AUTONOMY IN ROBOTICS

Seneca

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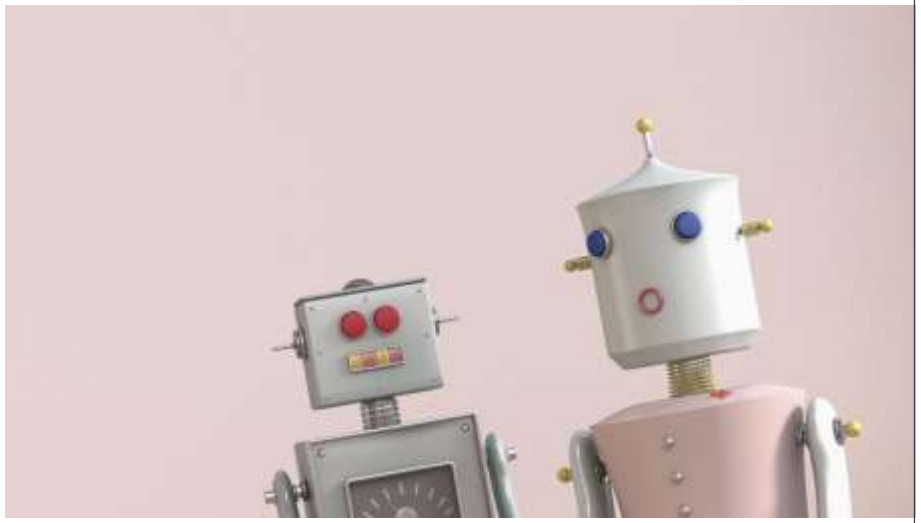
Summer 2022



Safety First

Circuit Breakers and Fuses

Reset circuit breaker to return electrical system to normal operation

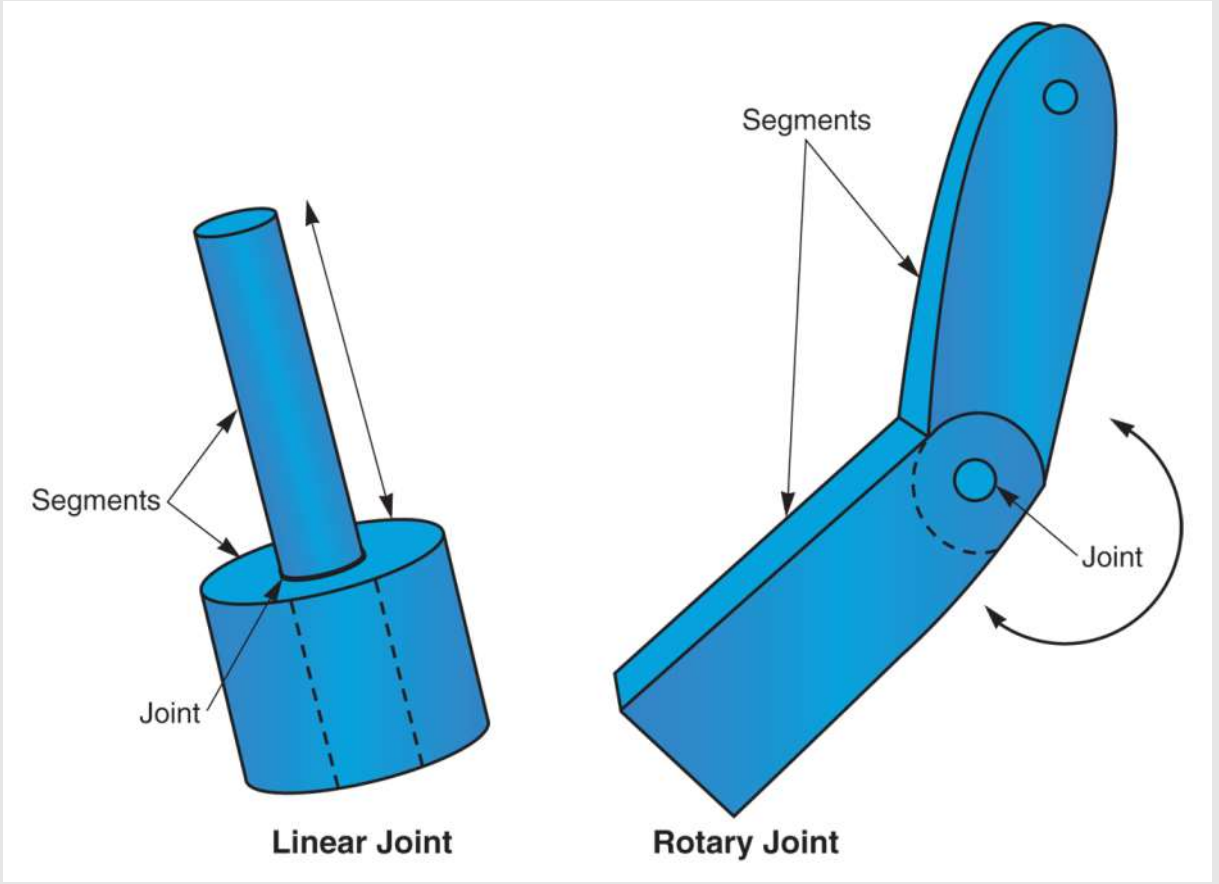
- Fuse provides overload protection in electrical systems
- Element inside melts, interrupts flow of current

