Basic Robotics Course

Class 1 - Introduction

Course’s goal

- Teach robotics to people who are not from computer-related areas of knowledge. That is beginners in programming or the general functioning of computers and robots.
  - People that probably won’t make robots.

Why a robotics course to people that won’t make robots?

Robots in Industry

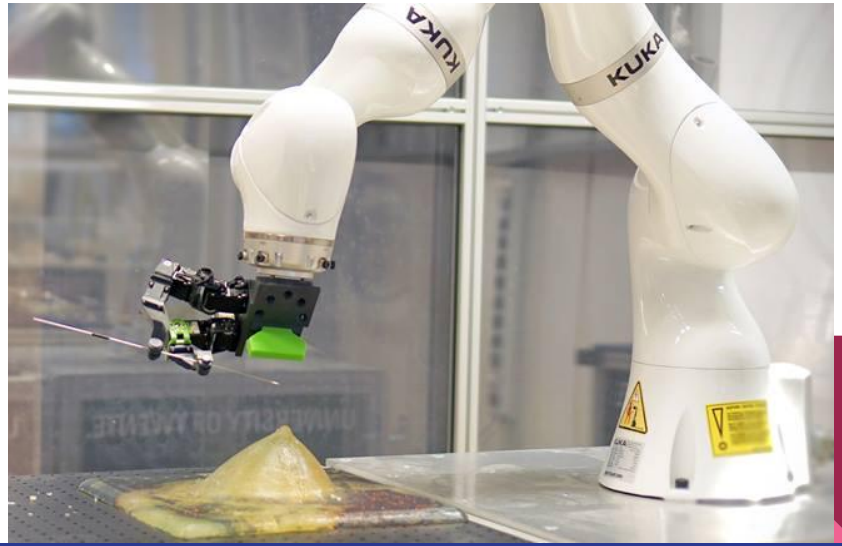
FANUC (Japan) robots at AUDI Hungary

Medical Robots

Surgical Robot
da Vinci (USA)

Exoskeleton
Gogoa (Spain)

Biopsy Robot
MURAB (NLD, ITA, DEU and AUT),
robotic arm of KUKA (DEU)



Robots on Agriculture

Robotic Weeder
ecorobotix (Netherlands)

Mapping Drone
DroneBee (Italy)

Autonomous Pulverizer
Jacto (Brazil)

Robots on Construction

House 3D Printer
WinSun (China)

Mapping Drone
The Bionic Eye (UK)

Brick-layer Robot
FastBrick Robotics (Australia)

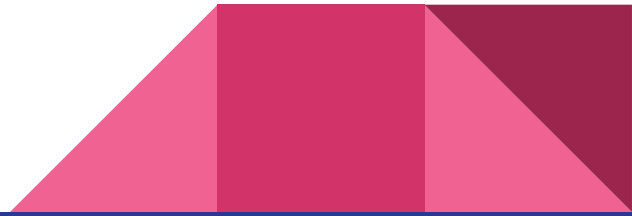
Course’s goal

- Teach robotics to people that probably won’t build robots;
- BUT probably will use them to make their works more efficient

What is a Robot?

Robot

What do you think when we talk about robots?



Robot

What do you think when we talk about robots?

