ID 6040
Introduction to Robotics

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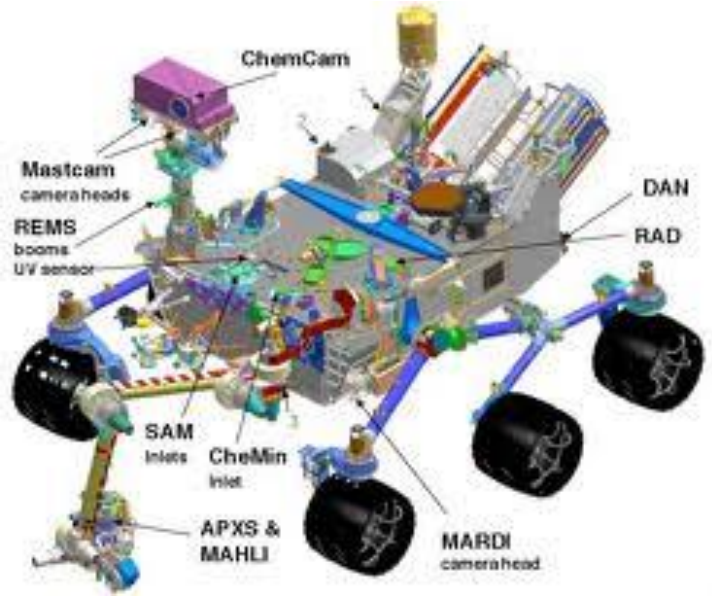
Contents

- **Robots everywhere, for every one**
- **How do you define a robot**
- **Laws of Robotics**
- **History and Evolution of Robotics**
- **Classifications**
- **Major topics in Robotics**

NASA's Mars rover Curiosity lands

NASA's Mars rover Curiosity Lander finally landed on after cruising across 350 million miles of interplanetary space for 8-1/2 months and this event is all over the news. Mars is practically on the far side of the Sun from Earth, 154 million miles (1.7 astronomical units) away.

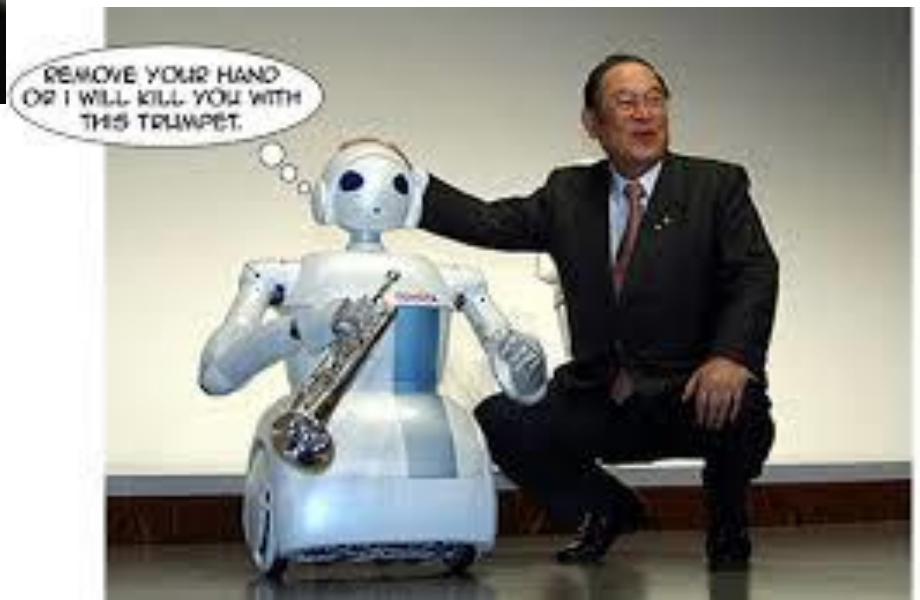


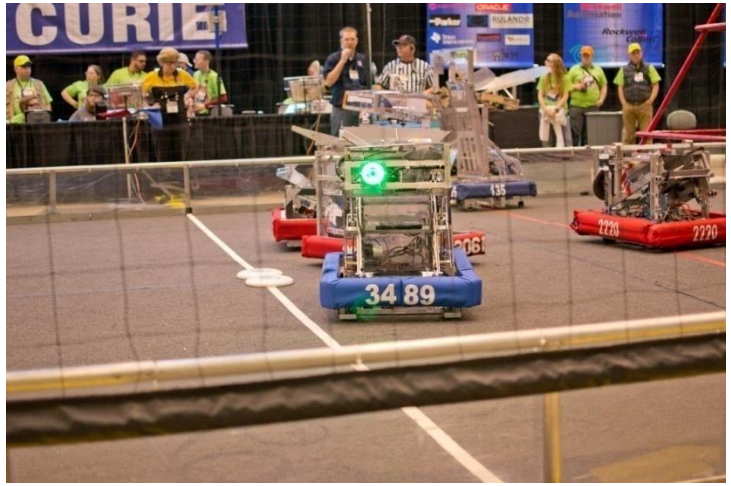
Global Luna Rover Challenge: Indian Participation by “Team Indus”

Google LUNAR X PRIZE


Courtesy of DEKA Research & Development and
The Rehabilitation Institute of Chicago

Elderly Assistant





Tour..\Videos\CMU_Tour_Guide.avi
Guide

How do you define a Robot ?

Robotics can be a hobby, a science fiction genre, a scientific/engineering discipline, or an industrial technology. As a sometimes controversial subject, it is often misrepresented in the popular media, by advocates and opponents. No single definition is going to satisfy such a variety of perspectives and interests.

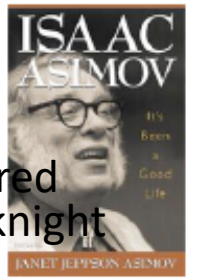
Definition

A *robot* is a software *controlled* mechanical device that uses *sensors* to guide one or more of *end effectors* through programmed motions in a *workspace* in order to *manipulate* physical objects.

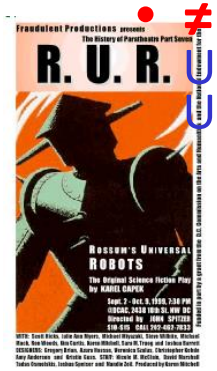
Robotics is the intelligent connection of perception to action

History ⟶

Robotics- Timeline



- #**1495** Leonardo DaVinci designs a mechanical device that looks like an armored knight. The mechanisms inside "**Leonardo's robot**" are designed to make the knight move as if there was a real person inside.
- ≠ 1920Czechoslovakian playwright Karel Capek introduces the word robot in the play *R.U.R.* - *Rossum's Universal Robots*. The word comes from the Czech *robota*, which means tedious labor.
- ≠ 1942 Isaac Asimov publishes *Runaround*, in which he defines the Three Laws of Robotics.
- ≠ 1951 In France, Raymond Goertz designs the first teleoperated articulated arm for the Atomic Energy Commission. This is generally regarded as the major milestone in force feedback technology.
- ≠ 1954George Devol designs the first programmable robot and coins the term Universal Automation, planting the seed for the name of his future company - Unimation.



