Introduction:
History of Robotics - past, present and future

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10,000 BC Stone tools used in early civilization: *tools make better tools*.

- Design of simple automation (150 BC) moving engine, Heron's door etc. in Greece.
- 1780 AD saw the creation of automatic dolls which could write, draw pictures etc.
- Punch cards used in power looms in France in 1801 for manufacture of textiles Joseph-Marie-Jacquard.
Automation in ancient Greece (150 BC)

Steam engine

Herons Door
Programmed textile loom: 1801 in France
Hard Automation in Ford Motor Company 1904

- Idea of transfer lines in which a car was assembled at different stations.
- First use of hard automation – alignment devices, transfer devices etc.
- 1904 Henry Ford’s mass production of vehicles in the USA.
Just for History!

- 1921 Karel Kapec’s play depicting human like mechanical man - robots.

- 1942 Isaac Asimov first used the term *Robotics.*
Origin of robots

- 1945 master slave manipulator made for radioactive material handling for the Atom Bomb project.

A strictly mechanical device

Motion transfer by wire rope and pulleys

master

slave
What changed everything?

- Mechanical systems became electro-mechanical!
What changed everything?

Microprocessor (1949) : concept of reprogram!

- **1950** *SHAKY* : First robot- Stanford University

- **1952** George Dovel : teach / play back devices for NC machines/ robots.
Clumsy *robots* to sophisticated *humanoids*
Evolution of NC technology
Flexible Manufacturing System

Machine worktable

Robot

Machine tool

Parts carousel
Computer integrated manufacturing

Industrial robots spot weld automobile bodies on an assembly line.
Automated material handling

(a) Forklift

(b) Chassis with drive wheel and bumper

(c) Electrified rail with vehicle electrical pickup, monorail (I-beam), and motorized vehicle

(d) Conveyer belt with rolls and frame

(e) Crane with crane rail and hoist
What is the definition of a Robot?

- Nobody seems to agree!

- To be called a robot it should do some or all of the following:
  - move around
  - sense and manipulate the environment.
  - display intelligent behavior

Is a CNC machine a Robot?
Differences between Robotics and Automation?

- Robotics focuses on systems incorporating sensors and actuators that operate autonomously or semi-autonomously in cooperation with humans.

- Robotics research emphasizes intelligence and adaptability to cope with unstructured environments.

- Automation research emphasizes efficiency, productivity, quality, and reliability, focusing on systems that operate autonomously, often in structured environments over extended periods, and on the explicit structuring of such environments.
Three generations of robotics / engineering

- **First generation of robots**: simple pick and place devices with no external sensors.

- **Second generation robots**: external Sensors (vision, tactile, etc) for interaction with the environment.

- **Third generation robots**: intelligence, smart materials, bio, etc.

- **Future robots**: bio-robots, micro, nano, cyborgs, aneroids etc.
First Generation Robots : 1950 - 1970
NC technology

- Simple motion capabilities for pick and place applications

- Robots made of revolute joints actuated by open loop or closed loop control.
Second generation of robots (1970 ... 1990)

Electronics: smaller, faster and cheaper processors

- External sensors: interaction with the environment
  - vision
  - advanced sensors: gyro, inclination, force, slip.
  - advanced controllers: microcontroller, DSP
  - speech recognition
  - AI
Third generation robots 1990 - 2000

- New materials – smart materials, smart actuators.
- Interest in emulating biological design paradigms.
- New areas like: Micro, Nano-robotics, Vision, bio-robotics, etc.
Size Effect ??
Future robots --- ????

- Exoskeletons: wearable devices.
- Neuro robotics: cyborgs, aneroids.
- Robotic drugs: nano robots for curing diseases, surgery.
- Assistive / Rehabilitation robotics.
- Outer space / nuclear applications
- Defense: soldier, autonomous armaments.
- Replacement of body functions: artificial muscles.
- IOT, CPS
- ????
Future ?? 2016 -
Micro robot ‘drugs’ to cure diseases

Fig. Killing viruses or bacteria
Micro - Robot Surgeon for bypass surgery!

