SS-3406
Introduction to Robotics

Lecturer: Ong Wee Hong
Email: weehong.ong@ubd.edu.bn, Office: FOS M2.08
Universiti Brunei Darussalam

Acknowledgement

Some content (especially images and videos) on the slides used in this course are extracted from various sources especially the internet as well as books.

INTRODUCTION

Course Outline

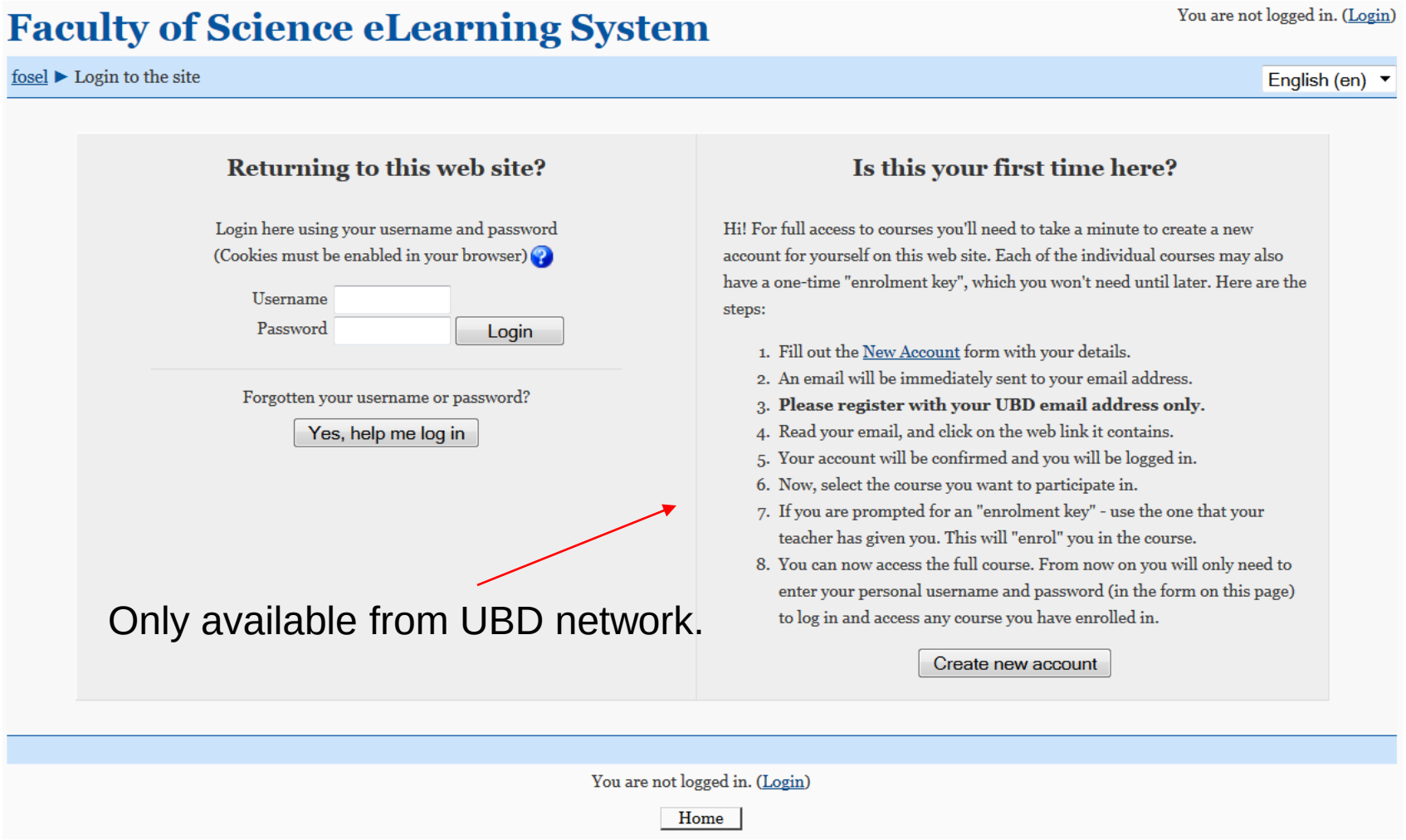
- To introduce to the students the basic concepts of robotics, such as controller, sensors and actuators. It is intended to make a student “robotics literate”.
- After successfully completion of this module, students will be able to:
  - explain the basic components of a robot
  - describes the different areas and applications of robotics
  - design robots for simple applications
  - write simple programs for robots
  - determine their future direction in robotic research, if they wish

What for?