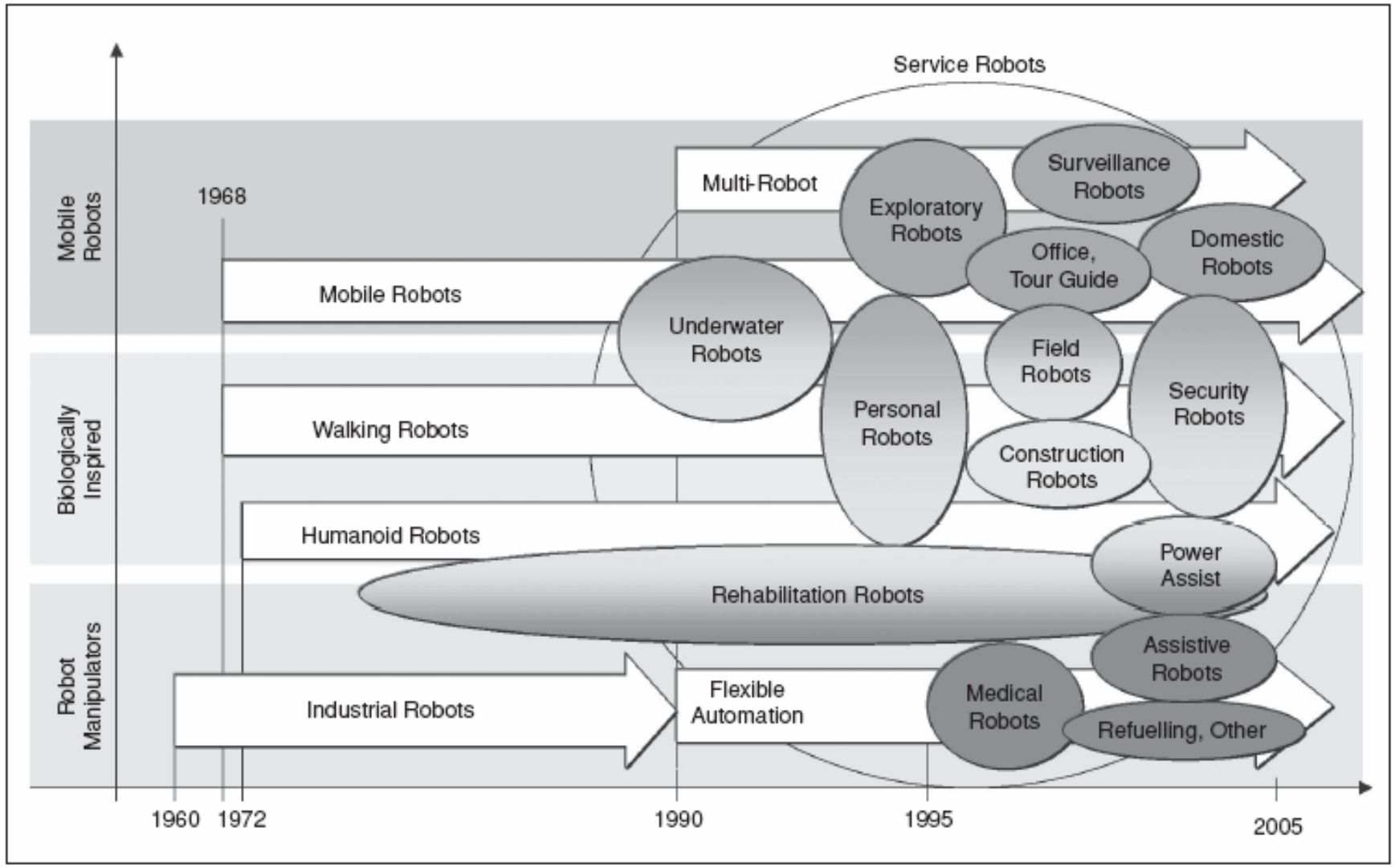
- 1962 General Motors purchases the first industrial robot from Unimation and installs it on a production line. This manipulator is the first of many Unimates to be deployed.
- ≠1965 Homogeneous transformations applied to robot kinematics - this remains the foundation of robotics theory today
- 1970 Professor Victor Scheinman of Stanford University designs the Standard Arm. Today, its kinematic configuration remains known as the Standard Arm.
- 1978 Using technology from Vicarm, Unimation develops the PUMA (Programmable Universal Machine for Assembly). The PUMA can still be found in many research labs today.
- 1978 Brooks Automation founded 1979 Sankyo and IBM market the SCARA (selective compliant articulated robot arm) developed at Yamanashi University in Japan
- 1982 Fanuc of Japan and General Motors form joint venture in GM Fanuc to market robots in North America.
- 1994 CMU Robotics Institute's Dante II, a six-legged walking robot, explores the Mt. Spurr volcano in Alaska to sample volcanic gases.
- 1995 Intuitive Surgical formed by Fred Moll, Rob Younge and John Freud to design and market surgical robotic systems. Founding technology based on the work at SRI, IBM and MIT.
- ≠ 1997 NASA's Mars PathFinder mission captures the eyes and imagination of the world as PathFinder lands on Mars and the Sojourner rover robot sends back images of its travels on the distant planet.
- 2000 Honda showcases Asimo, the next generation of its series of humanoid robots.
- 2000 Sony unveils humanoid robots, dubbed Sony Dream Robots (SDR), at Robodex.
- 2001 Built by MD Robotics of Canada, the Space Station Remote Manipulator System (SSRMS) is successfully launched into orbit and begins operations to complete assembly of International Space Station

The Laws of Robotics (according to the Handbook of Robotics, or more precisely, Isaac Asimov):

A robot may not injure humanity or, through inaction, allow humanity to come to harm. (This was added after the initial three laws.)

1. A robot may not injure a human being, or, through inaction, allow a human being to come to harm.
2. A robot must obey the orders given to it by human beings except where such orders would conflict with the First Law.
3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

Evolution of Robotics Research

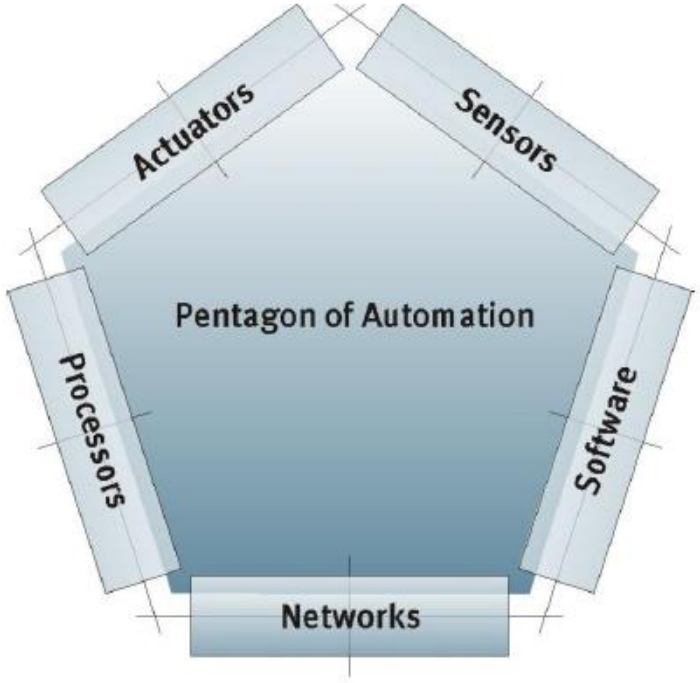


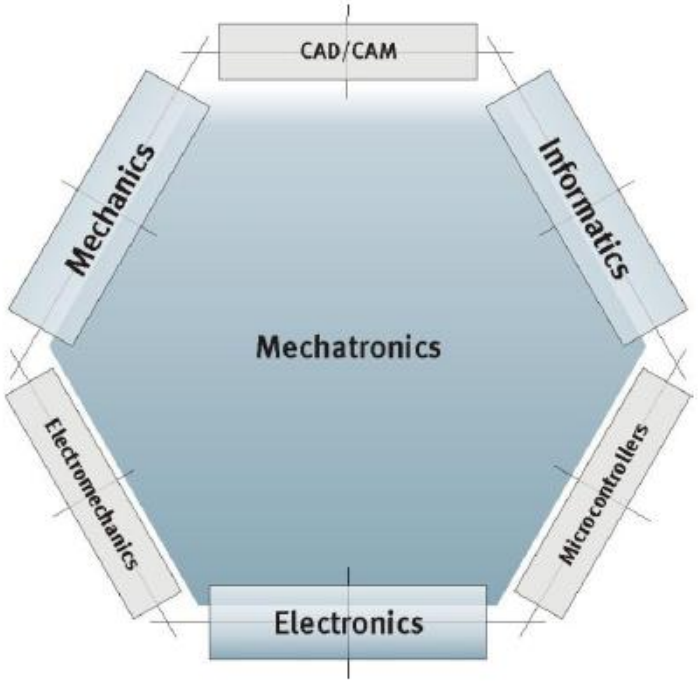
Five Myths and Facts About Robotics Technology Today

By Shahin Farshchi, IEEE Spectrum, 2014

- **Robots are intended to eliminate jobs: MYTH**
- **Manufacturing and logistics must adopt robots to survive: FACT**
- **Autonomous robots are still too slow: FACT**
- **Robots are too expensive: MYTH**
- **Robots are difficult to use: FACT**

Enabling Technologies: Automation Pentagon





Mechatronics: " Not only a trend in technology – it is a way of thinking "

Challenge: How do we motivate the youngsters to learn all these ?

Classifications

- **Industrial Robots**
- **Field and Service Robots**
- **Entertainment/Educational Robots**

Field and Service Robots

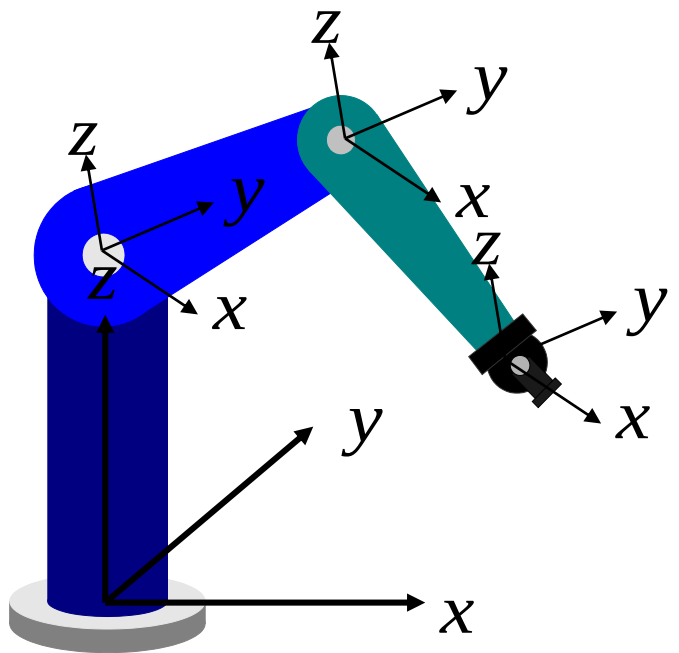
Wheeled mobile robots/intelligent vehicles
Walking robots (robot dogs, biped robots, etc.)
Humanoids
Climbing, Crawling robots (robot spiders, Robot Snakes)
Aerial Robots
Medical Robots
Agricultural robots