Nanorobots

Technology is shrinking fast. Computing technology that would have filled a warehouse 30 years ago can now be squeezed onto a chip a fraction of the size of your thumbnail. The very smallest scale of engineering is called nanotechnology. A nanometer is a billionth of a meter, about the width of ten atoms. Nanotechnology may, one day, be capable of producing fully working robots to that scale, called nanorobots or nanobots. Working at an almost atomic level, nanorobots could build complex items cheaply and repair clothes, equipment, and even people without being noticed. They could also be used to rid the atmosphere of pollution and to repair holes in the ozone layer.

Bottom up

Researchers are looking at different ways to construct nanorobots. The “bottom up” approach uses individual atoms and molecules as building blocks. This stick figure was created from just 38 carbon nanotube molecules.

A more sober

A type of 20,000 of these stick figures in mere minutes is a human body.

Top down

Known as “top down,” one potential way of building nanorobots lies in miniaturizing existing machines. There have been some incredible feats, including this fully working electric motor, just 0.07 in (1.8 mm) in size.

Pumping in contrast

A piston, 0.06 in (0.15 mm) across, sits on one of the engine’s caps, measuring 0.32 in (0.8 mm).

Blood vessel wall

Red blood cell

Plaque attacks

The diseased sections of the blood vessel are covered with a type of plaque containing cholesterol.

Building blocks

Each block contains one atom. The whole gear measures just a few nanometers in diameter.

Waste away

The nanorobots would either remain inside the blood system, constantly performing their tasks, or be programmed to self-destruct safely, exiting the body through one of the human body.

A nanosurgeon

Machine made from individual atoms, like this differential gear, have reached the computer modeling stage, but have yet to be built. For nanotechnology to work, they would need to be made in large numbers. Scientists are looking to nature for guidance on how nanorobots may be self-replicating, like plant and animal cells.

May the force be with you

This nanosurgeon is a big step toward an assembly that can build nanorobots from atoms. It uses an atomic force microscope, together with sophisticated handling tools, to manipulate atomic particles.

Getting the needle

A hypodermic needle, less than 0.12 in (0.30 mm) in diameter, would inject nanorobots into the bloodstream.

Disabling It up

A communication device enables control and remote instructions and data from a controller outside of the body.

Medical nanobots

Medicine is one of the most exciting application areas for nanobots. It may become possible to inject a fleet of nanobots to perform vital work inside a human body without resorting to surgery. Irrigation fluids filled of nanorobots equipped to locate and destroy plaque, or membranes built to clean a diseased blood vessel.

Micro-clencher

A nanosurgeon would pick up the vessel plaque for removal inside the nanorobot.

Snap ‘n’ scrape

An incredibly small robotic arm would scrape the plaque from the blood vessel wall.

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Micro-robot Dentist!
Micro Robotic Hair Cut!
Hand with no joints: Artificial muscles

- Five finger hand with artificial muscles (EAP)
Snake, bird made of artificial muscles

- Emulating biology
Social robots
Robots for rehabilitation

Fig. HAL (Human assistive locomotion) Univ. of Tsukuba, Japan
Physical therapy for stroke patients
Recover after surgery or stroke
Autonomous transport
Happy robot or sad robot??

Platforms for EAP demonstration

Android facial expressions (photographed at JPL)

Courtesy of David Hanson, U. of Texas at Dallas
Automatic road tracking
Driver tracking
Ethics, laws etc.
Lastly we need to remember:

One robot can do the task of a hundred men but a hundred robots cannot do the task of one extraordinary man.
Robot Joints and work volume

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Robot arm = links + joints + sensors + actuators
Prismatic joint : DOF 1
Revolute (DOF 1) / Cylindrical joint (DOF 2)

Fig. Revolute

Fig. Cylindrical
Spherical joint : DOF 3
Work Volume

- Volume inside which the robot can position its gripper.

- The job to be performed must be inside the work volume.
Cartesian robot

Side view

Top view
Cylindrical robot
Articulated
SCARA

Side view

Top view
How to decide

- How many degrees of freedom are required for a task?
- Link lengths? (for humans ??)
- Link velocities during control ??
Thank you
THANK YOU