Robot Definition

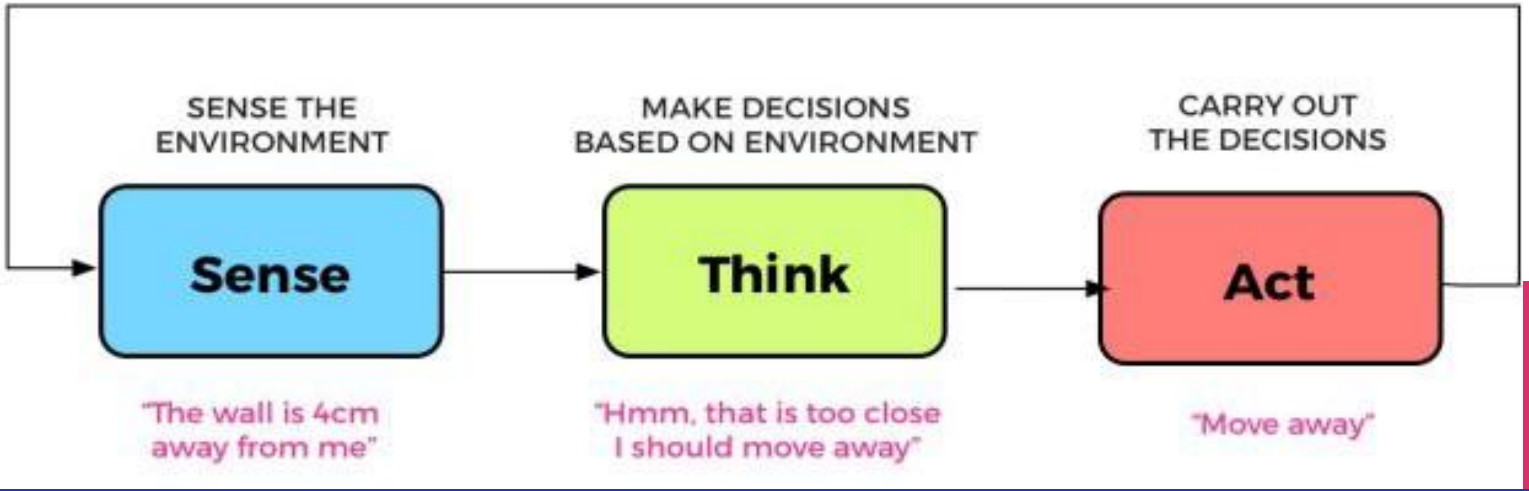
- “A machine controlled by a computer that is used to perform jobs automatically” (Cambridge Dictionary)
  - Is a printer a robot?
- “Actuated mechanism programmable in two or more axes with a degree of autonomy, moving within its environment, to perform intended tasks” (ISO 8373:2012)
  - Autonomy is defined as the ability to perform intended tasks based on current state and sensing, without human intervention.

Robot Definition

- “A robot is an autonomous machine capable of sensing its environment, carrying out computations to make decisions, and performing actions in the real world.” (IEEE)
  - Is an elevator a robot?

Robotic Paradigm

- Sense the environment
- Carrying out computations to make decisions
- Performing actions