General Safety Guidelines

- Research characteristics of robot used
- Work station design allows safe operation
- Control panels outside work envelope
- Interlock access to controller

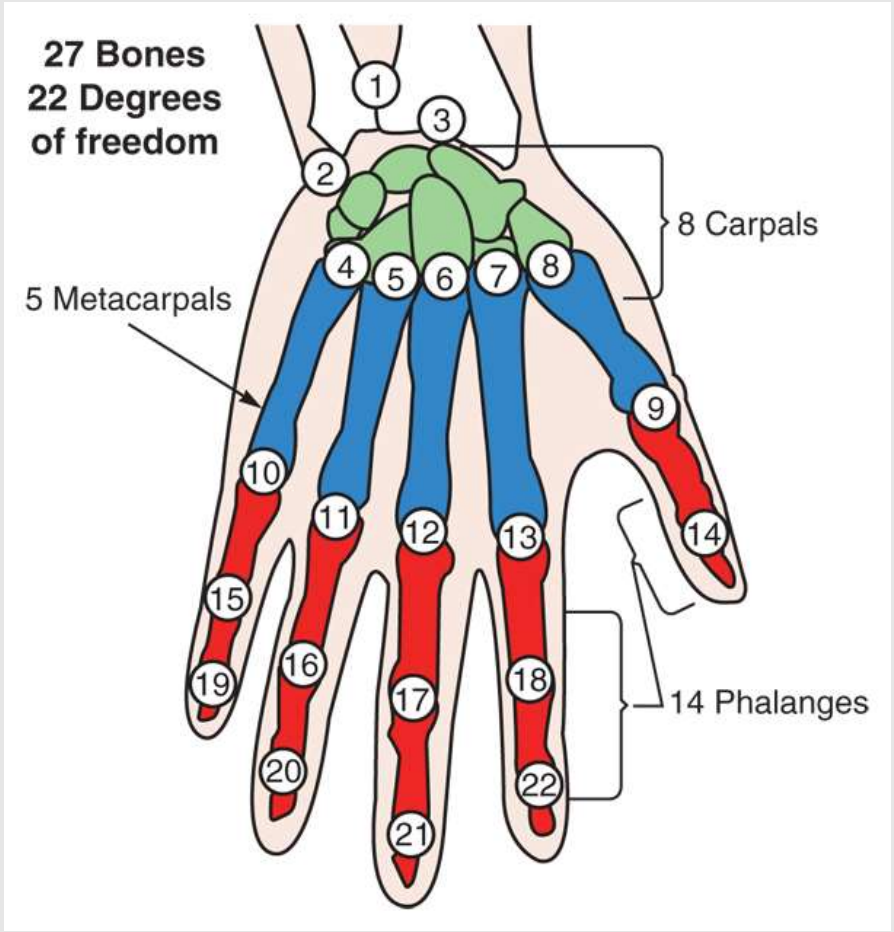
Manipulator

- Joints provide linear or rotary movement



Degrees of Freedom

- Robot dexterity does not compare to a human

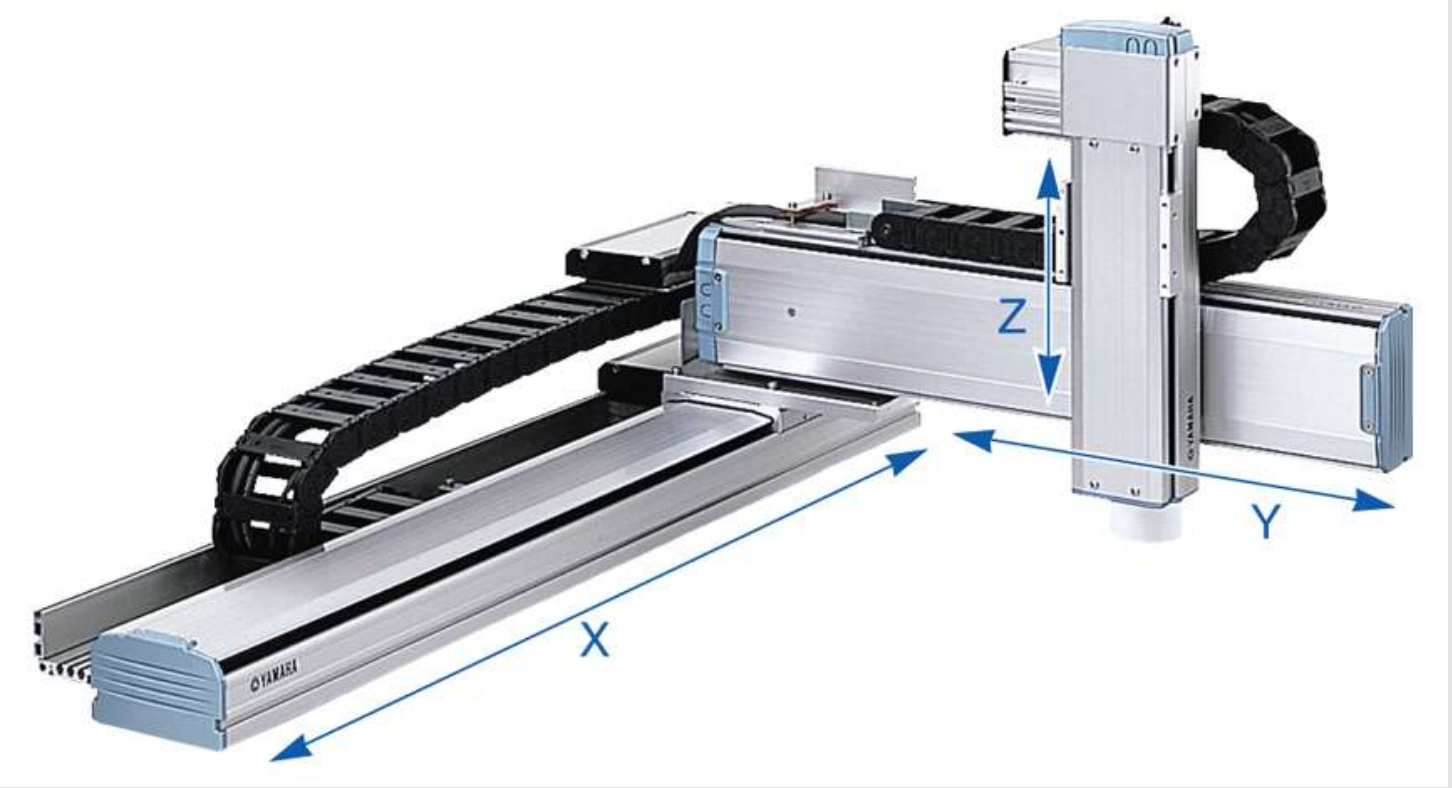


