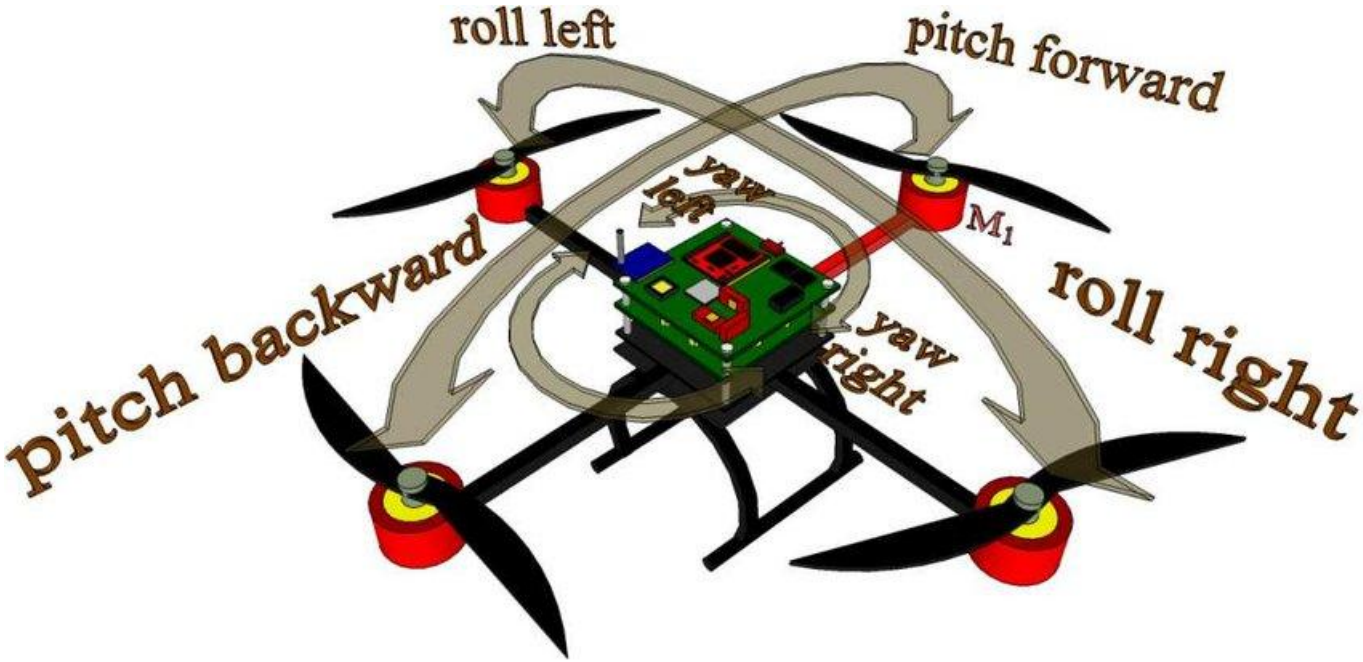
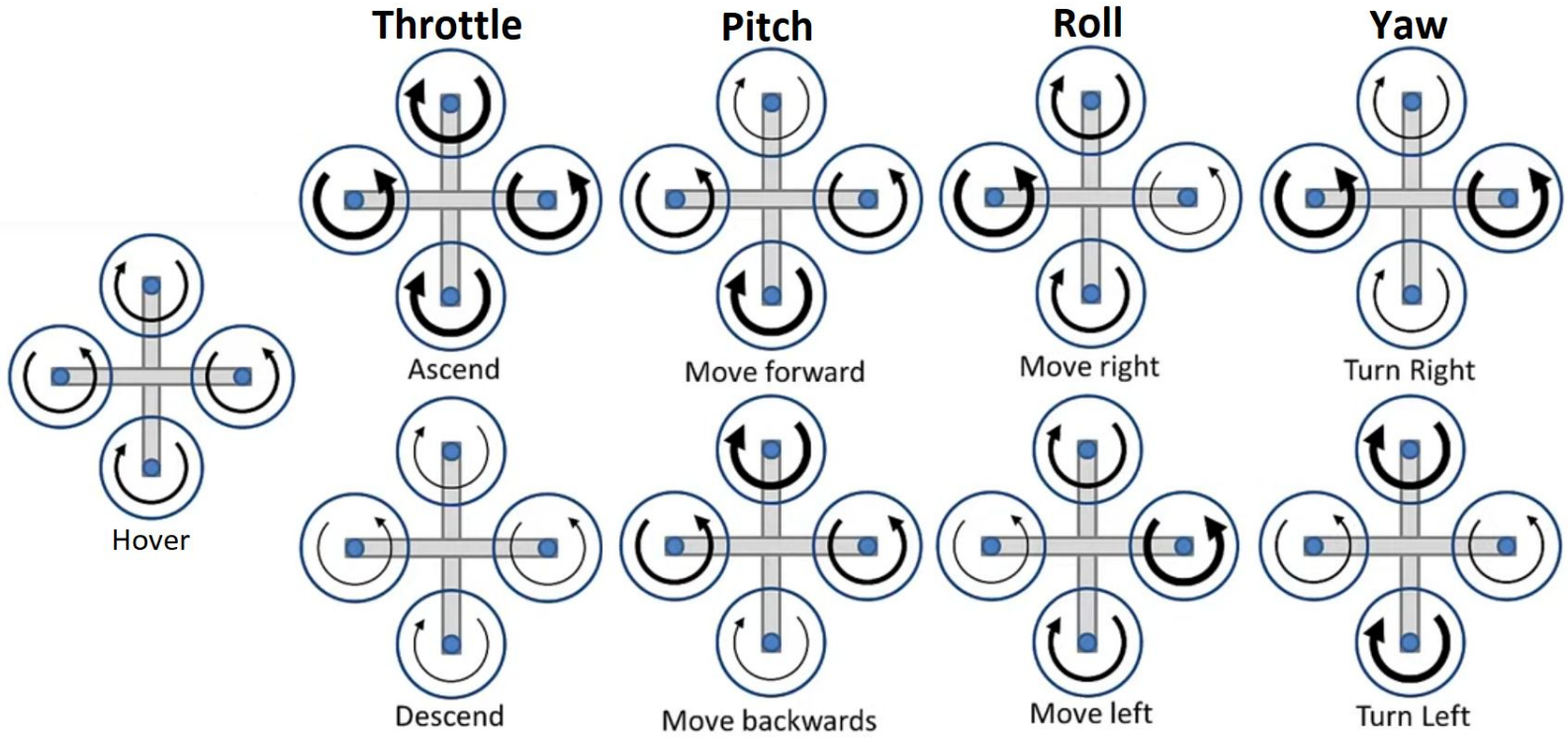
Basic Robotics Course