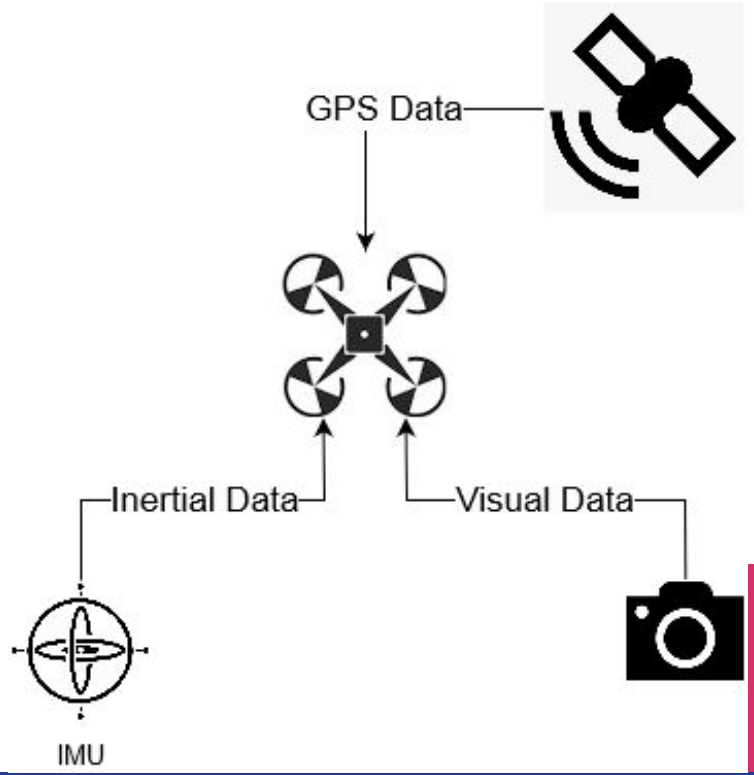


Example: Moving a drone to a position

1. You send a signal with the desired position (waypoint) by radio.

Example: Moving a drone to a position

2. The drone receives data from its sensors

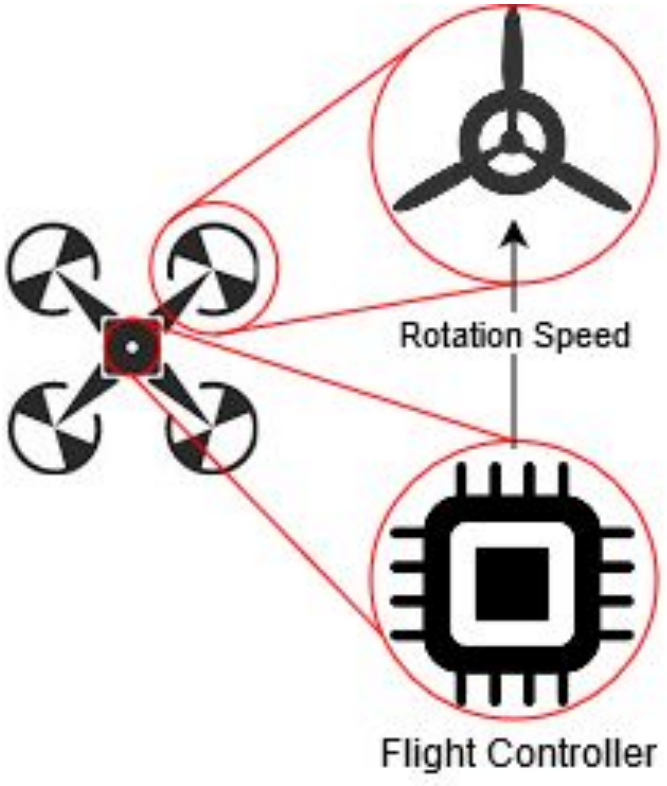


Example: Moving a drone to a position

3. The flight controller makes the sensor fusion (if necessary) and makes a decision based on the current state of the drone and the desired position.
    a. How far is the drone from the target?
    b. What velocities to adopt?
    c. How to control each propeller to make it?