- Do you know the next hot gadget after smartphone may be the robots?
- It will be good to appear robotic literate.
- Robots are fun. No?!
- No examination! (Shhh …)
- 4MC!

Course Resources

- **Course Materials**: http://fos.ubd.edu.bn/moodle
  - Register an account. Please use your full name and UBD email address.
    - Registration: must be done within UBD only.
    - Accessing: either within UBD or outside UBD.
    - Enrolment key:
  - **Mandatory** to be enrolled in SS-3406 in the Moodle.
    - All materials and announcements made on the Moodle are assumed to have reached you.
    - Check in the Moodle regularly.


Faculty of Science eLearning System
You are not logged in. (Login)
fosel ▶ Login to the site
English (en)
Returning to this web site?
Login here using your username and password
(Cookies must be enabled in your browser)
Username
Password
Login
Forgotten your username or password?
Yes, help me log in
Is this your first time here?
Hi! For full access to courses you'll need to take a minute to create a new account for yourself on this web site. Each of the individual courses may also have a one-time "enrolment key", which you won't need until later. Here are the steps:
1. Fill out the New Account form with your details.
2. An email will be immediately sent to your email address.
3. Please register with your UBD email address only.
4. Read your email, and click on the web link it contains.
5. Your account will be confirmed and you will be logged in.
6. Now, select the course you want to participate in.
7. If you are prompted for an "enrolment key" - use the one that your teacher has given you. This will "enrol" you in the course.
8. You can now access the full course. From now on you will only need to enter your personal username and password (in the form on this page) to log in and access any course you have enrolled in.
Create new account
Only available from UBD network.
You are not logged in. (Login)
Home

Books

- There is no mandatory text book for this course.
- The following are good introductory books.
  - The Robotics Primer, Maja J. Mataric, 2007, MIT Press
  - Robot Building for Beginners, 1 edition, David Cook, 2002, Apress
  - Absolute Beginner's Guide to Building Robots, Gareth Branwyn, 2003, Que

Course Syllabus

- Given this is a breadth course catering for non-engineering students, this introductory course is different from those offered for engineering students in other universities.
- Topics:
  - Robot components
    - Sensors
    - Actuators
    - Power Sources
  - Robot movements (mobile robot)
  - Robot controls
    - Microcontroller
  - Robot learning (may be)
- Mainly on mobile robot.

Course Management

- Learning activities (subject to alternative arrangements)
  - Lectures, practical and tutorials
    - 10:10-12:00pm, Thursday, FOS M1.12 (Computer Network Lab)
    - 2 hours practical/tutorials by arrangement
- Assessment scheme: 100% Coursework
  - Assignment 1: 10%
  - Class Test 1: 10%
  - Assignment 2: 10%
  - Class Test 2: 10%
  - Project: 60%

Schedule

Week 1		L1: Introduction	Robotic Lab	
Week 2		L2: Sensing	Robotic Lab	Assignment 1 Out
Week 3		L3: Actions 1: Effectors & Actuators	Robotic Lab	
Week 4		L4: Actions 2: Locomotion & Manipulation	Robotic Lab	Assignment 1 Due
Week 5		L5: Power Source	Robotic Lab	Assignment 2 Out
Week 6		L6: Robot Brain	Robotic Lab	
Week 7		Class Test 1 (L1-L5)	Robotic Lab	Assignment 2 Due
Week 8		Mid-semester Break		
Week 9		Programming	Programming	Project Out
Week 10		Project Task 1 Presentation	Programming	
Week 11		Programming	Programming	
Week 12		Project Task 2 Presentation	Robotic Lab	
Week 13		Class Test 2 (L6, Programming)	Robotic Lab	
Week 14		Project Task 3 Presentation	Robotic Lab	
Week 15		Robotic Lab	Robotic Lab	
Week 16		Revision Week		
Week 17-18		Exam Week		

Better learning environment

- **No chitchat** during the lecture time.
  - You don't need to be in the class to chat with your friends.
  - Chitchatting annoys your friends who want to listen to the lecture.
- **No PC** and **digital devices** during the lecture time: screens OFF.
  - Use only when requested.
- Keep room **tidy** and **clean**.
  - No littering, put chairs back.

Today's Menu

- Robot: The Fame
- Applications of Robots
- What is a Robot?
- Fields of Study
- Types of Robots
- Components of Robots

LET'S START …

Robot: The Fame

- **Robot** is probably no new term to anyone. It's one of the most well known technical terms, which even little kids know.
- Its fame is created by the science-fiction novels and popular movies.