Class 2 - Quadcopter Parts

Pitch, Roll and Yaw



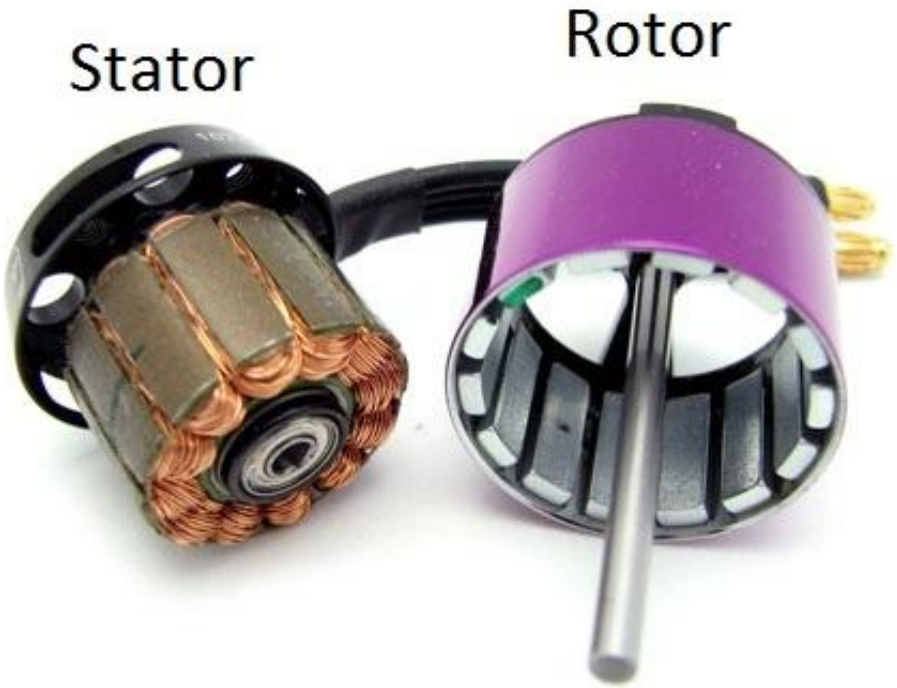
Drone Movements



Brushless Motors

- Direct Current (DC) Motors
- Advantages (compared to Brushed Motors)
  - More efficient.
  - Higher life expectancies and lower maintenance costs.
  - Accelerate and decelerate easier.
  - There is no sparking and less noise.
- Disadvantages (compared to Brushed Motors)
  - More expensive.

Brushless Motors - Inside



- There are permanent magnets on the rotor.
- Applying DC Power to the coils, they become electromagnets.
- These electromagnets interact with the permanent magnets and make the rotor spin.

Brushless Motor - Working

- When energizing a coil, it attracts the rotor to its position.
- By alternating which coil is energized, we make the rotor spin.