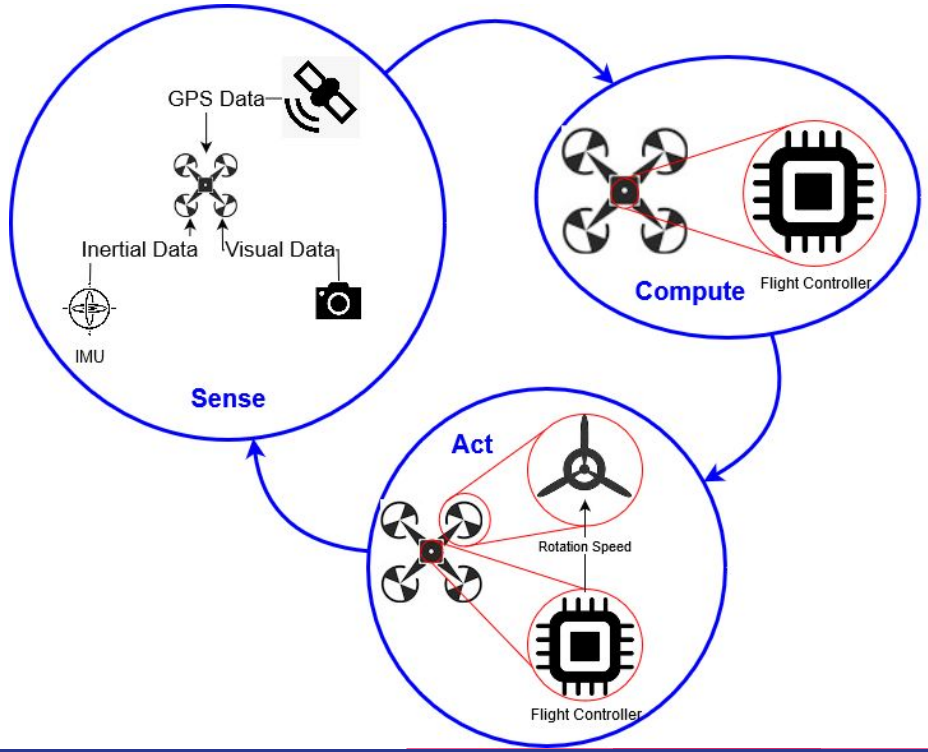
Example: Moving a drone to a position

4. The flight controller sends commands to each propeller.



Example: Moving a drone to a position

5. The cycle of sensing, computing, and acting continues.



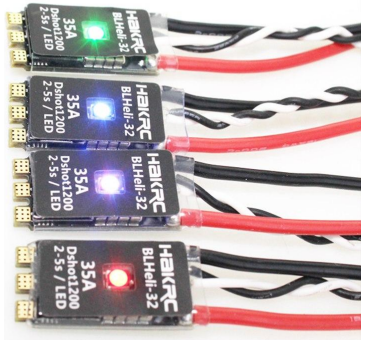
By the way, we'll focus on quadcopter drones

The parts of a typical quadcopter

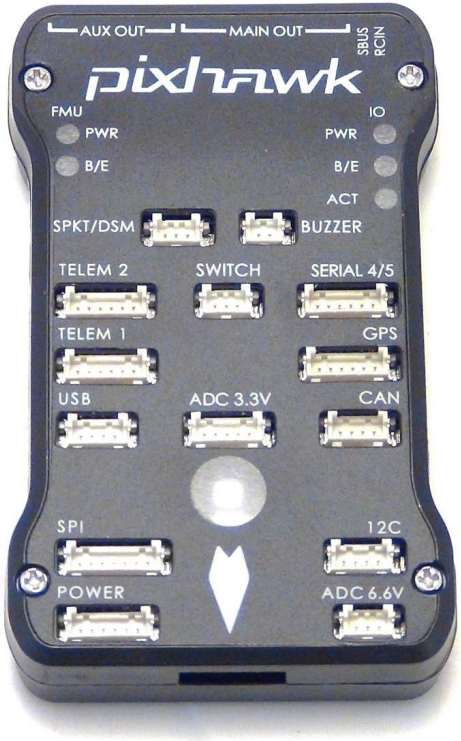
- Frame
  - The mechanical structure of the drone.
  - Support to motors, electronics, and structure to land safely.

The parts of a typical quadcopter

- Actuators.
  - Brushless Motors.
  - Propellers.
- ESCs (Electronic Speed Controller).



The parts of a typical quadcopter



- Flight Controller
  - Motors control.
  - Stabilization.
  - Position Control (on more advanced controllers).

The parts of a typical quadcopter

- Radio
  - Communication between drone and the controller (joystick, notebook, smartphone, etc).

The parts of a typical quadcopter

- Sensors
  - IMU (Inertial Measurement Unit) and Barometer.
    - modern Flight Controllers have them embedded.
  - GPS.
  - Camera.