Revolute Configuration

- Five revolute joints in vertically articulated configuration

Cartesian Configuration

- Arm movement along three intersecting perpendicular lines



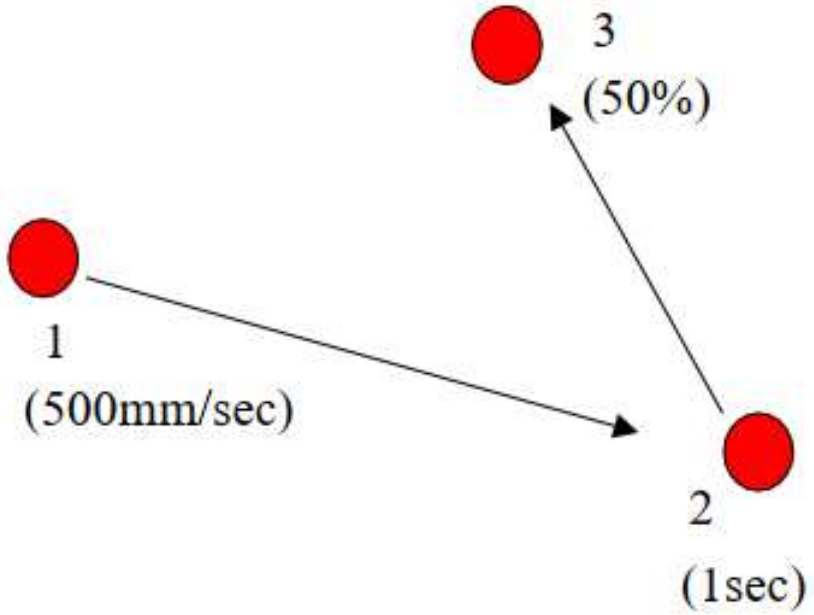
Speed Control

The point speed has a few different options.

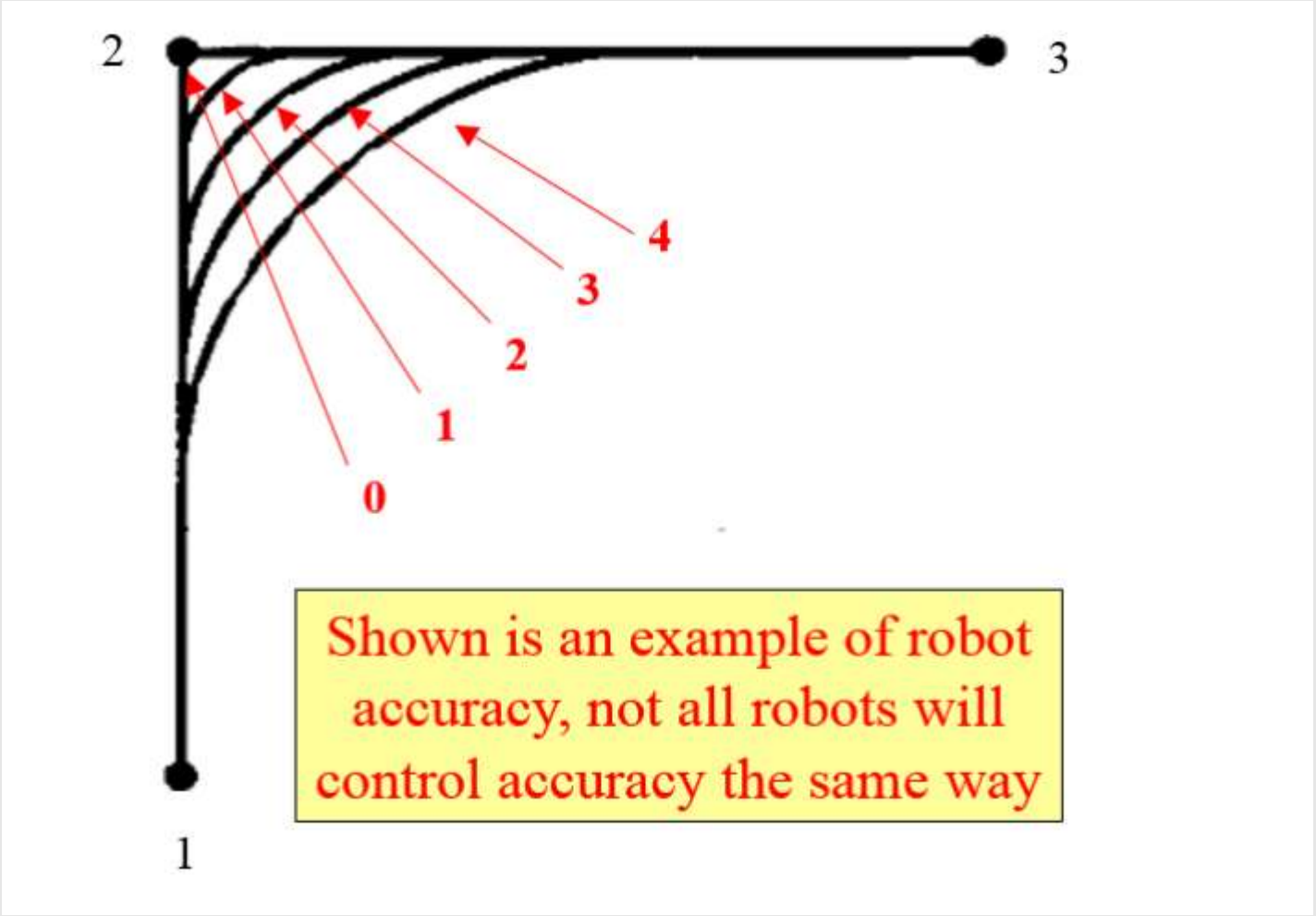
Distance / Time: the robot will travel so far in so much time. (500mm/sec)