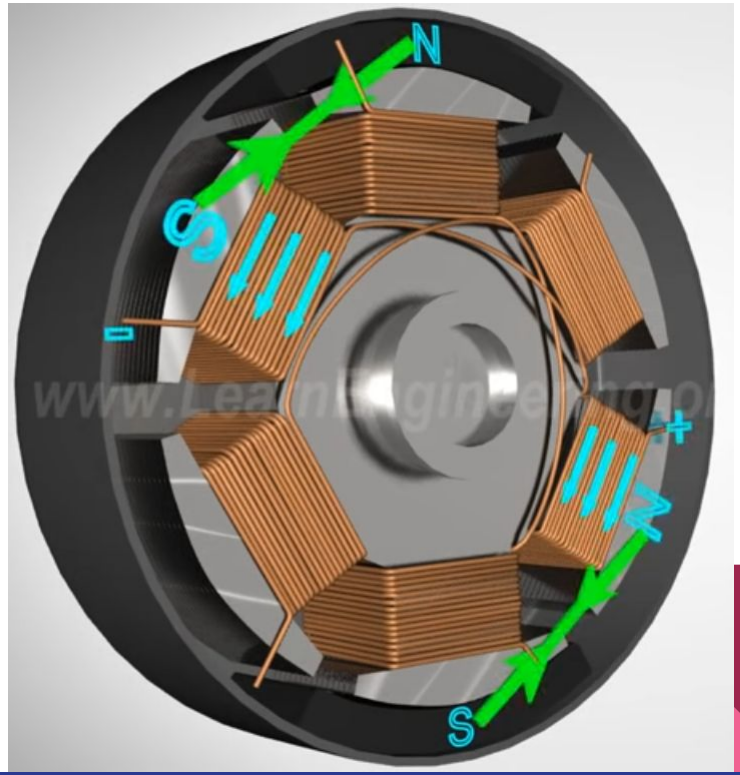


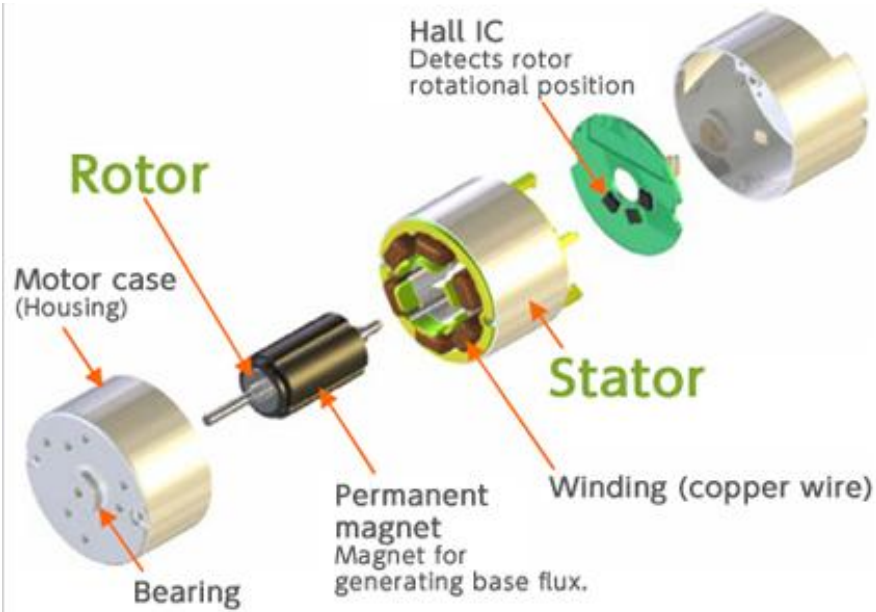
Image from https://youtu.be/bCEiOnuODac

Brushless Motor - ESC

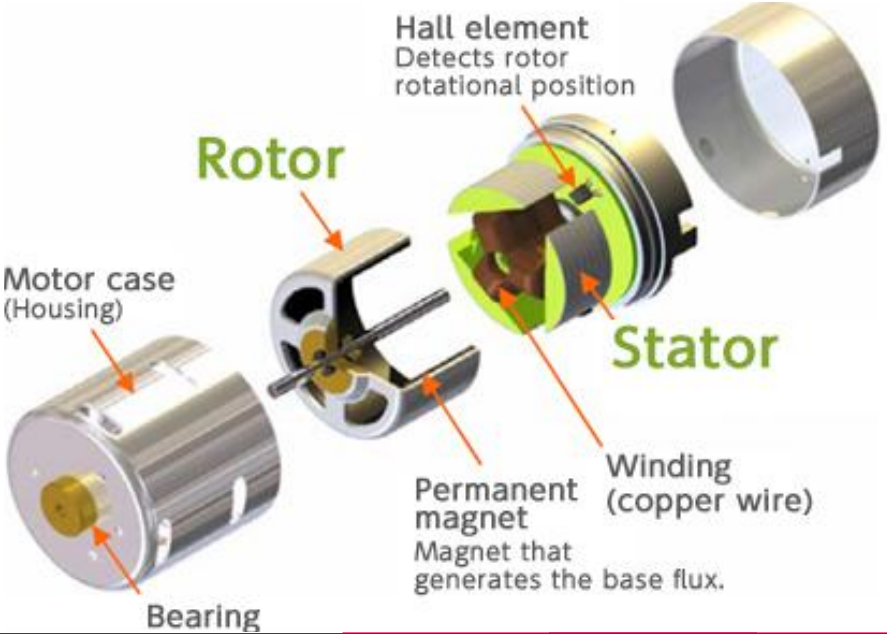
- The energized coil is electronically alternated.
- This is done by the ESC (Electronic Speed Controller).
- Receives speed command and makes the motor spin.