Industrial Robots (Manipulators)

Industrial robots

Pick and Place
Assembly
Welding
Painting
Machining

- Mostly, six-axis articulated configuration (serial arm)
- Electric/Hydraulic actuation
- Robot workcells consist of manipulators, end effector tools, conveyors, sensors (vision, force, proximity etc.)
- Programmed through special robot programming languages
- Once setup, runs without major deviations
- Needs calibration
- Online/offline programming
- Kinematics, Dynamics and Control

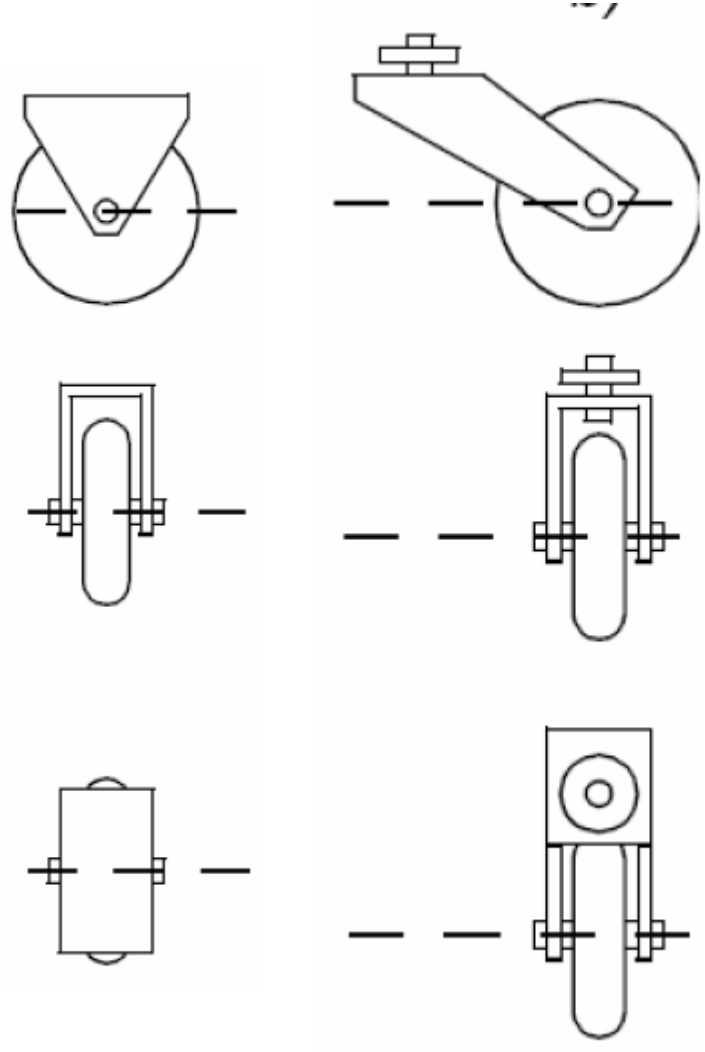


Field and service robots

Wheeled Mobile robots

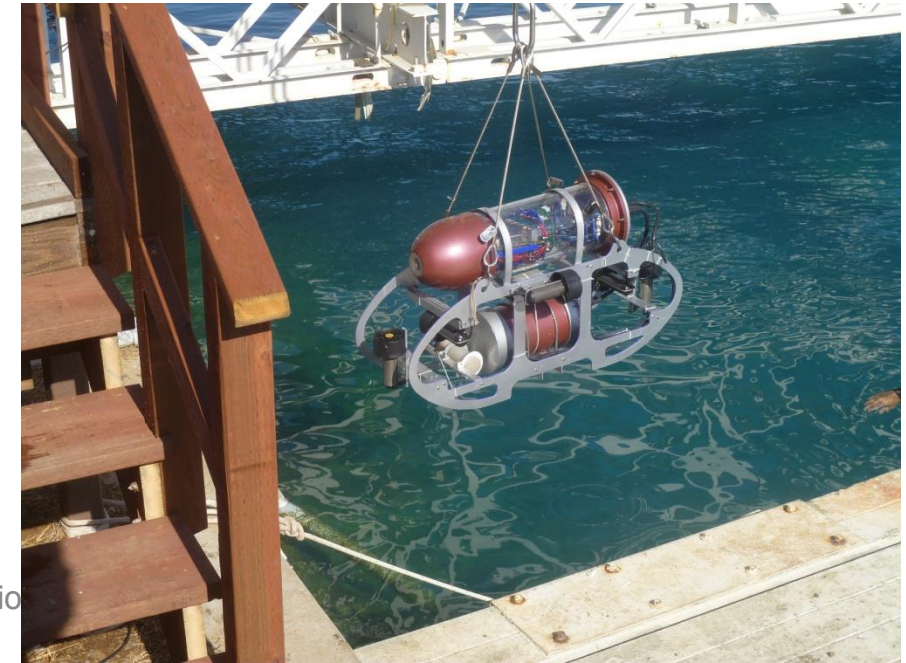
- Muir and Newman (1987)
  - A WMR is "a robot capable of locomotion on a surface solely through the wheel assemblies mounted on it and in contact with a surface.
  - A wheel assembly is a device which provides or allow relative motion between its mount and the surface on which it is intended to have single-point of rolling contact".

- Wheel Design
- Wheel Geometry/configuration
- Stability
- Maneuverability
- Controllability



Standard wheel Castor wheel

Underwater Robots



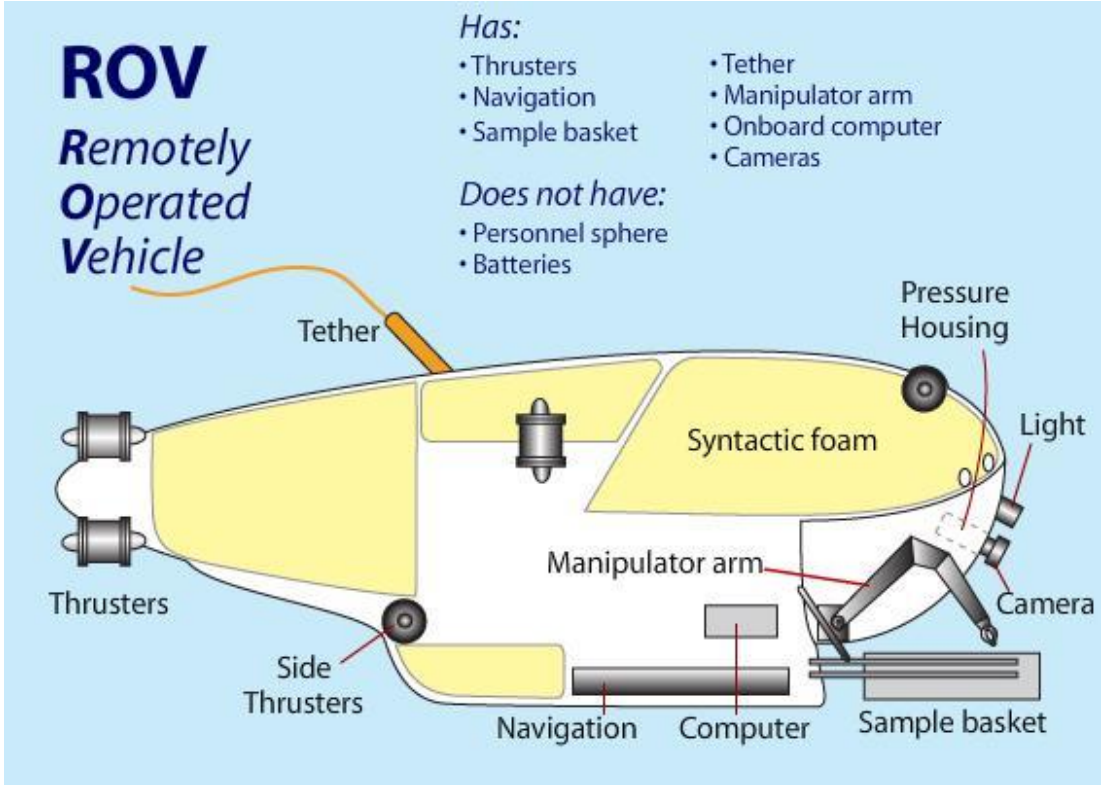
Underwater Robots

A mobile robotic device designed and developed to work in underwater environment to accomplish specific tasks which are normally performed by human operators

Remotely Operated Vehicle (ROV)