Time: The robot will take a preset amount of time to move to the next point. (1sec)

Percentage: The robot will move at a percentage of full speed to the next point. (50%)

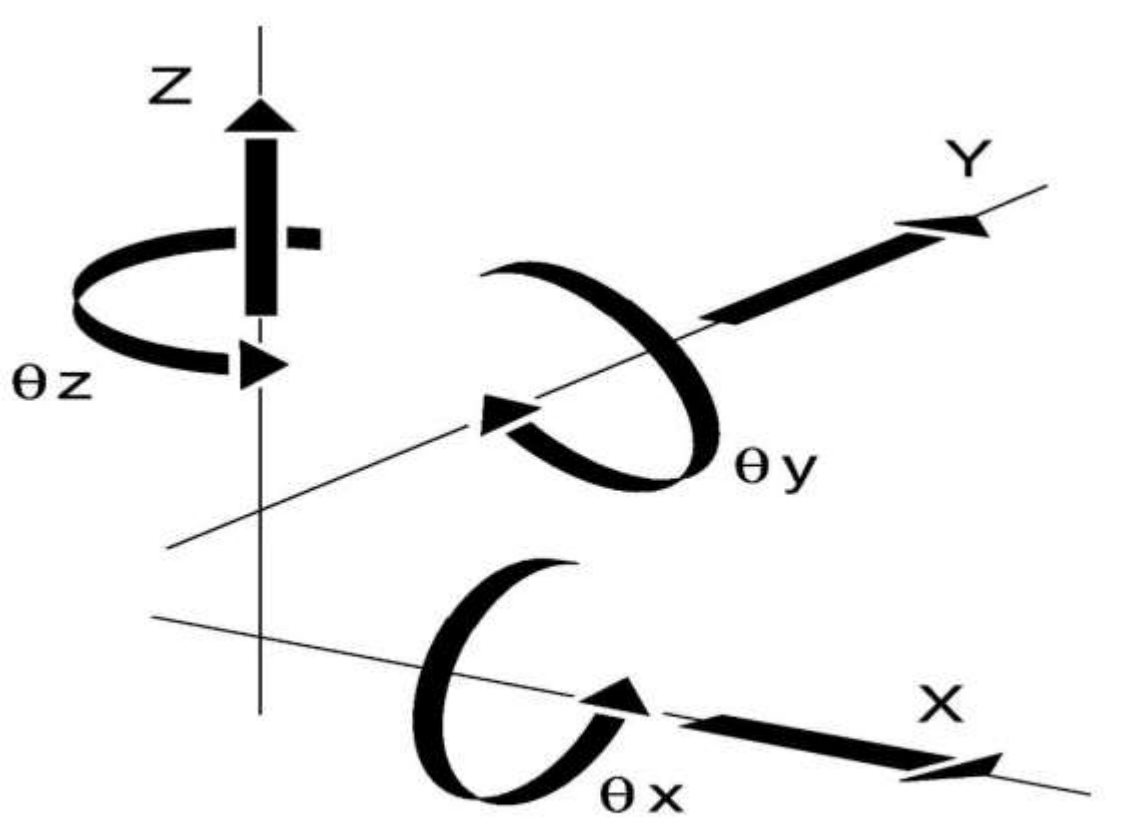


Accuracy


2
3
4
3
2
1
0
1
Shown is an example of robot accuracy, not all robots will control accuracy the same way

Degrees of Freedom

Degrees of Freedom allow the motion of a robot in each axis.