However, it’s not just science-fiction.
Robots have their important roles in real world …

Let the robots do the **dull**, **dirty** and **dangerous**: 3D jobs.

APPLICATIONS OF ROBOTS

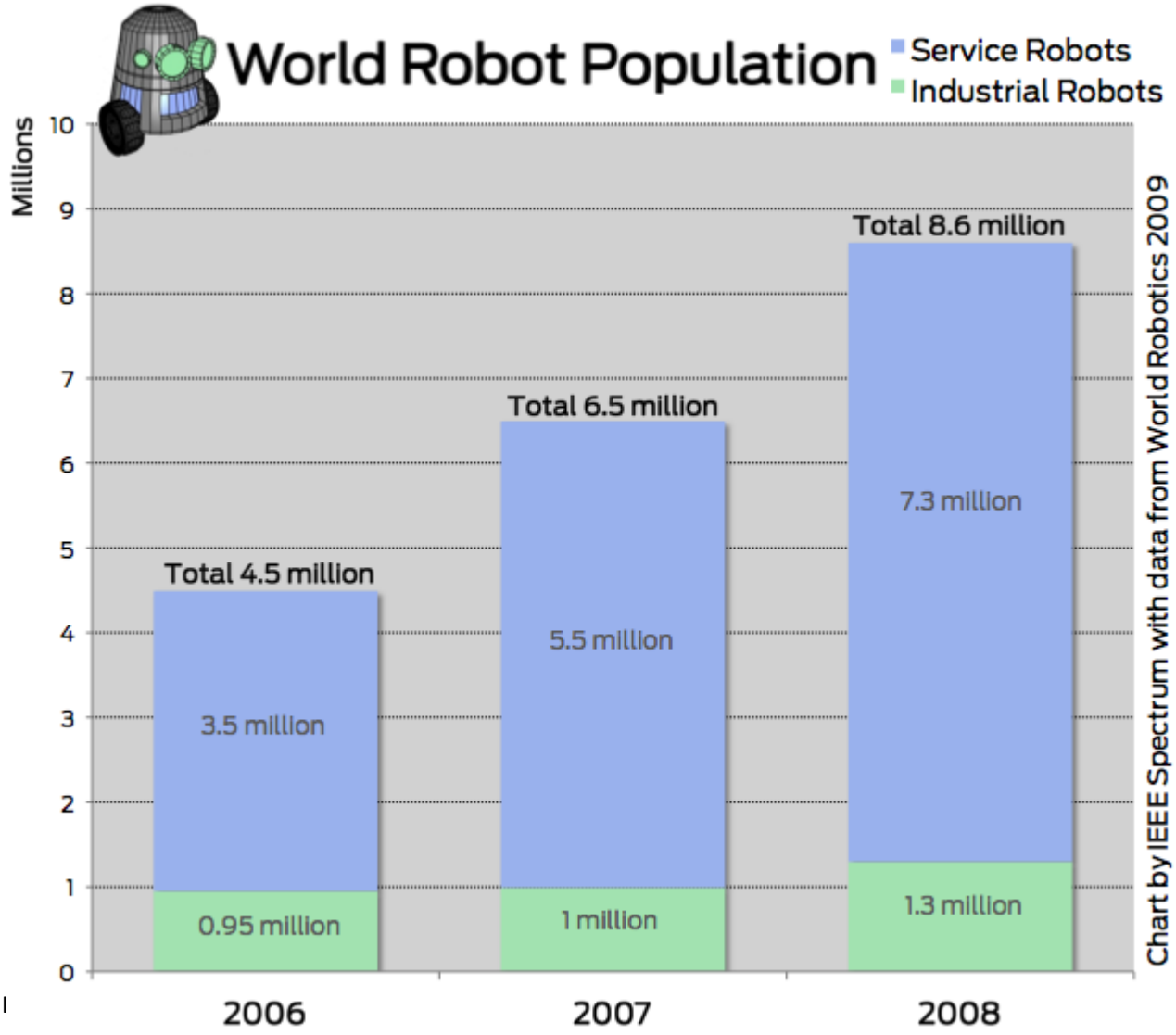
Industrial Robots

- The most extensive use of “real” robots are in the industry: factories.
- These robots are fixed in place – making their operations easy to automate. They are also 3D!