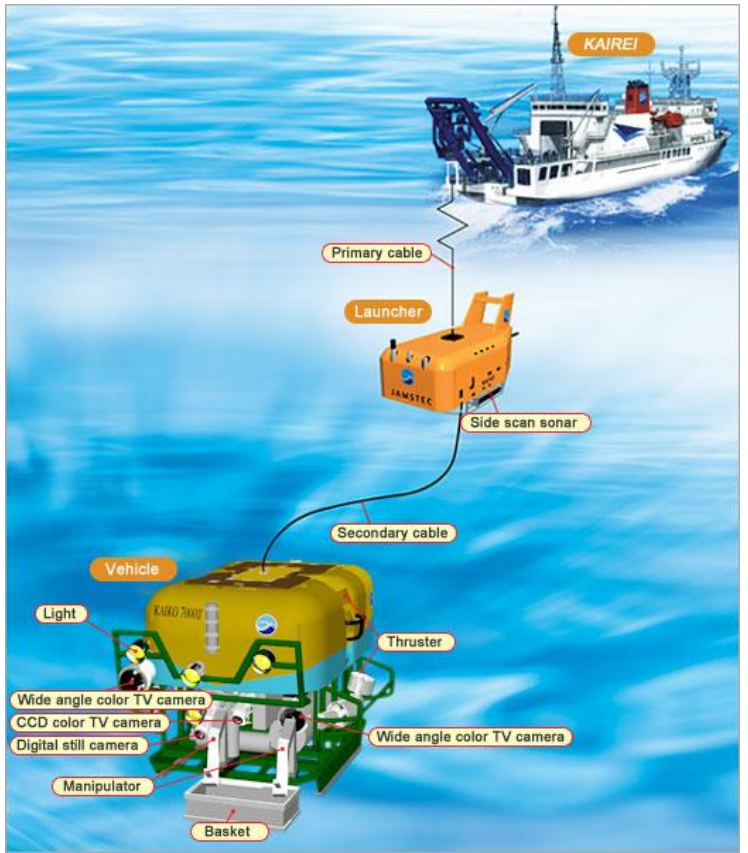
Tethered Supervised Vehicle:

The vehicle is connected to a mother ship by a cable through which communications, data transmissions and power supply are carried out.



ROV Deployment and Applications

- Diver Observation
- Platform Inspection
- Pipeline Inspection
- Surveys
- Drilling Support
- Construction Support
- Debris Removal
- Platform Cleaning
- Sub-sea Installations
- Telecommunications Support
- Object Location and Recovery



Autonomous Underwater Vehicle (AUV)

It is a robotic device that is driven through the water by a propulsion system, controlled and piloted by an onboard computer and maneuverable in three dimensions.

- It needs to be Pre-programmed
- Degree of human intervention will be a function of communication capability
- AUV will require fool-proof navigation, control and guidance systems on board to meet the mission accuracy requirements
- Transmission of data back to mother ship if on-board data storage with post mission retrieval does not meet the mission requirements

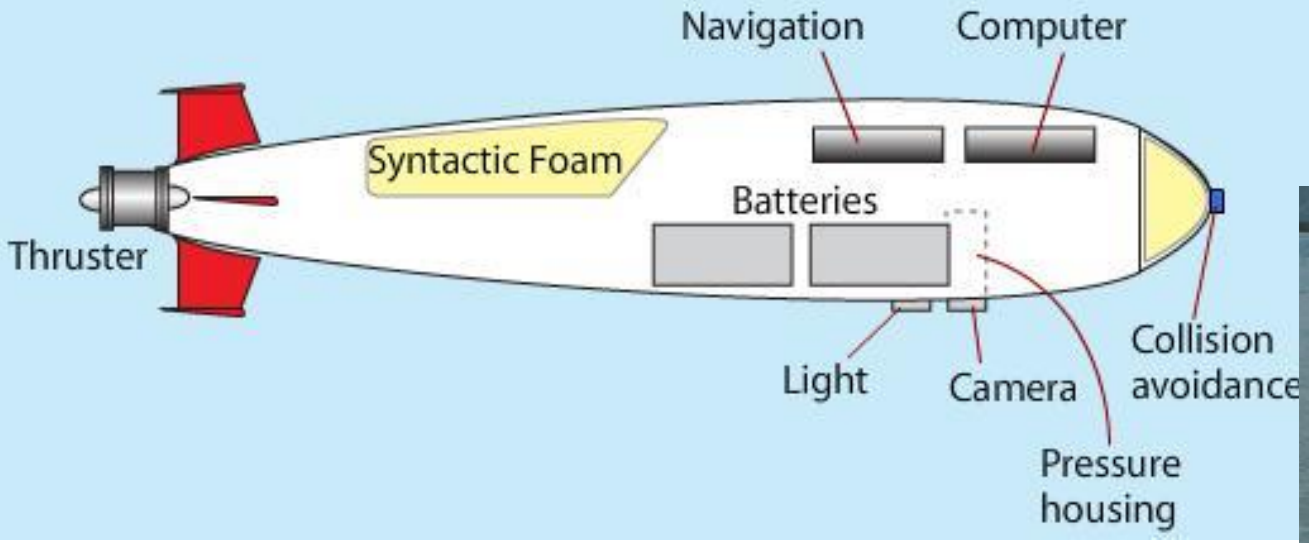
Autonomous Underwater Vehicle (AUV)

AUV

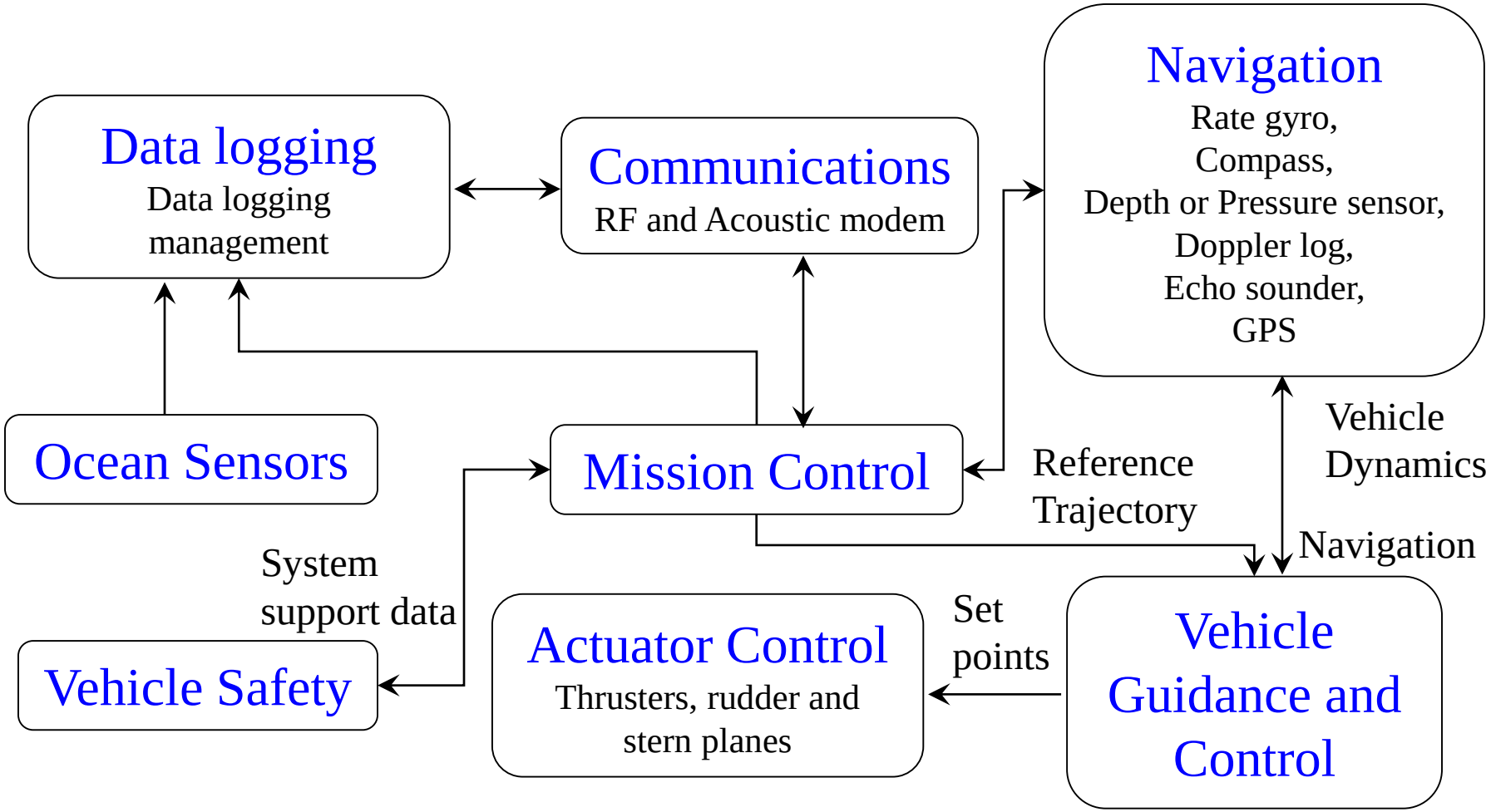
***A**utonomous*
***U**nderwater*
***V**ehicle*