Brushless Motors - Inner and Outer

Inner



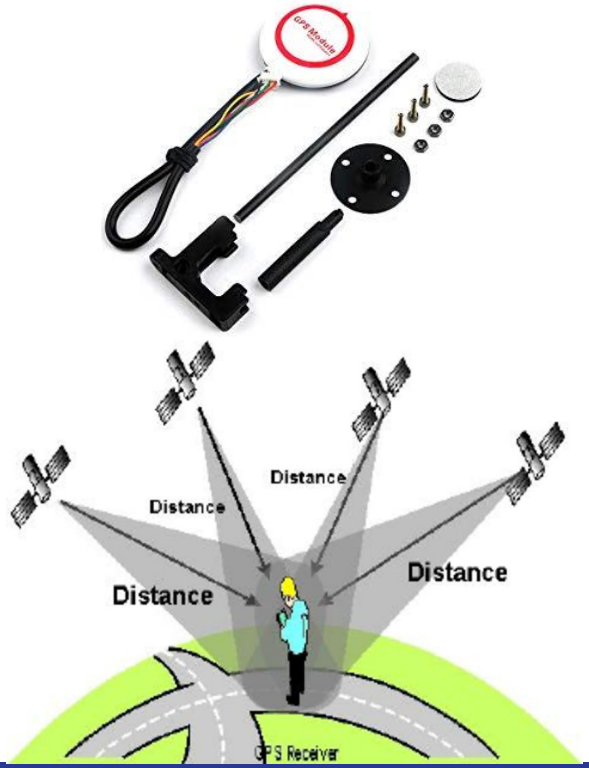
Outer



Sensors - IMU

- Inertial Measurements Unit.
- An electronic device that gathers different sensors:
  - Accelerometers: measure the linear accelerations.
  - Gyroscopes: measure the angular positions and velocities.
  - Magnetometer: measure the direction and strength of a magnetic field. It’s used to measure the orientation relative to the Earth’s magnetic field (like a compass).
- Modern Flight Controller have the IMU embedded.

Sensors - GPS



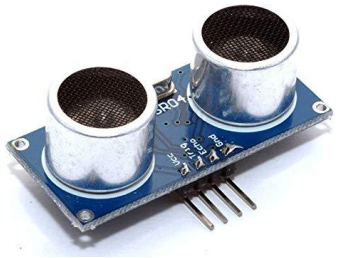
- Global Positioning System.
- Global position estimated by the distance to different GPS satellites.
- We desire at least six visible satellites for robust and reliable position estimations.

Sensors - Distance Measurement

- Used to measure the distance to the ground or to avoid obstacles.
- Different sensors for different necessities.

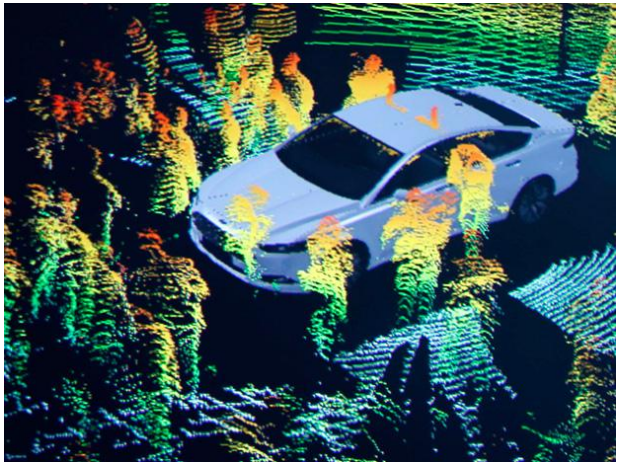
Sensors - Distance Measurement

- Sonar (Ultrasonic Sensor)
  - Emits and receives a sonic wave.
  - The time elapsed between emitting and receiving is used to calculate the distance.
  - Cheap and Lightweight, but have limited range and are inaccurate.
- RaDAR (Radio Detecting and Ranging)
  - Same working principles, but with radio waves or microwaves.
  - Accurate and wide-angle, but heavy and expensive.



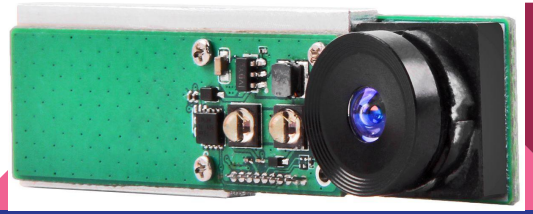
Sensors - Distance Measurement

- LRF (Laser Range Finder)
  - Emits and receives a laser signal.
  - Accurate and with long-range, but expensive
- LiDAR
  - An LRF spinning. It is used to 3D mapping the surroundings.
  - Accurate and with long-range. But expensive, heavy and fragile.