Working Principles

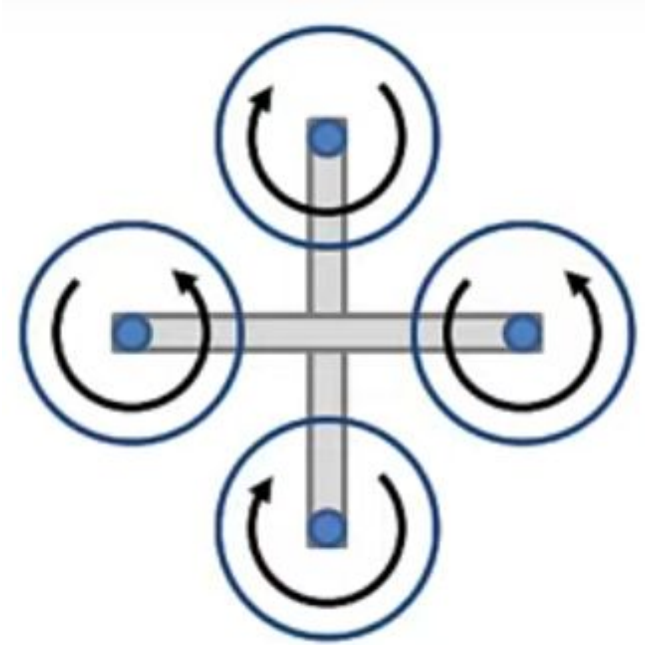
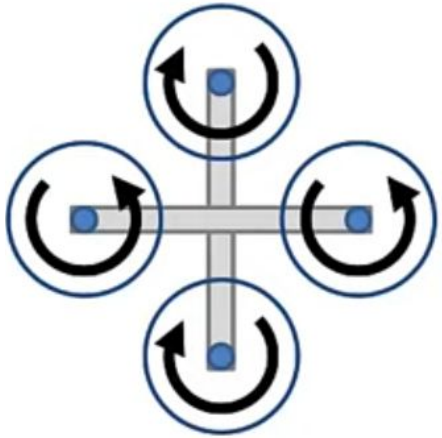


Image from https://youtu.be/-UbKb5Q_qIM

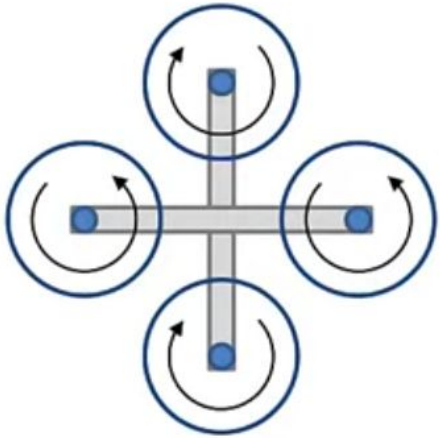
- Two propellers are rotating clockwise and two counterclockwise.
  - They are placed in alternated positions.
- This model is on Plus Configuration (AKA Quad+ or Quad-P).

Working Principles

- We vary all the rotation speeds to make the drone ascend or descent.
- We call this property **Throttle**.



Ascend



Descend

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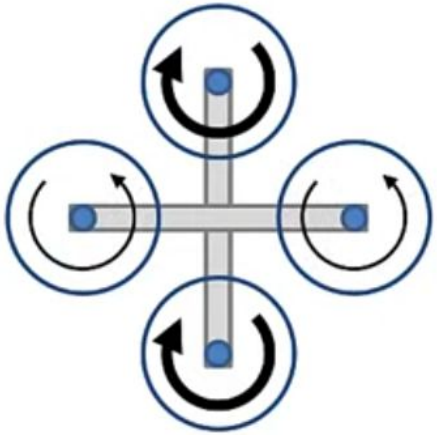
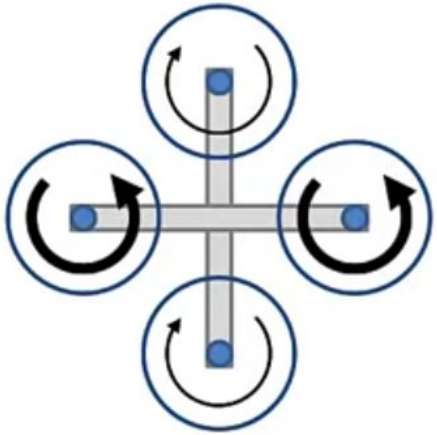
Working Principles

- To rotate the drone without moving it, we rise the rotation speed of the clockwise propellers and reduce the rotation speed of the counterclockwise ones. Or vice-versa.
- This is a movement on the **Yaw** axis.