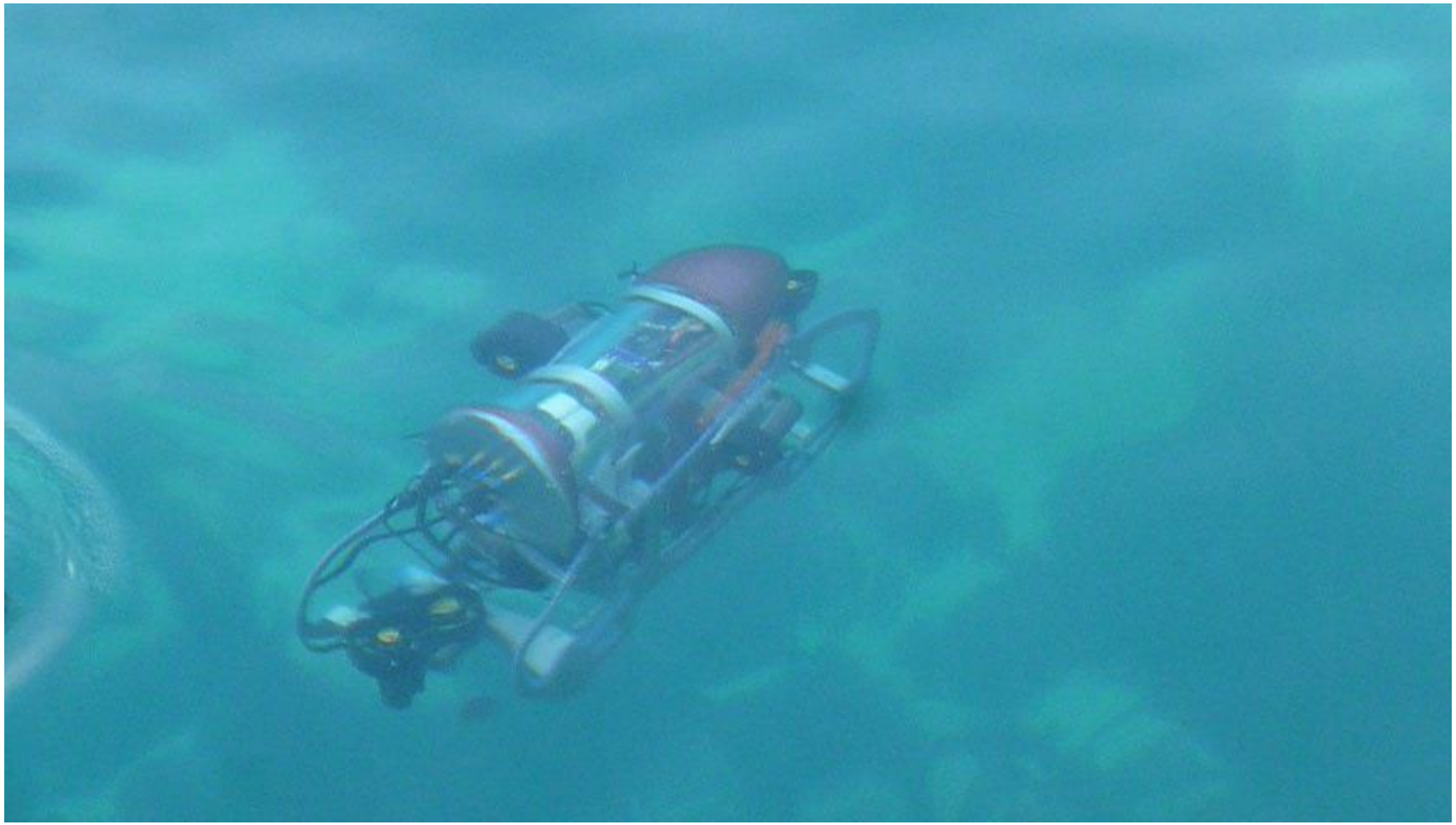
Has:
- Thrusters
- Batteries
- Navigation
- Onboard computer
- Pressure housing