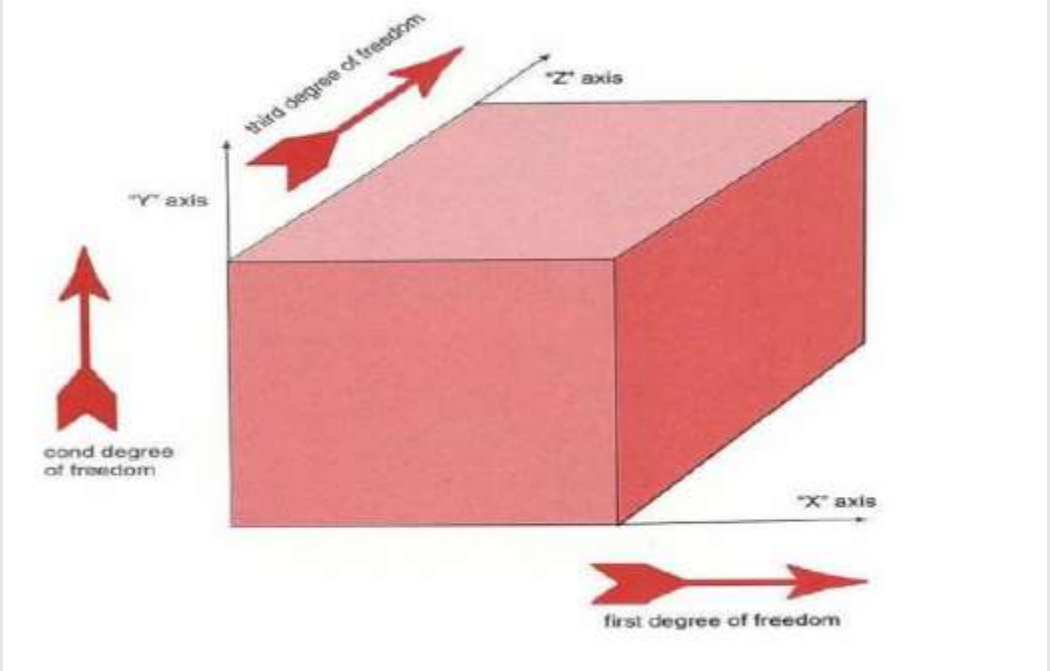


Axis of motion (Linear and Rotational)