Out of the Factories

- Real robotic applications started prominently in the factories.
- But, that has changed. Robots are going in every places … including our homes.
  - Can you think of some applications for robots?

World Robot Population



Let’s get started by knowing the main terms …

WHAT IS A ROBOT?

The Definition

- The term “Robot” has different definitions from different sources. There is no one definition that satisfies everyone.
- This is the definition from “The Robotics Primer”, Maja J Mataric:

  A robot is an autonomous system (agent) which exists in the physical world, that can sense its environment (including its own internal state) and act on its environment to achieve some goals.

Machines vs Robots

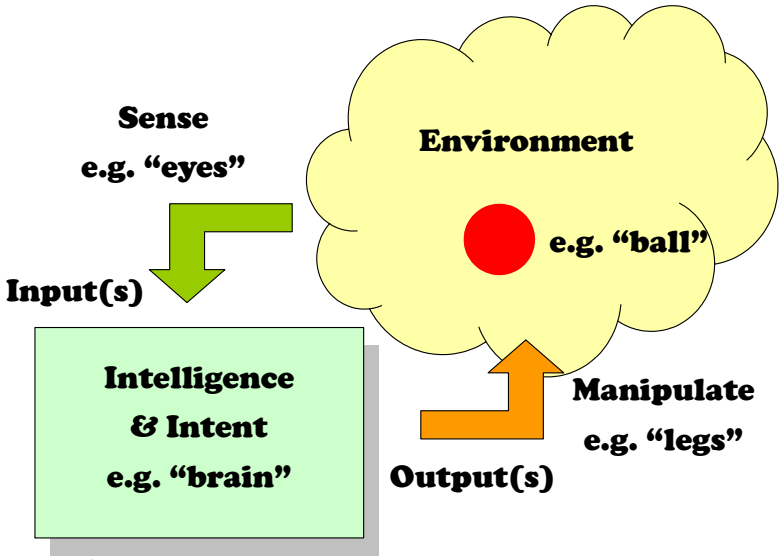
- Definition of terms are not unified, changing and getting overlap.
  - Is sewing machine a robot?
  - Is bicycle a machine?
  - Is car a machine? Is it a robot?
  - Is computer a machine? Is it a robot?
- What do you think?

Autonomous Embodied Agent

- For this course, a **robot** is an **Autonomous Embodied Agent**.
- **Embodied**: it has body, i.e. in physical form.
- **Autonomous**: to be independent, free of constraints, able to act on ones own initiative. No remote control (if fully autonomous).
- **Agent**: anything that can be viewed as perceiving its environment through sensors and acting upon the environment through effectors.
- **Autonomous Agent**: an agent that while working on behalf of someone else, makes decision on its own, guided by feedback from its sensors.

Properties of Robots

- Robots will usually have the following properties:
  - Can **sense** its environment, i.e. have inputs
  - Can **manipulate** things in its environment, i.e. have outputs
  - Have some degree of **intelligent** - programmed by human
  - Appear to have **intent** or **agency**, i.e. they have their purpose

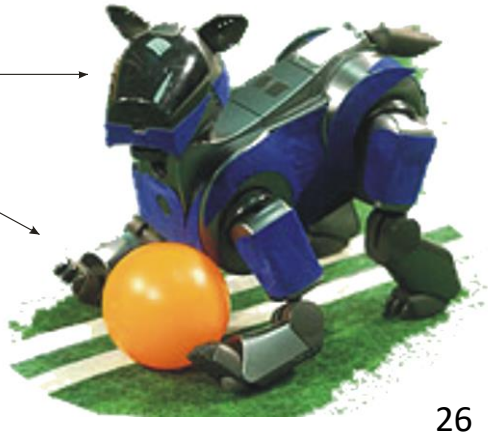


"Brain" for the intelligence
"Intent" to win the game

"Eyes" to sense the ball

"Legs" to manipulate the ball

Human made!



FIELDS OF STUDY RELATED TO ROBOTICS

Major Field of Study

- **Control Theory**
  - Automated control of an artificial system: E.g. adjust some inputs (e.g. heat) to maintain some outputs (e.g. temperature).
- **Cybernetics**
  - Study of the control of artificial systems based on understanding of systems in nature (e.g. biological): E.g. humanoid robots.
- **Artificial Intelligence**
  - When machines trying to be smart? E.g. winning a Chess game with a human.

