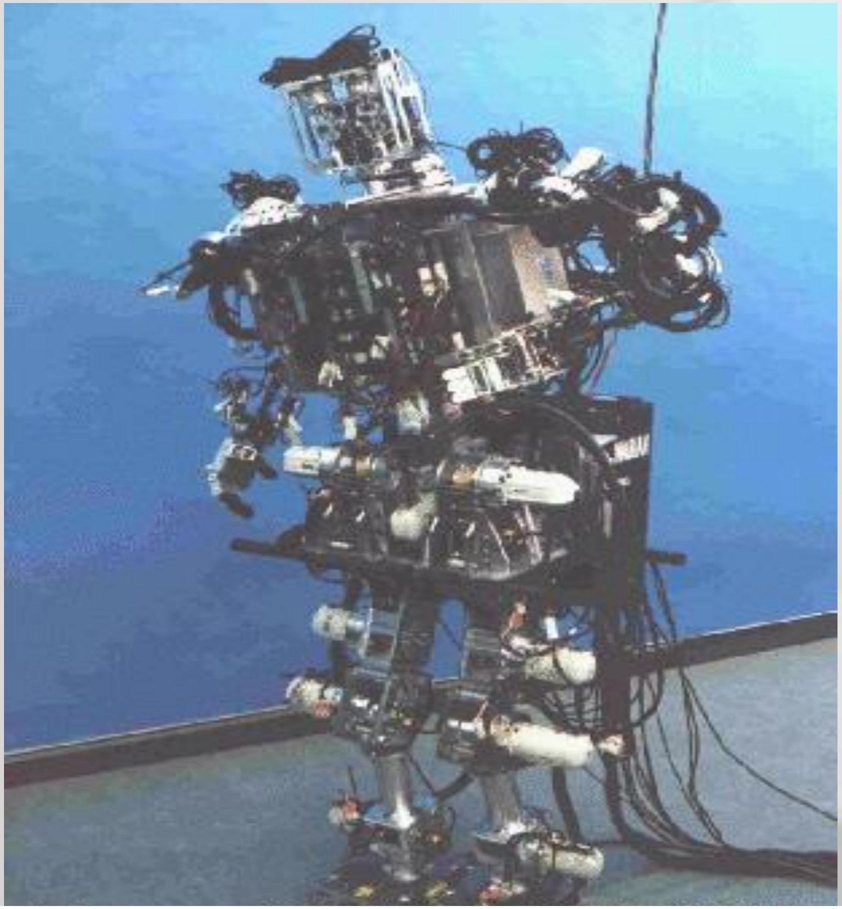


Typical Workspaces



Typical workspaces for common robot configurations.

Future Directions



New Directions

- Entertainment / social robots
- Humanoid robots
- Swarm / distributed robots
- New robot locomotion mechanisms
- Application-specific robotics (e.g., service industry, military, etc.)
- Medical robots
- Telemedicine

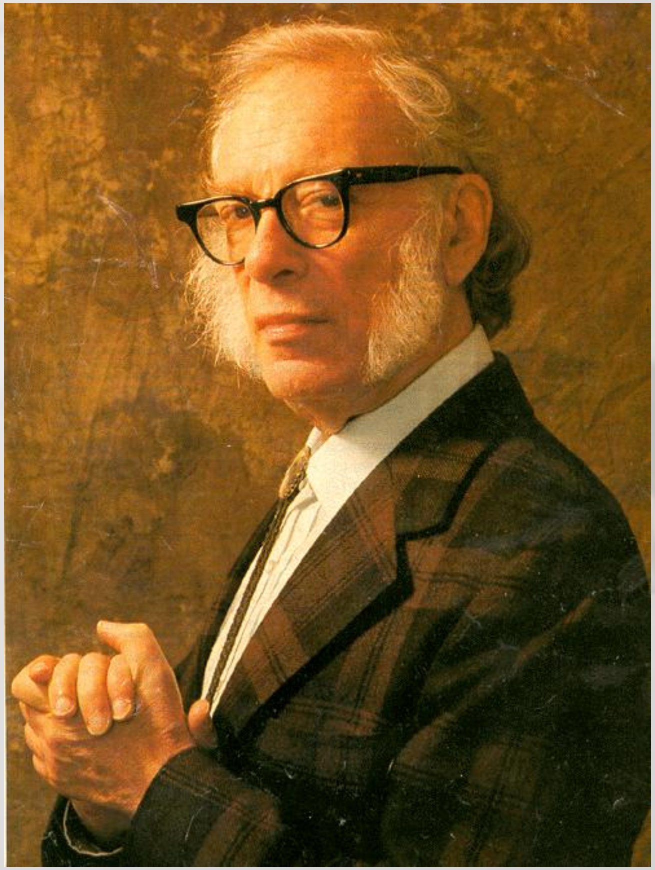
INTELLIGENCE

Discussion of Ethics and Philosophy in Robotics

- •Can robots become conscious?
- •Is there a problem with using robots in military applications?
- •How can we ensure that robots do not harm people?
- •Isaac Asimov’s Three Laws of Robotics ????

Isaac Asimov (1920 -1992)

- •Born inPetrovichi, Russia
- •Grew up in Brooklyn, New York
- •Became U.S. citizen at age 8
- •Earned B.S., M.S., and Ph.D. from Columbia University
- •Worked for many years as instructor in biochemistry at Boston University School of Medicine
- •Prolific writer of science fiction
  - –1st 19 years: 100 books
  - –Next 10 years: 100 more books
  - –Next 5 years: 100 more books
  - –Lifetime: Over 500 books



- **Robots: Common Theme in Asimov’s Writings**

- •Asimov began writing about robots at age 20
  - –Asimov: “In the 1920’s science fiction was becoming a popular art form for the first time .. And one of the stock plots … was that of the invention of a robot … Under the influence of the well-known deeds and ultimate fate of Frankenstein … there seemed only one change to be rung on this plot --robots were created and destroyed their creator … I quickly grew tired of this dull hundred-times-told tale … Knowledge has its dangers, yes, but is the response to be a retreat from knowledge? …. I began in 1940, to write robot stories of my own --but robot stories of a new variety …
  - My robots were machines designed by engineers, not pseudo-men created by blasphemers”
- •Asimov demonstrated enormous imagination and persistence in development of his robot stories --well-engineered, non-threatening robot

Asimov's Development of the Laws of Robotics

- Asimov: developed 3 laws of robotics to cope with potential for robots to harm people
- All robots in Asimov's books were subject to these laws
- Laws built-in to robots' "platinum-iridium positronic brains"
- Laws first appeared publicly in Asimov's 4th robot short story, "Runaround"

Asimov's Laws of Robotics

- First law (Human safety):
  - A robot may not injure a human being, or, through inaction, allow a human being to come to harm.
- Second law (Robots are slaves):
  - A robot must obey orders given it by human beings, except where such orders would conflict with the First Law.
- Third law (Robot survival):
  - A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

These laws are simple and straightforward, and they embrace the essential guiding principles of a good many of the world's ethical systems.

– *But: They are extremely difficult to implement!!!*

The Session is ended

Please Discuss Your Learnings