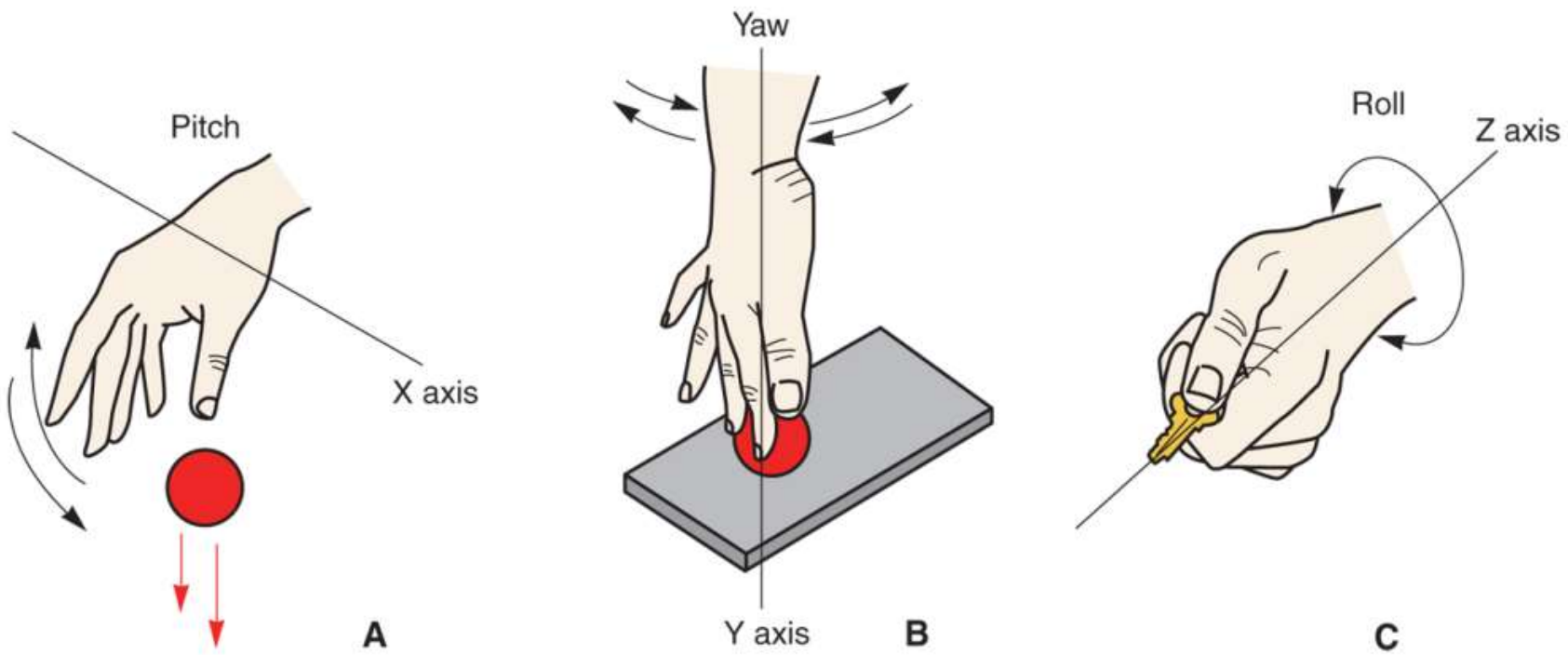
Axes of Motion – Degrees of Freedom

Linear (Cartesian)
- X-axis
- Y-axis
- Z-axis

Angular (Rotation)
- About X-axis
- About Y-axis
- About Z-axis

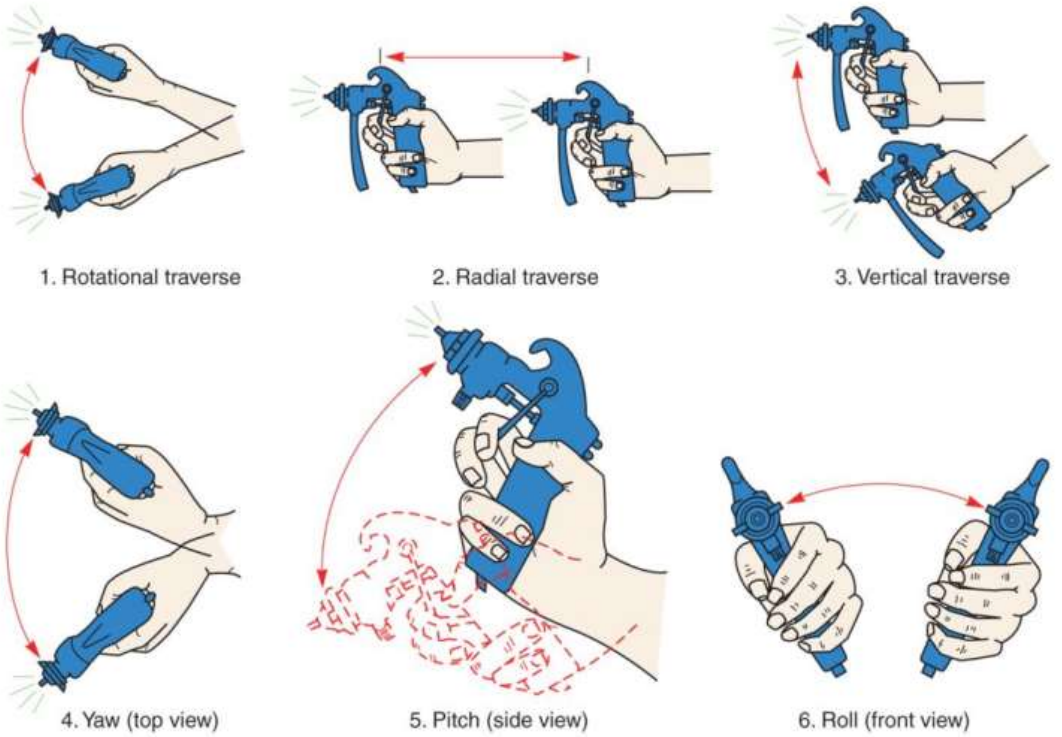


Degrees of Freedom - Rotation



Degrees of Freedom

Wrist and arm movements for degrees of freedom



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What is Autonomy?

- In general, autonomy is the ability to make one's own decisions and act on them.
- In robotics, autonomy is to take an appropriate action bases on a given situation.
- Autonomy can be **complete** or **partial** (tele-operated robots).

Components of Autonomous Robotics

Sensors

- Physical device that provides information about the world
- Sensing is sampling the environment to understand and **perceive** it. This process is commonly referred to as **perception**.