Turn Left

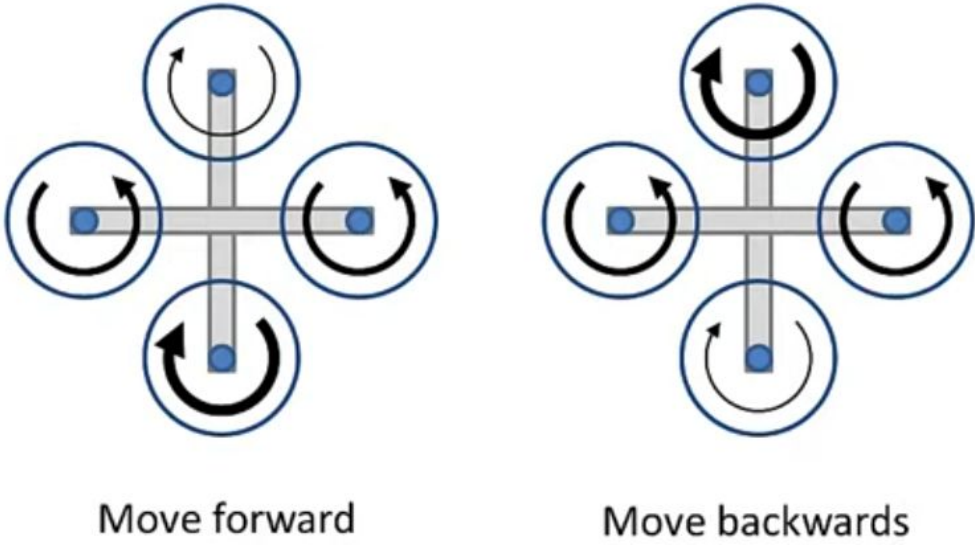


Turn Right

Image from https://youtu.be/-UbKb5Q_qIM

Working Principles

- To move the drone forward or backward, we rise the rotation speed of the front propeller while reducing the rotation speed of the back one. Or vice-versa.
- The drone tilts. We call this a movement on the **Pitch** axis, which makes the drone go forward or backward.



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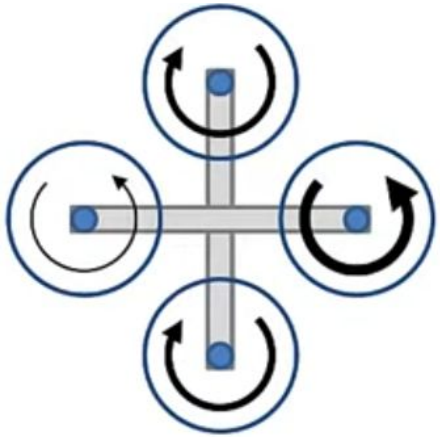
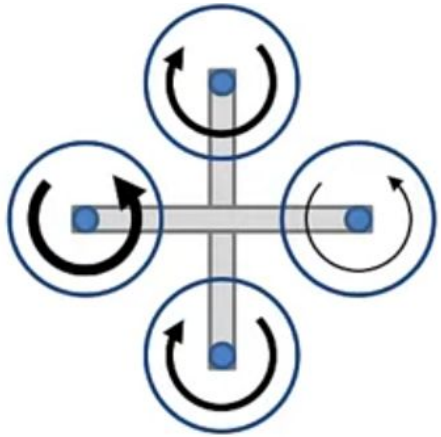
Working Principles

- To move the drone to the left or the right, we rise the rotation speed of the right propeller while reducing the rotation speed of the left one. Or vice-versa.
- The drone tilts. We call this a movement on the **Roll** axis, which makes the drone go left or right.