Sensors - Distance Measurement

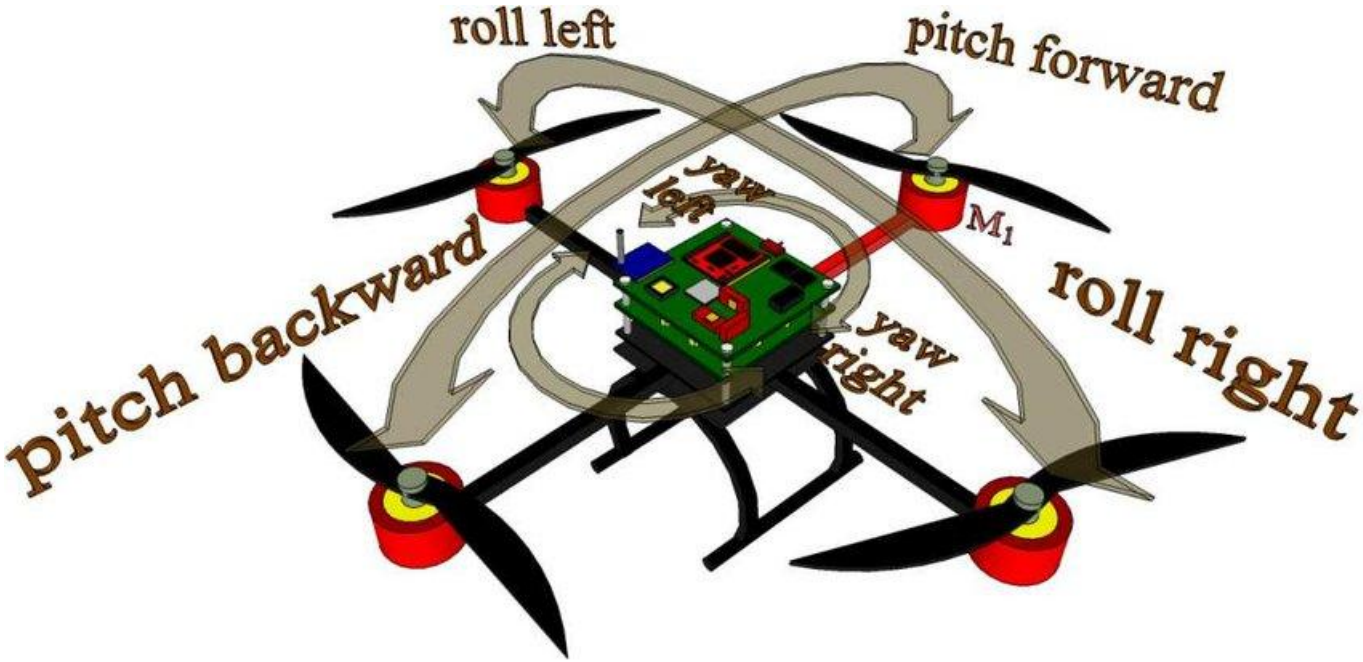
- Infrared Proximity Sensor
  - Emits and receives IR signals, then analyses the intensity.
  - Cheap and lightweight, but inaccurate and have limited range.
- Time of Flight Camera
  - Emits pulses of light and measure the return time for each pixel. It is used for 3D mapping.
  - Accurate, but sunlight sensitive and have limited range.