$$a_x$$

$$v = \int a_x dt$$

$$x + \Delta x = \int v dt = \int \int a_x dt = \int \int (a_x + \delta) dt$$

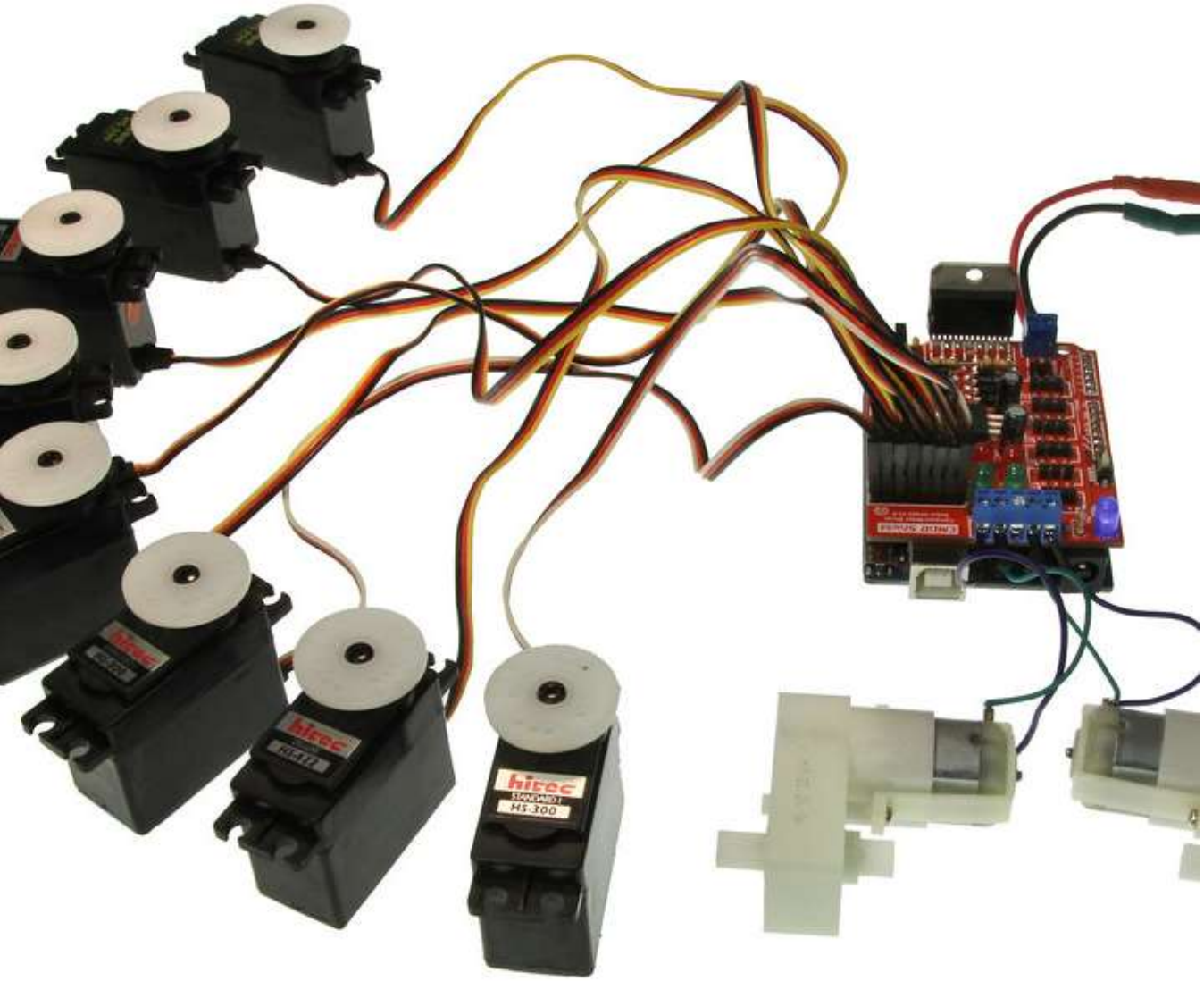
* A

$v_0 = 0$

$x_0 = 0$

* B

$x_b = ?$



Components of Autonomous Robotics

Effectors

- Any device on the robot that have an impact on the environment.

Actuators

- A mechanism that enables the effector to execute an action. They are used for locomotion and manipulation.

Components of Autonomous Robotics

Control

- The regulation of the behavior of a system to make it perform as desired.
- Controllers enable robots to be autonomous.

Components of Autonomous Robotics

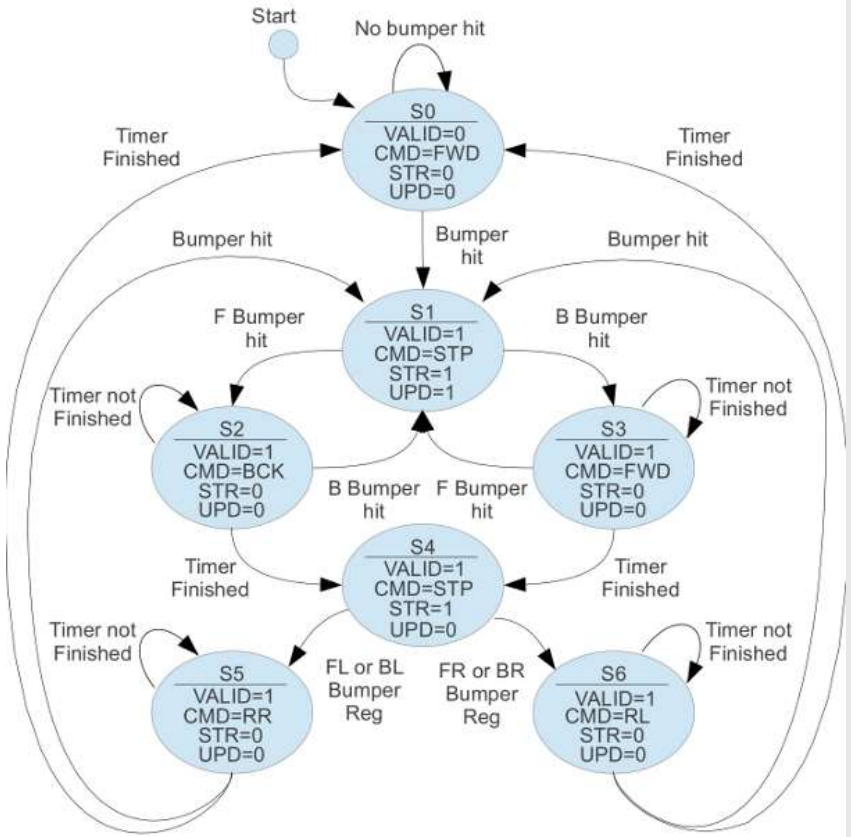
System

- A group of interacting items that form a unified whole.

Components of Autonomous Robotics

Agent

- Any system which can be viewed as perceiving its environment through **sensors** and acting upon it through **effectors**.



Obstacle avoidance: if the robot hits an obstacle it will stop, move away from the obstacle, turn 90 degrees, so that it faces away from the obstacle and then continue moving forwards.