Move left



Move right

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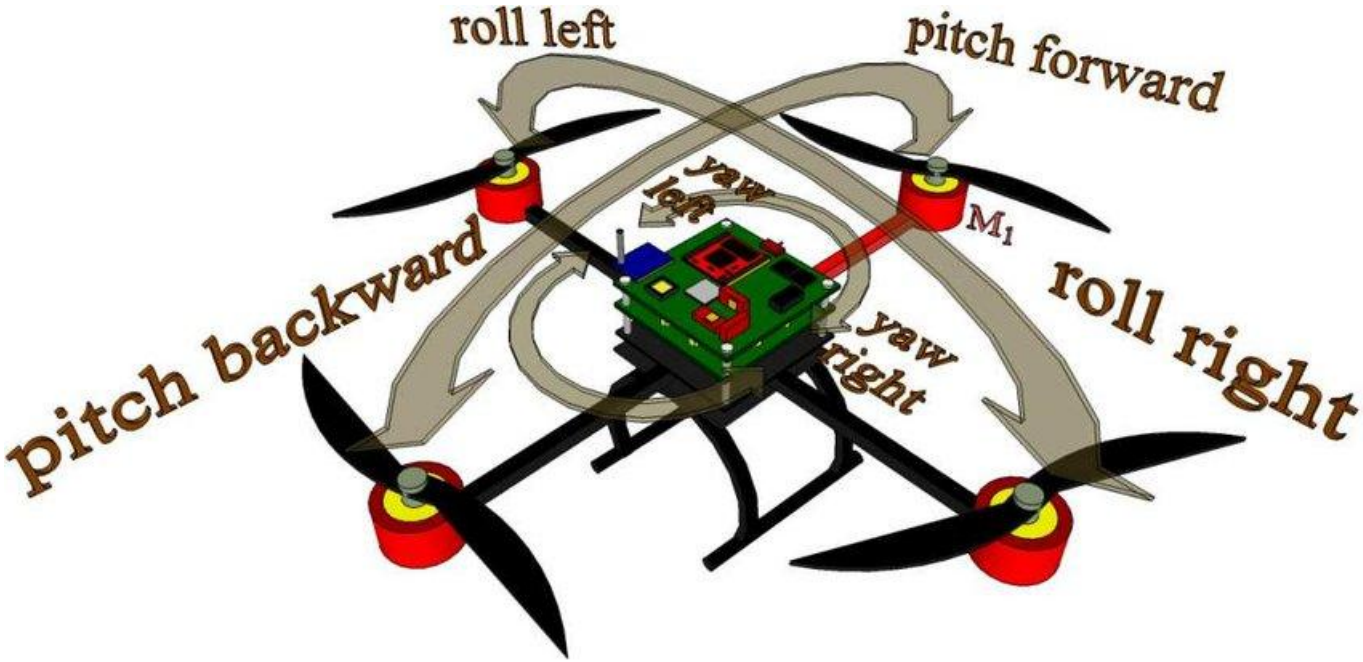
Pitch, Roll and Yaw



Safety

- Drones can cause injuries or patrimonial damage (on the environment or on the drone itself).
- There are safety measures for indoor and outdoor flights.
- There is an adequate drone for each situation.

Indoor Safety

- Maintain the drone distant of walls, ceiling, and floor (the airflow can get in the way).
- Use protections on the propellers.
- Prepare the space to fly (removing furniture and other items).
- Consider the use of safety glasses, gloves, and nets.

Outdoor Safety

- NEVER LOSE VISUAL CONTACT.
- Don’t fly near airports or control towers (is indicated 5 km of distance).
- Don’t fly near people (is indicated 30 m of distance).
- Don’t send the drone higher than 120 m.
- Preferably fly on the day.
- Be aware of the battery level and land the drone before it’s empty.

Battery Safety

- Drones generally use a Lithium Polymer battery.
  - They can explode if not correctly handled.
  - Use a proper LiPo charger.
  - Beware the temperature.
  - The right charge for storage.