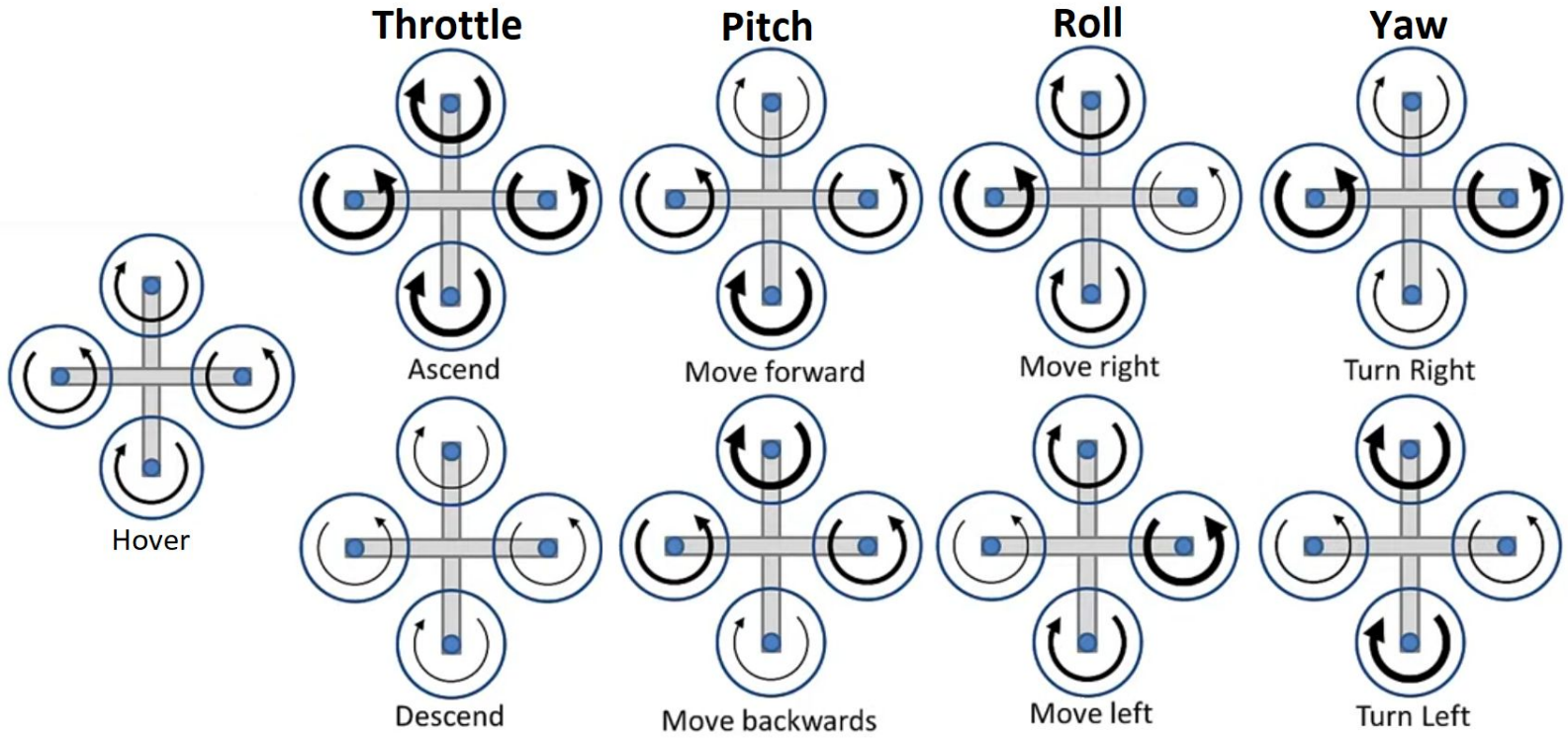
Flight Controller

- Reads the sensors and controls the motors to make what the drone is commanded to do.
- Some advanced features:
  - Gyro stabilization: making the drone stable on the flight.
  - Altitude hold: make the drone hover.
  - Position control: command the drone to certain positions.
  - Position hold: maintain the on the same geographic position.

Pitch, Roll and Yaw



Drone Movements

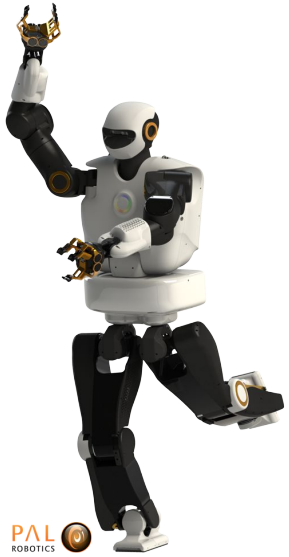


Simulation Time

ROS - Robotics Operating System

ROS

Robot Dog Aibo
Sony (Japan)

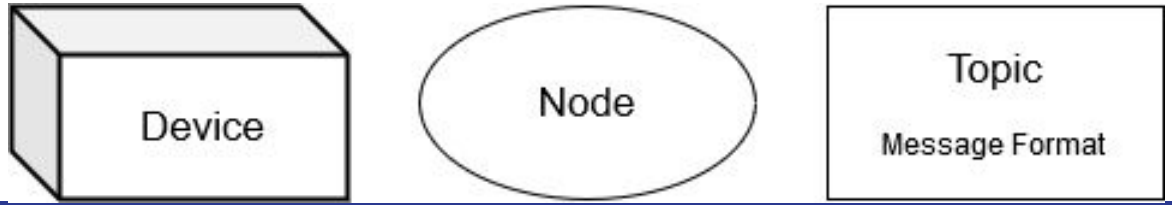


Humanoid TALOS
PAL Robotics (Spain)

- An open source meta-operating system for robotics.
  - It provides the expected services for an operating system (like hardware abstraction and low-level device control) but is built on the top of the operating system.
- It is used to simplify the integration between different parts of a robot.

ROS - Robotics Operating System

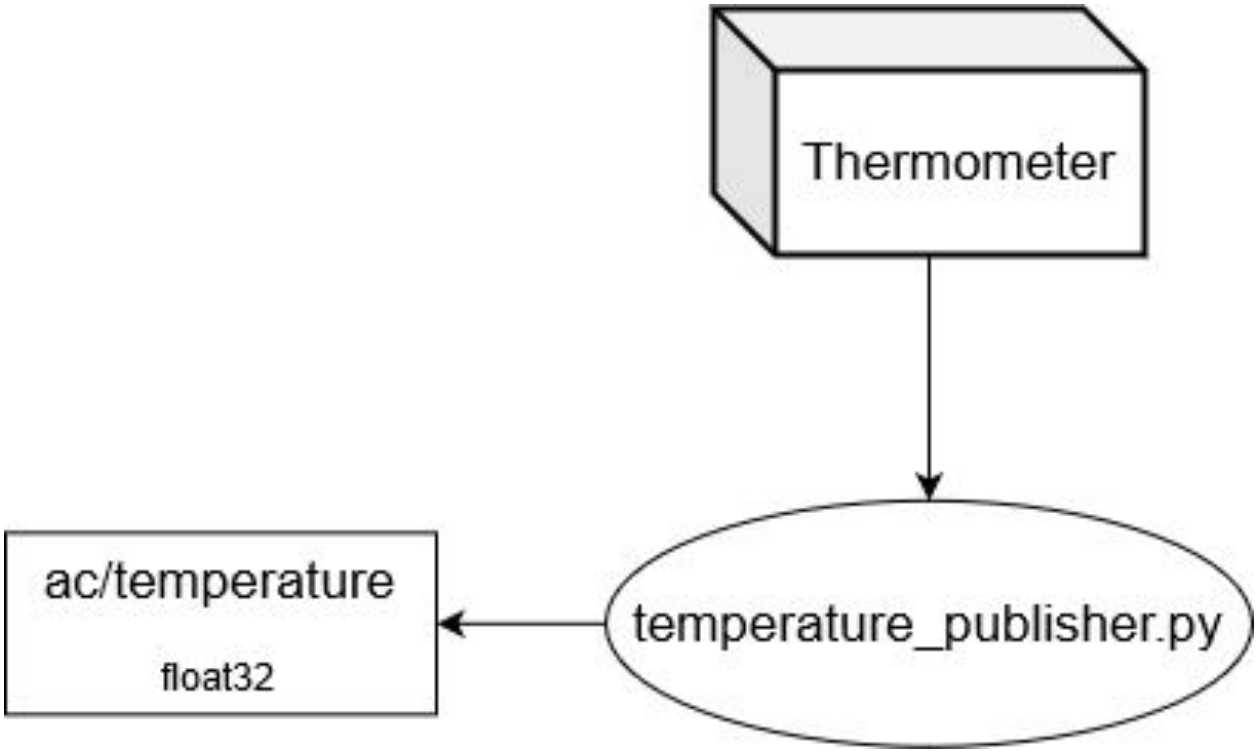
- Node: processes that perform computation. A robot control system usually comprises many nodes
- Message: a message is simply a data structure, comprising typed fields. Nodes communicate with each other by passing messages.
- Topic: messages are routed via a transport system with publish / subscribe semantics. A node sends out a message by publishing it to a given topic. A node that is interested in a certain kind of data will subscribe to the appropriate topic.