VALID = obstacle avoidance active
CMD = Movement Command
STR = Start Timer
UPD = Bumper Reg Update

FL = Front left bumper
FR = Front right bumper
BL = Back left bumper
BR = Back right bumper
F = Front middle bumper or FL or FR
B = Back middle bumper or BL or BR

STP = Stop = 0
FWD = Forwards = 1
BCK = Backwards = 2
RR = Rotate right = 3
RL = Rotate left = 4
TR = Turn right = 5
TL = Turn left = 6
BRK = Break = 7

Components of Autonomous Robotics

State

- State is a description of the robot (of a system in general) and its environment.
- Sates in a robot can be:
  - Observable: the robot knows its state entirely
  - Partially Observable: the robot only known a part of its state
  - Hidden: the robot does not have any access to its state
  - Discrete: up, down, …
  - Continuous: speed

Autonomy in Robotics

Levels of Autonomy

- Level 0: Not autonomous at all; driver has sole control of the vehicle.
- Level 1: A single function is automated, but does not necessarily use information about the driving environment. A car operating under simple cruise control would qualify as Level 1.
- Level 2: Acceleration, deceleration and steering are automated, and use sensory input from the environment to make decisions. Modern cars that have cruise control and automated lane maintenance or collision-avoidance braking would fall into this category. The driver is still ultimately responsible for the safe operation of the car.

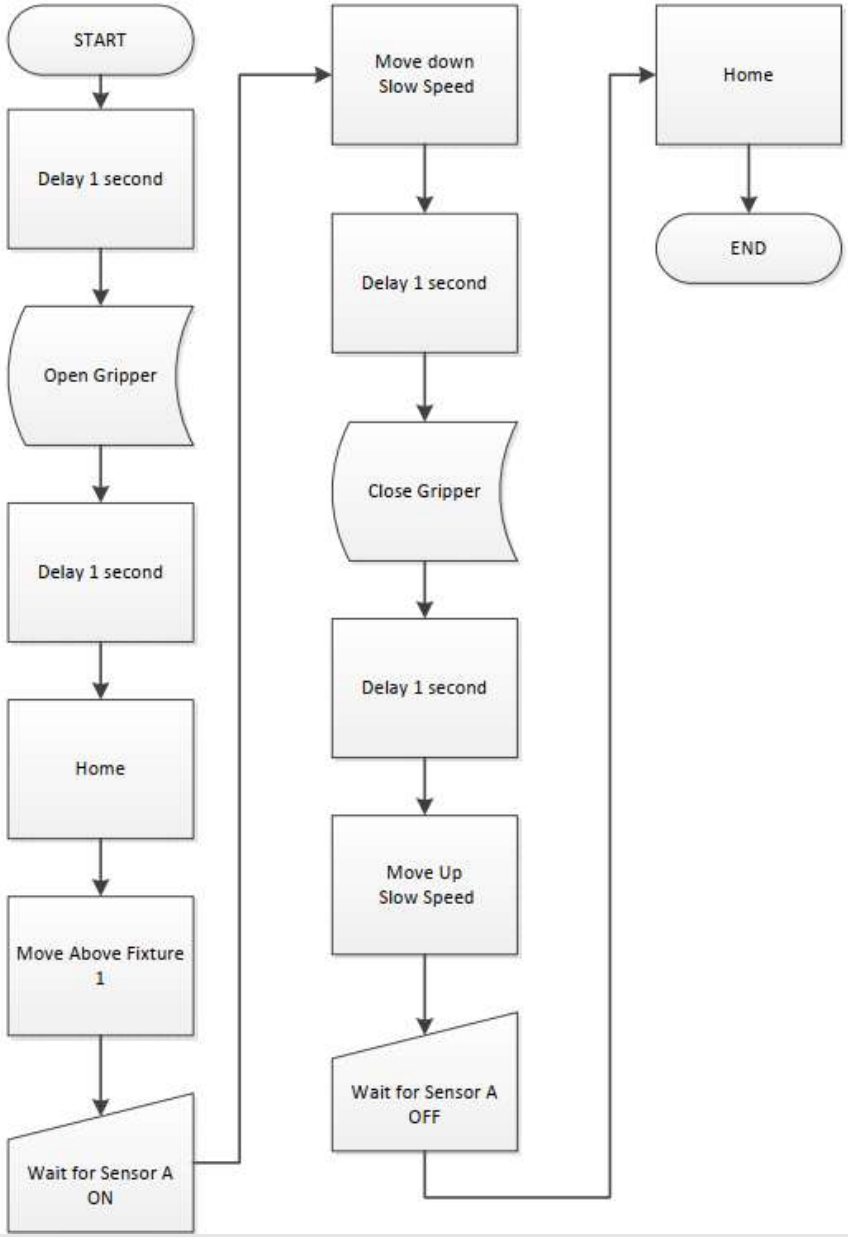
Autonomy in Robotics

Levels of Autonomy

- Level 3: In this level, all safety functions are automated, but the driver is still needed to take over in an emergency that the car can't handle.
- Level 4 and 5: These are the fully autonomous levels, where the car handles all driving decisions with no input from a human at all. The difference is that Level 4 cars are limited to a specific set of driving scenarios, such as city, suburban and highway driving, whereas Level 5 cars can handle any driving scenario, including off-road operation.
- https://www.sae.org/standards/content/j3016_202104/

AUTONOMOUS ROBOTICS EXAMPLES

AUTONOMOUS ROBOTICS EXAMPLES



Flow Chart Example for a program that starts at the home position, picks up a block from fixture 1 and returns to the home position.

Use this symbol if you need to break your flowchart across pages.