Does not have:
- Tether
- Manipulator arm
- Sample basket
- Personnel sphere



Main Building blocks of AUV Control System

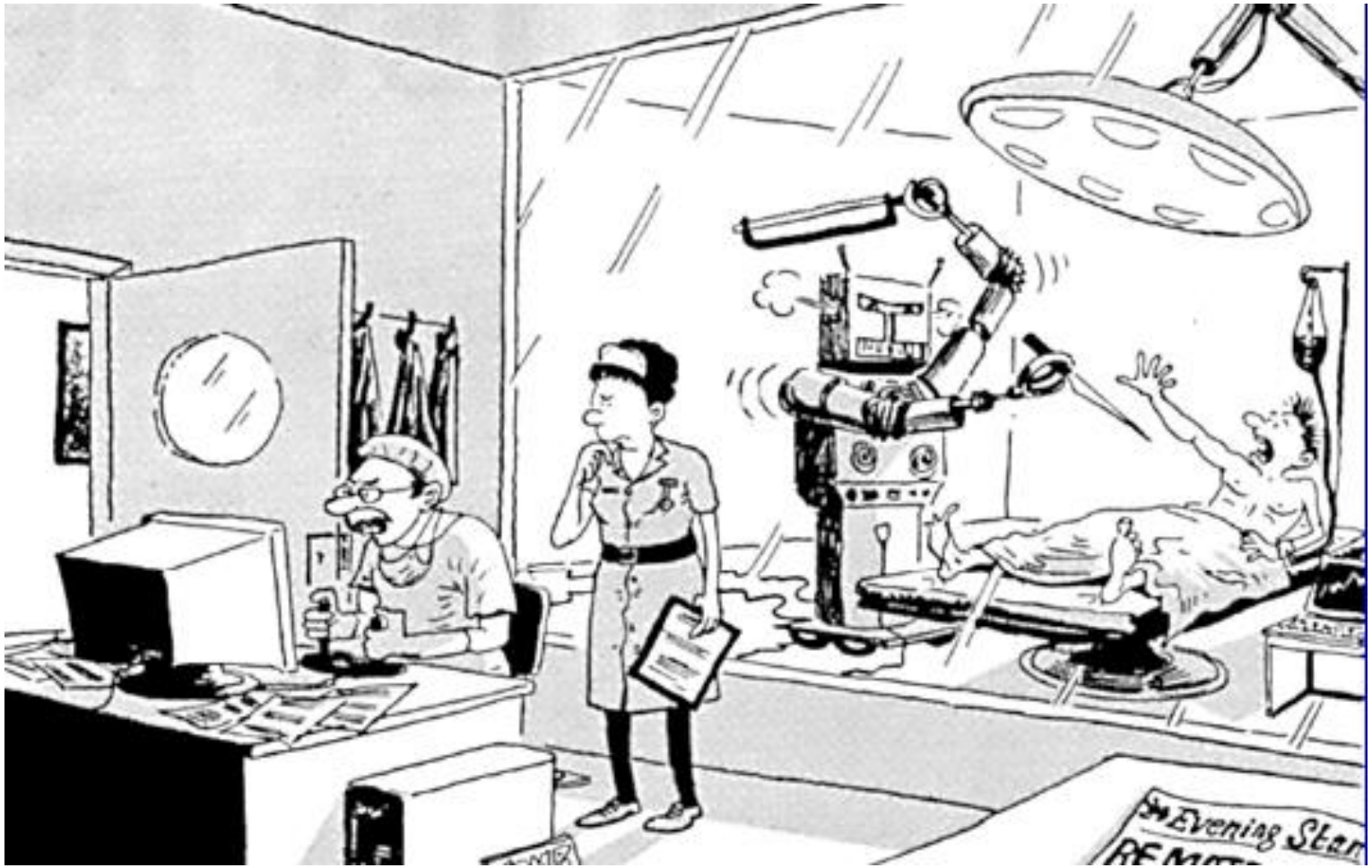




RoboSub competition 2014: San Diego

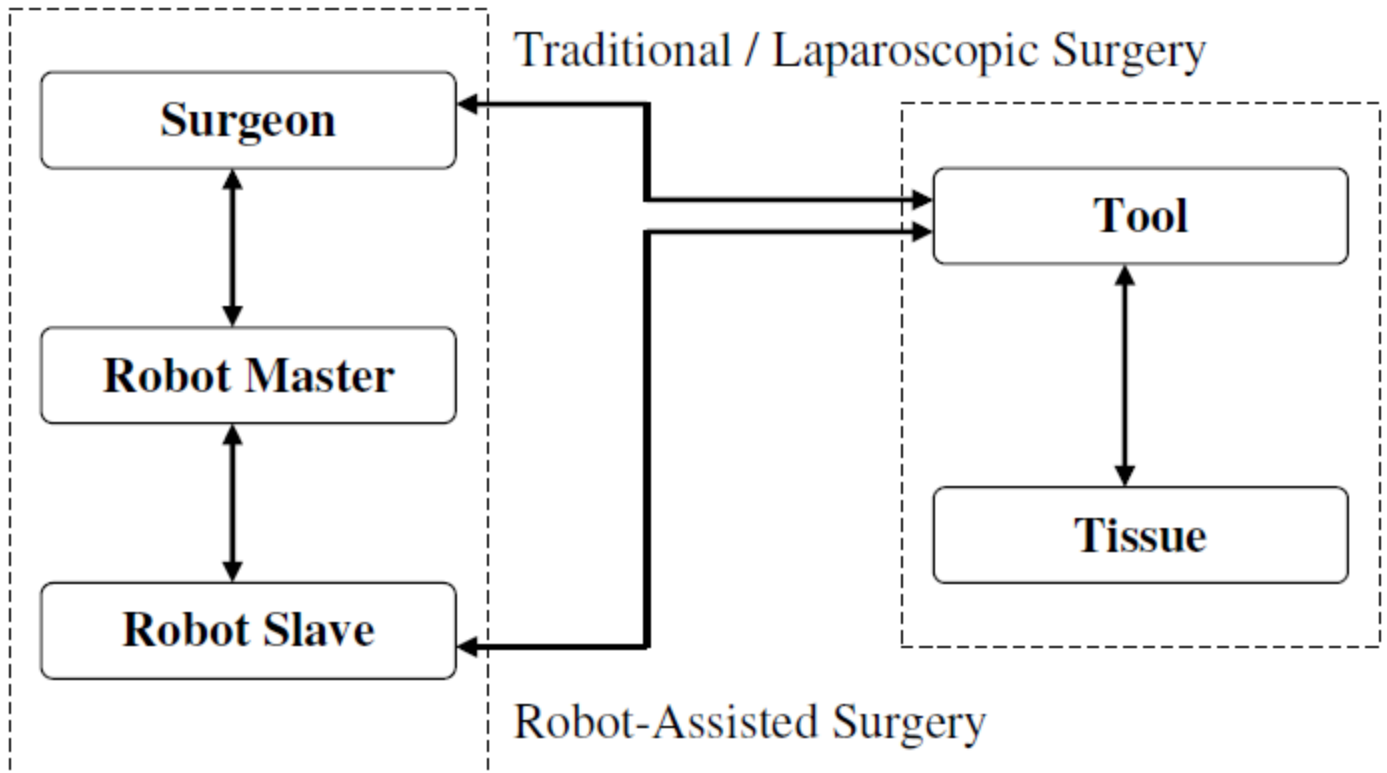
Robotics for Healthcare

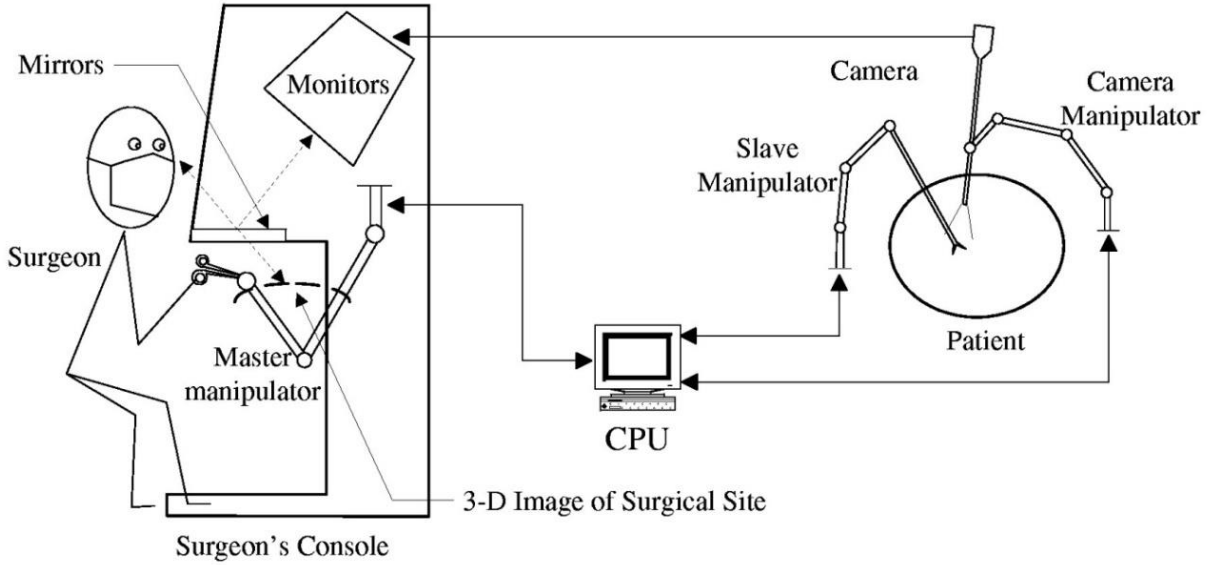
Robots in Hospitals?? What for?



Biorobotics

It is a new area of research at the interface of biology and robotics and covers a wide spectrum of research areas like medical robotics, rehabilitation robotics, biologically inspired robotics, haptic devices etc.


Traditional / Laparoscopic Surgery
Surgeon
Robot Master
Robot Slave
Tool
Tissue
Robot-Assisted Surgery


Mirrors
Monitors
Camera
Camera
Manipulator
Slave
Manipulator
Surgeon
Master
manipulator
Patient
CPU
3-D Image of Surgical Site
Surgeon's Console

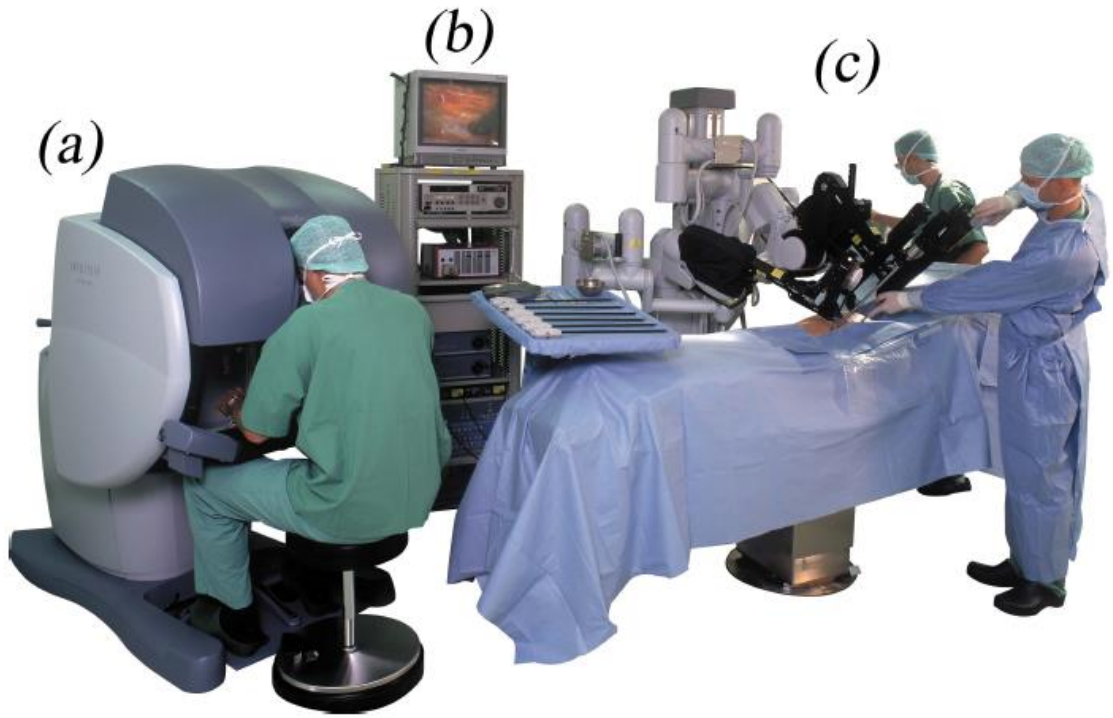
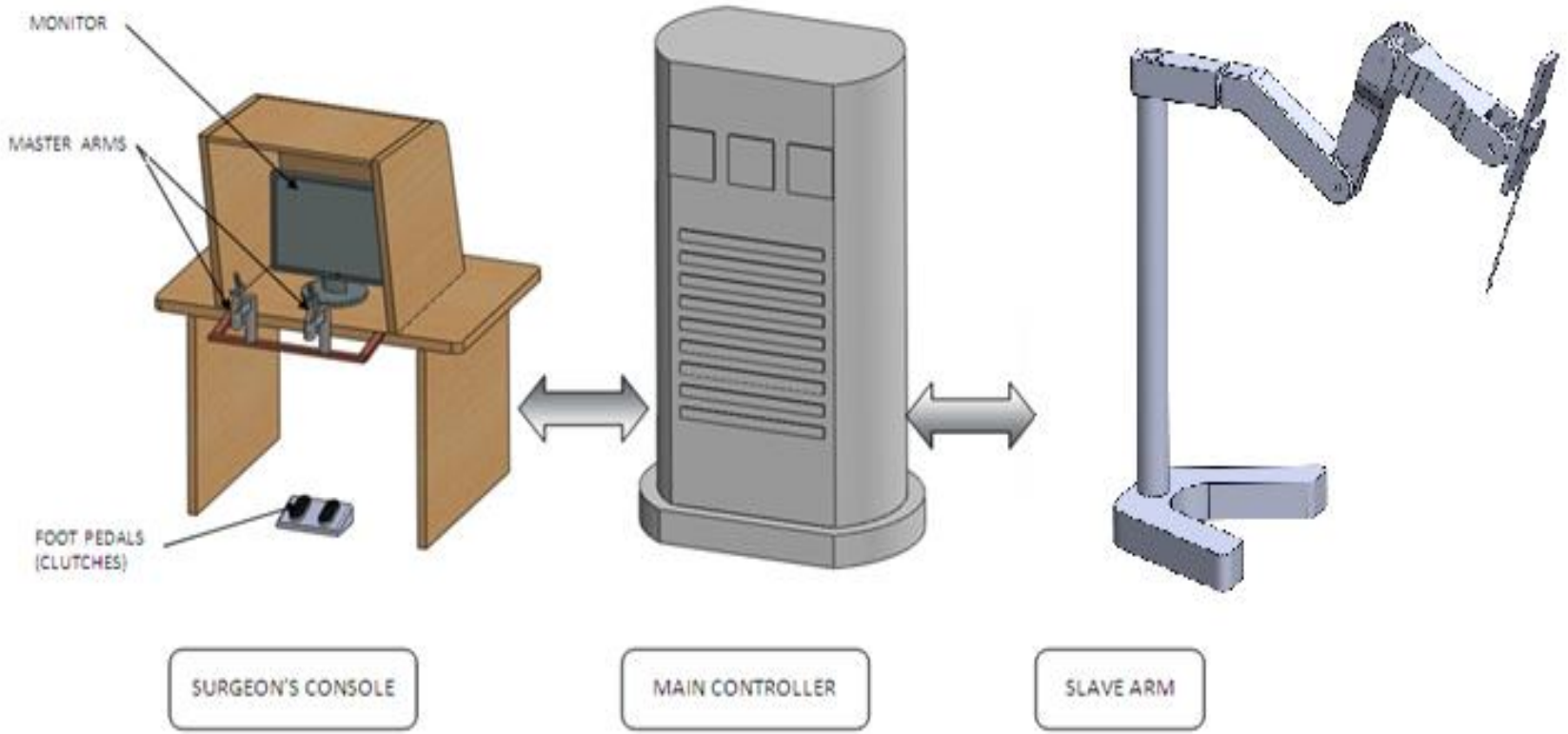