Robotics: All-in-1 Solution

- The term "**Robotics**" refers to the science and technology of robots: their design, manufacture and applications.
- Robotics is a **fusion** of a wide variety of science and technologies encompassing mechanical, electronics, control, instrumentation, communication, information, internet, artificial intelligence, audio and visual, embedded systems, and many more including non-technical aspects such as psychology and art.
- This not only makes Robotic very **interesting**, but also makes robotic a **versatile** solution to wide variety of problems.

Robots can be categorized by different characteristics.

TYPES OF ROBOTS

Modes of Operation

- Not all robots are “fully” autonomous.
  - E.g. robots that are remotely controlled.
- A robot can be **autonomous** or **manipulators**.
  - **Autonomous** robots are robots that can act on their own without human intervention, while **manipulators** are manipulated or controlled by human (with some degree of autonomy).
- **Teleoperated** robots are robots controlled by a human in a remote location.
- **Augmenting** robots are connected directly to the human’s body, and controlled by human movements.
- Depending on the definition adapted, manipulators may not be considered as robots.

Asimo: autonomous

Kuratas: manipulated

Areas of Application

- Industrial robots
- Domestic robots, personal robots
- Medical robots
- Service robots
- Military robots
- Entertainment robots
- Space robots
- Hobby and competition robots

Fields of Operation

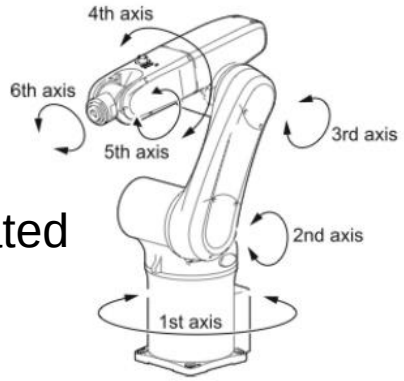
- **Stationary** robots are fixed in one place and cannot move.
- **Ground** robots operate on the ground surface.
- **Underwater** robots, often called Autonomous Underwater Vehicles (AUV), operate underwater.
- **Aerial** robots, often called Unmanned Aerial Vehicles fly in the air.
- **Microgravity** robots operate in low-gravity environments, such as earth orbit.

Mobile Robots

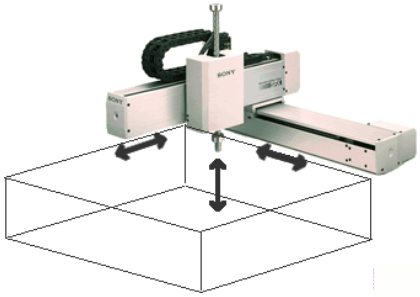
- They can move. Often used to refer to ground robots.
- Robots can be categorized by its mode of **movements** (locomotion):
  - **Wheeled** robots: single wheel, two-wheeled, more wheels.
  - **Tracked** robots
  - **Rolling** robots
  - **Legged**, or walking robots: bipedal (humanoid), tripedal, quadrupedal, hexapod, more legs.
  - **Swimming** robots.
  - **Flying** robots.

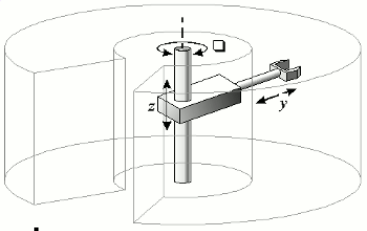
Industrial Robots

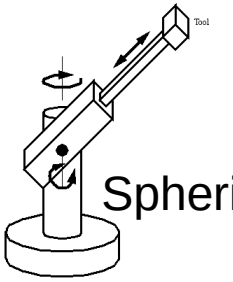
- They are mainly stationary robots.
- They are categorized by the design of their **moving** parts:
  - **Articulated**: with joints and links similar to an arm.
  - **Cartesian**: with linear movements similar to gantry.
  - **Cylindrical**: with rotary joint at the base.
  - **Polar** or **spherical**
  - **SCARA**
  - **Parallel**: e.g. delta.