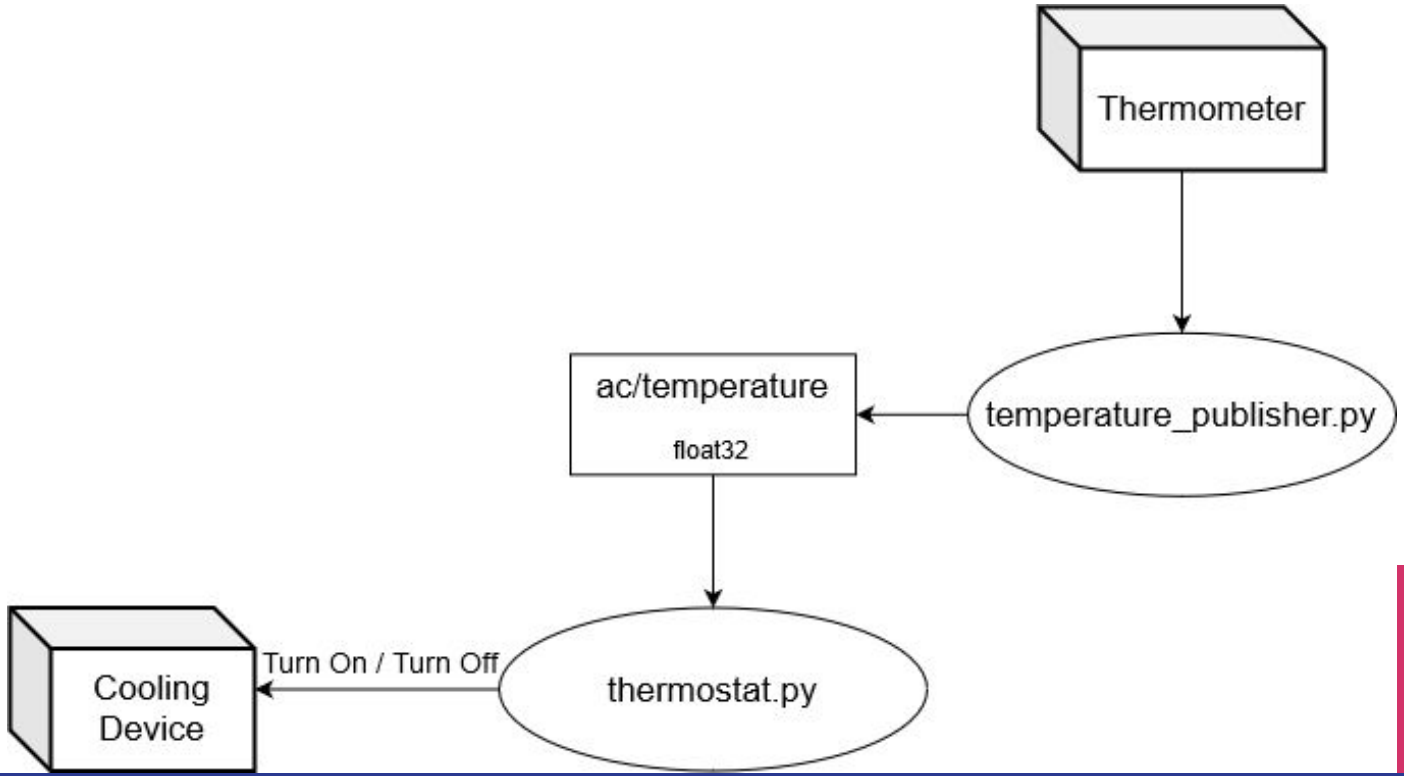
Concepts copied from http://wiki.ros.org/ROS/Concepts

How would we use ROS on an air conditioner?