Figure 1.2: The da Vinci Surgical System. System components include (a) the master

IITM Surgical Robot Trainer

- Robotic Assisted Minimal Invasive Surgery.



Rehabilitation Robotics

Rehabilitation robotics is a field of research dedicated to understanding and augmenting rehabilitation through the application of robotic devices. Rehabilitation robotics includes development of robotic therapies, and the use of robots as therapy aids instead of solely as assistive devices

Types of Rehab. Robots

- Upper-extremity robots
  - Haptic interface
  - Upper limb
- Lower extremity robots
  - Leg, ankle, foot
  - Pedaling, walking (gait)

Robot-Assisted Rehabilitation Systems

MIT Manus

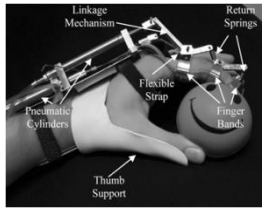
ARM Guide

MIME

GENTLE/s

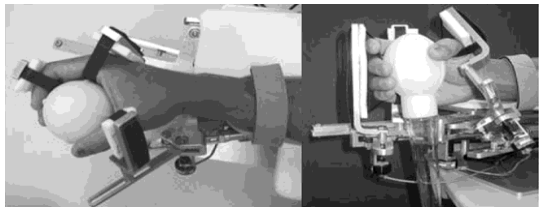
ADLER

Rutgers Master II-ND



Carnegie Mellon Hand Device

CyberGrasp

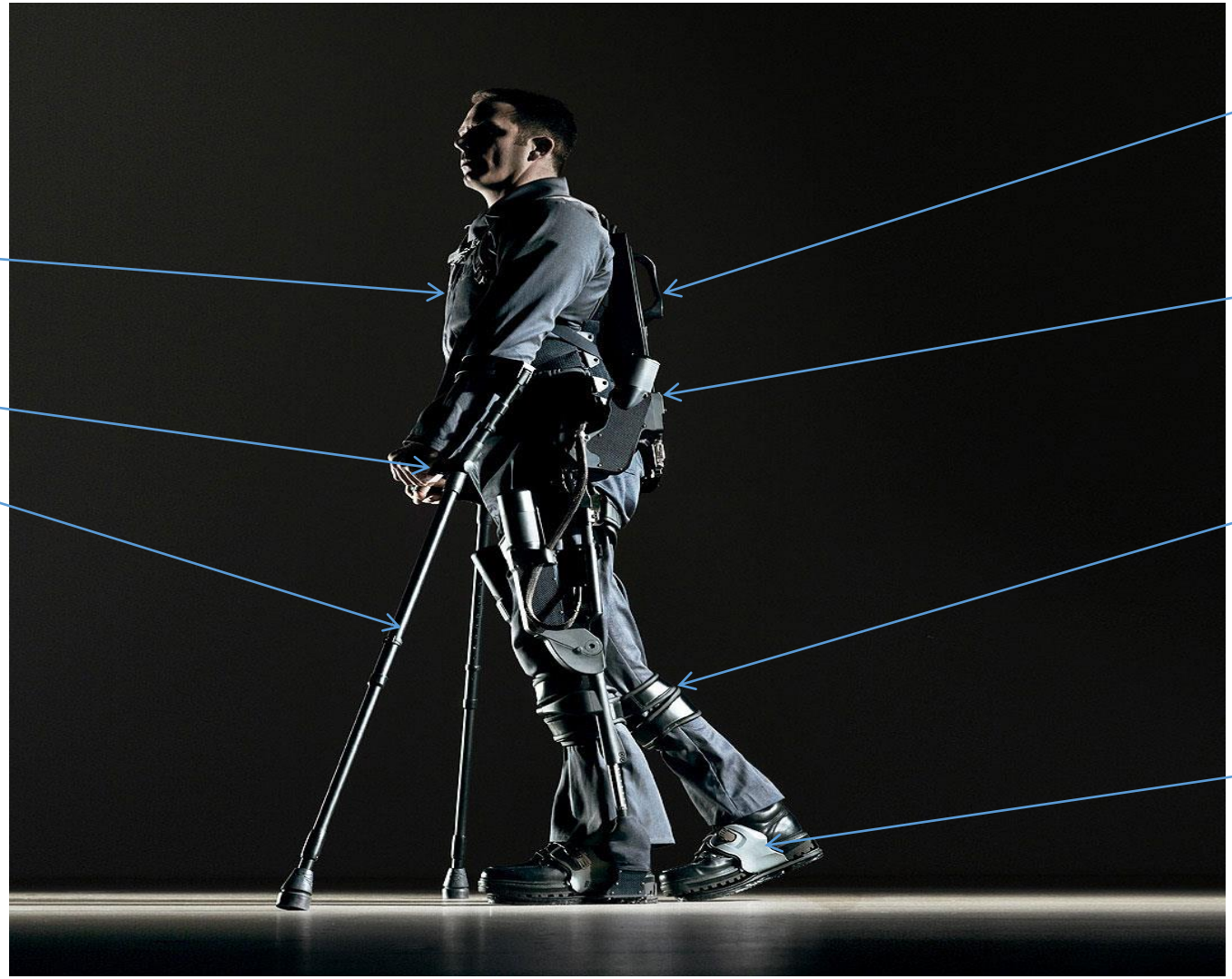


HWARD

Ekso – The Exoskeleton

- Product of Berkeley Bionics, California.
- Is used to enable the user to walk with the presence of limbs (usually for paralysed limbs).
- Also has crutches with buttons to activate the motors.

Ekso Structure



Robotised motor coordination analysis and therapy

Case in point: *The Locomat from Hocoma makes it possible to offer individually tailored and adaptable treatment to stroke patients undergoing therapy for restoring motor coordination.*

Intelligent prosthetics

Case in point: *A future development: the newest experimental hand prosthesis from Otto Bock with individual movement of fingers controlled by nerve signals.*

Bionic Arm

- Serves as a replacement limb for people who lost their arms due to accidents etc.
- Usually controlled by thoughts or through muscle control, if the part of the limb is intact.
- Made of Carbon Fibre.

- A bionic arm combines robotics, biotechnology, and electronics to recreate the functions of the human arm. Advances in bionics can improve the lives of millions of people with lost limbs.