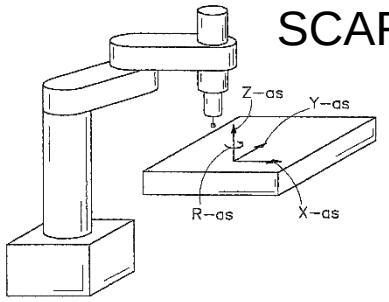
Articulated


Cartesian


Cylindrical


Spherical


Delta



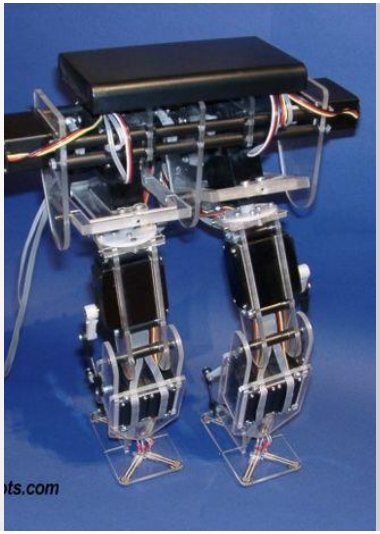
SCARA

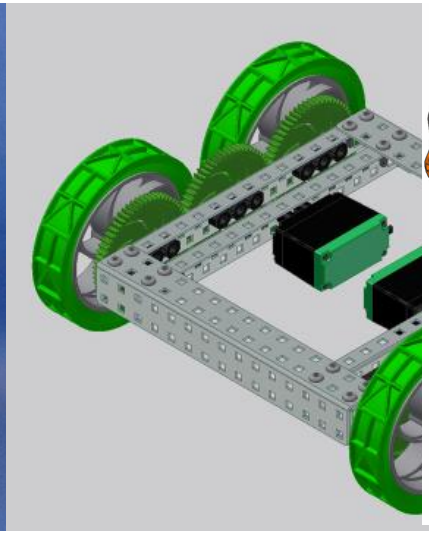
We will end this lecture with knowing what are involved in making of the robots

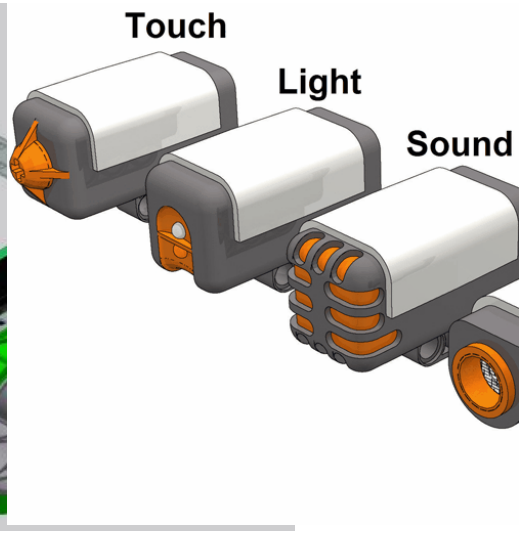
THE COMPONENTS OF ROBOTS

Components of Robots

- **Controller** (control, intelligence | analogy: brain) – Computing
- **Body** (mechanical construct) – Mechanical
- **Actuators**, **effectors** (mechanism and drive train | analogy: limbs, mouth, skin) – Mechanical, Electronics
- **Sensors** (perception| analogy: eyes, ears, skin) – Electronics, Mechanical
- **Power Source** (battery | analogy: food) – Electronics







Intangible Components

- **Arts**
  - Creativity in making a robot fun and appealing in its look is an important skill to mention. Robotics can be an art too.
- **Behavioral**
  - Communication ability
  - Understanding of human emotion while interacting with human
  - Expression of emotion while interacting with human
- **Safety**

Interesting Robots

Reading List

- A Robot in Every Home by Bill Gates on Scientific American
- On history of robotics:
  - RobotShop: http://www.robotshop.com/content/PDF/timeline.pdf.
  - MegaGiant Robotics: http://robotics.megagiant.com/history.html.
  - Science Kids: http://www.sciencekids.co.nz/sciencefacts/technology/historyofrobotics.html.
  - Industry tap: http://www.industrytap.com/brief-history-robots/29235.

To Do List

- Give two examples of something that you are doing, and that you think is:
  - **Dull** (give two examples)
  - **Dirty** (give two examples)
  - **Dangerous** (give two examples)
- Is there existing robot that can perform each of the above example tasks?
  - Find out and state.
- State five remarkable robotic achievements between 2011 to 2015.

Summary

- A **robot** is an autonomous system (agent) which exists in the physical world, that can sense its environment (including its own internal state) and act on its environment to achieve some goals.
- Robots have been bring to fame by many sci-fi **movies**.
- Robots **integrate multiple technologies** to make it highly potential to become useful in real physical.
- They are already delivering their potential in many **real applications**: especially in the industry.
- Robotic applications have extended beyond the industry and gone into our **personal living domain**.
- There are various **types** and **designs** of robots.
- Robot **components**: controller (brain), body, actuators & effectors (limbs, etc), sensors (eyes, etc), power source (food).