Rehabilitation Robots

http://ric.cachefly.net/bionic_arm%20%28with%20text%29.wmv

The DEKA Arm

Prosthetic Arm

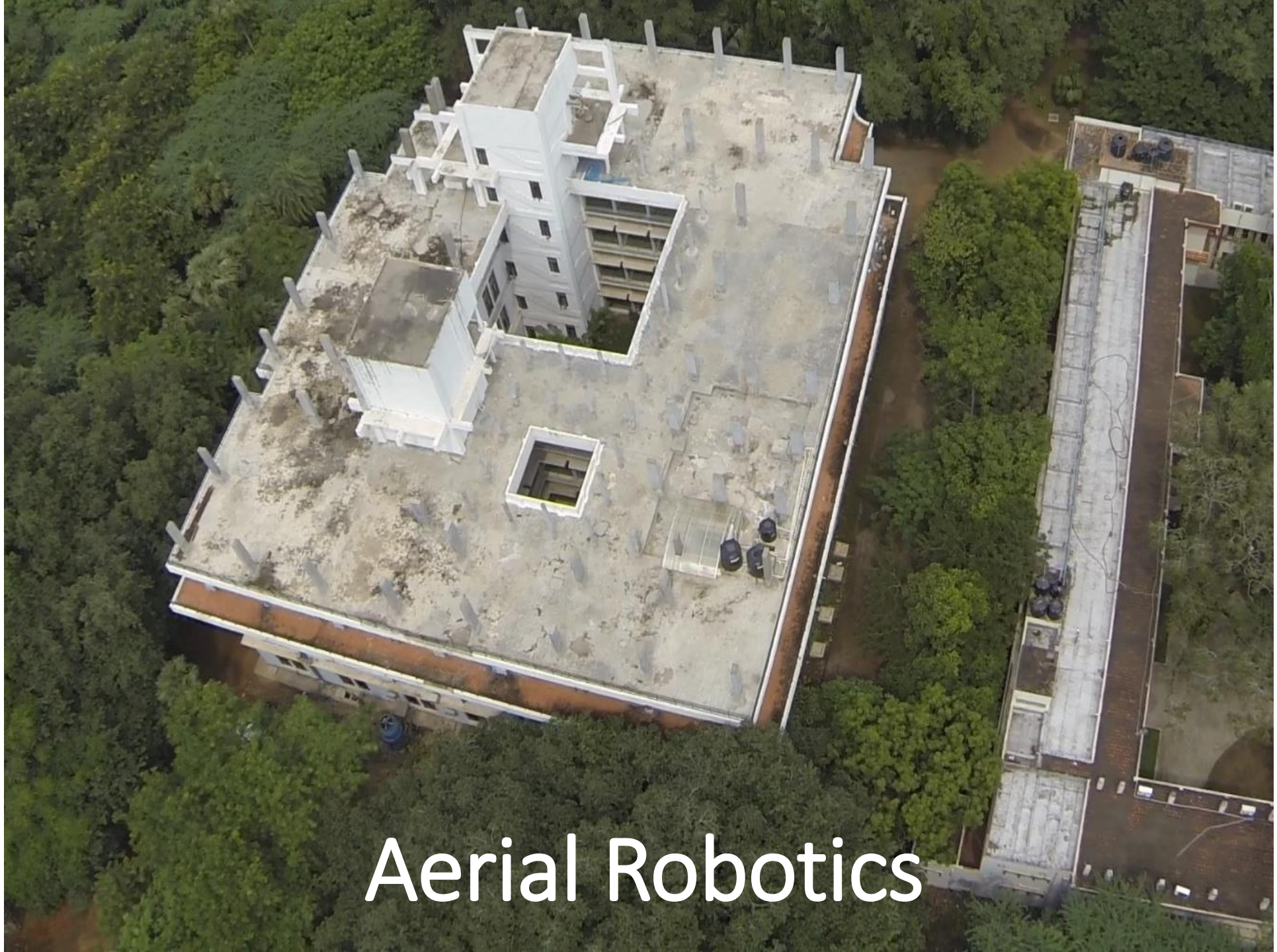
http://www.youtube.com/watch?v=X1OBzc9QfIs&feature=endscreen&NR=1

Claudia Mitchell, 28, of Arkansas, demonstrates advanced, multi-degree control of the DEKA Research arm at The Rehabilitation Institute of Chicago. Mitchell, who lost her arm in a motorcycle accident in 2004, underwent targeted muscle reinnervation in 2005. Video courtesy of the Rehabilitation Institute of Chicago and DEKA Research.

NANOBOTS

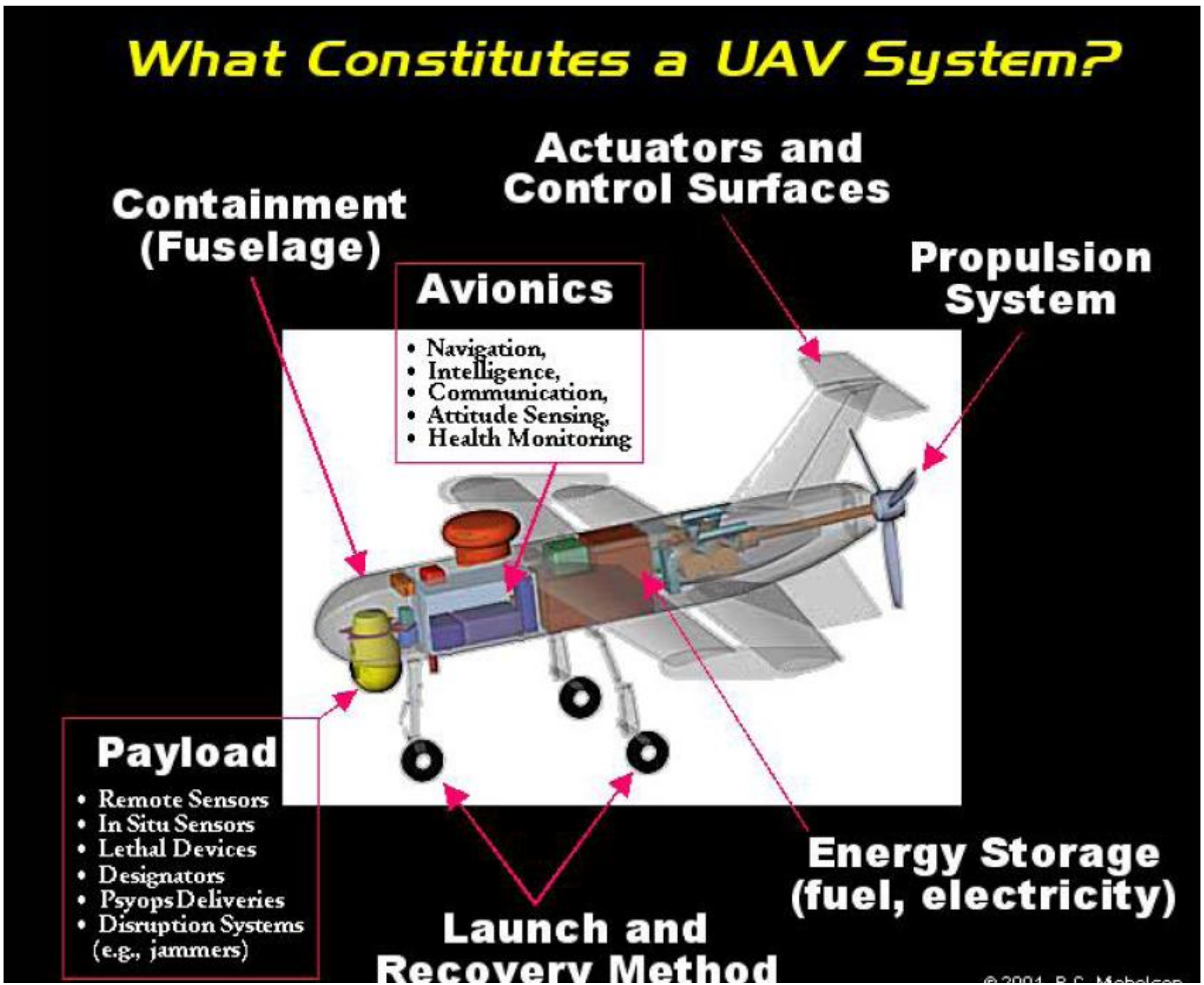
Where are we heading???

- Robots in molecular scale – ”Nanobots”.
- To carry out assembly work following sophisticated computer programs.
- Explore the human body, other organisms, repairing and correcting, providing information on the inside.



Aerial Robotics

What Constitutes a UAV System?



Taxonomy

Aerodynamic Configurations

- Lighter than Air
  - Airships
  - Blimps
  - Hot Air Baloons
- Heavier than Air
  - Fixed Wing
  - Flapping wings
  - Rotorcrafts

Multi-rotors

Ground Control Station

Waypoint Navigation around ED,IITM

Educational/Entertainment Robots

Domestic Robots

Humanoids

Reading Assignment

II. What is Robotics about?

- Programming a robot is significantly different from conventional computer programming due to the fact that robots interact with the physical world with physical actions. This important distinction leads to the following preferred definition of robotics:

Robotics is the intelligent connection of perception to action.

Contd….

We can realize this connection through the following sequence of processes:

* Modeling _ programming
* Planning /
* Measurement (sensing)
* Perception (responding) _ programming & control
* Action /

III. **Hardware & Software** Components of a Robot:

Hardware:

Mechanical Subsystem (arm, gripper, body and wheels, etc)

Electrical subsystem (motors, computers, ...)

Sensor Subsystem (camera, force sensor, …)

Software:

Modeling

Planning

Perception

Control

Simulation

The physical structure of a robot determines its working envelope, degrees of freedom, and the geometry or spatial configuration of its movement.

IV. Topics in Robotics

- **Kinematics**: deals with the spatial locations and velocities of a robot end effectors and its internal joints
- **Forward and Inverse** Arm kinematics
- **Statics**: analyzes the force/moment acting upon a robot when it is at rest.
- **Dynamics**: study the dynamic behavior of a robot, i.e., the relationship between the driving torques and the motions of the robot.
- **Trajectory Control**: deals with how to servo a robot's actuators to make the robot motion follow a desired trajectory.
- **Trajectory Planning**: determines a feasible and effective trajectory for a given path.
- **Path Planning**: determines a collision-free and effective path to accomplish a task.
- **Sensing and Perception**: obtain and reason about sensory information to acquire the state of a robot and/or its task.
- **Task Planning**: determines the sequence of primitive actions for a higher level task command (e.g., put the peg in hole) and the resources need.
- **World Modeling**: represent the knowledge about the robot, the task, and the environment in the computer.
- **Robot Programming**: program the robot tasks in various levels. **Sensor-based** programming.
- **Simulation/Haptics:** simulate physical movements and the tactile sensation associated with physical interaction.

Home Robotics