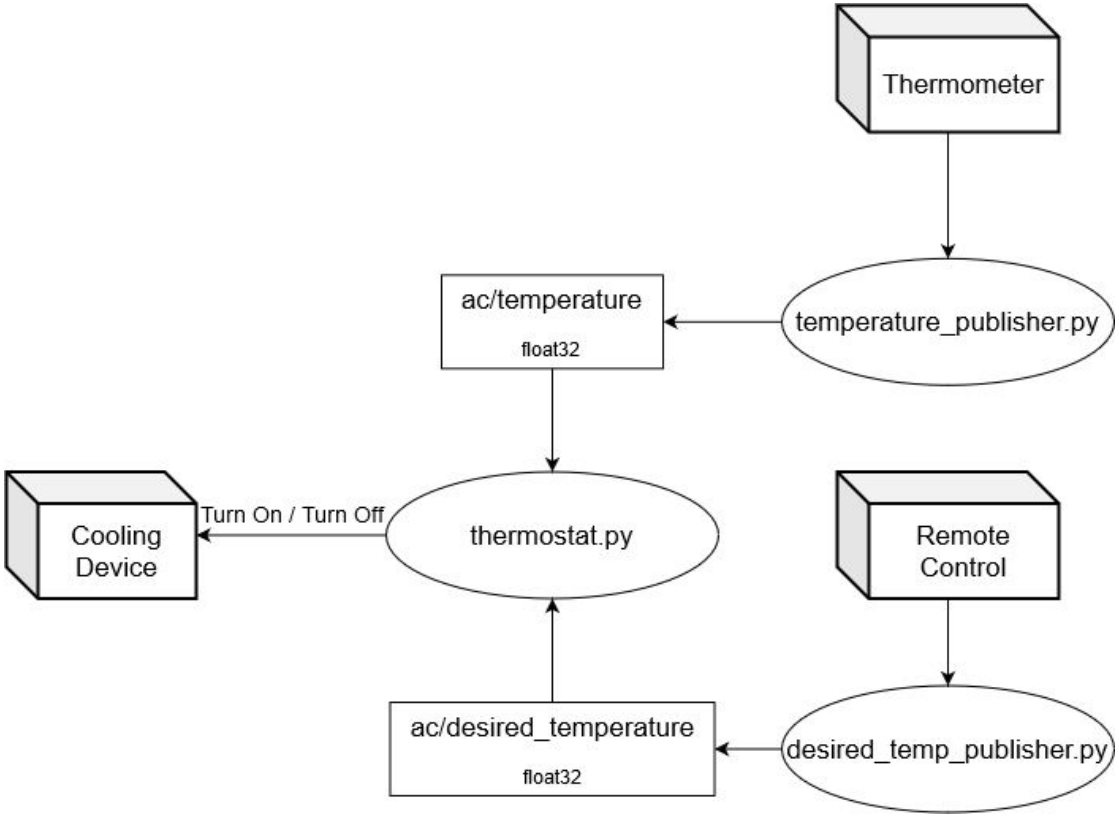
ROS - Air Conditioner



ROS - Air Conditioner

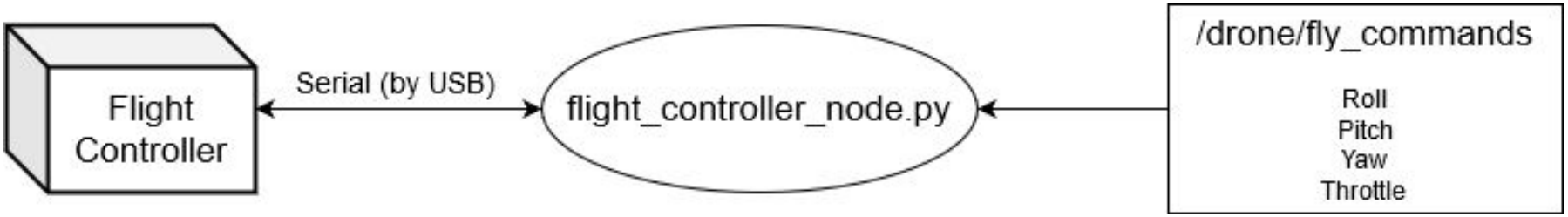


ROS - Air Conditioner

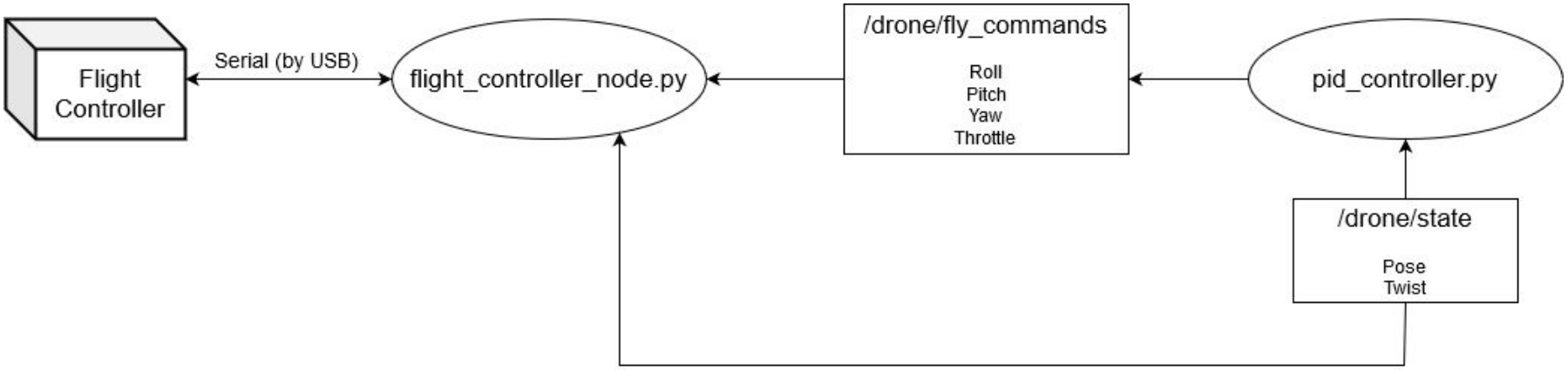


Let’s try a more complex example.

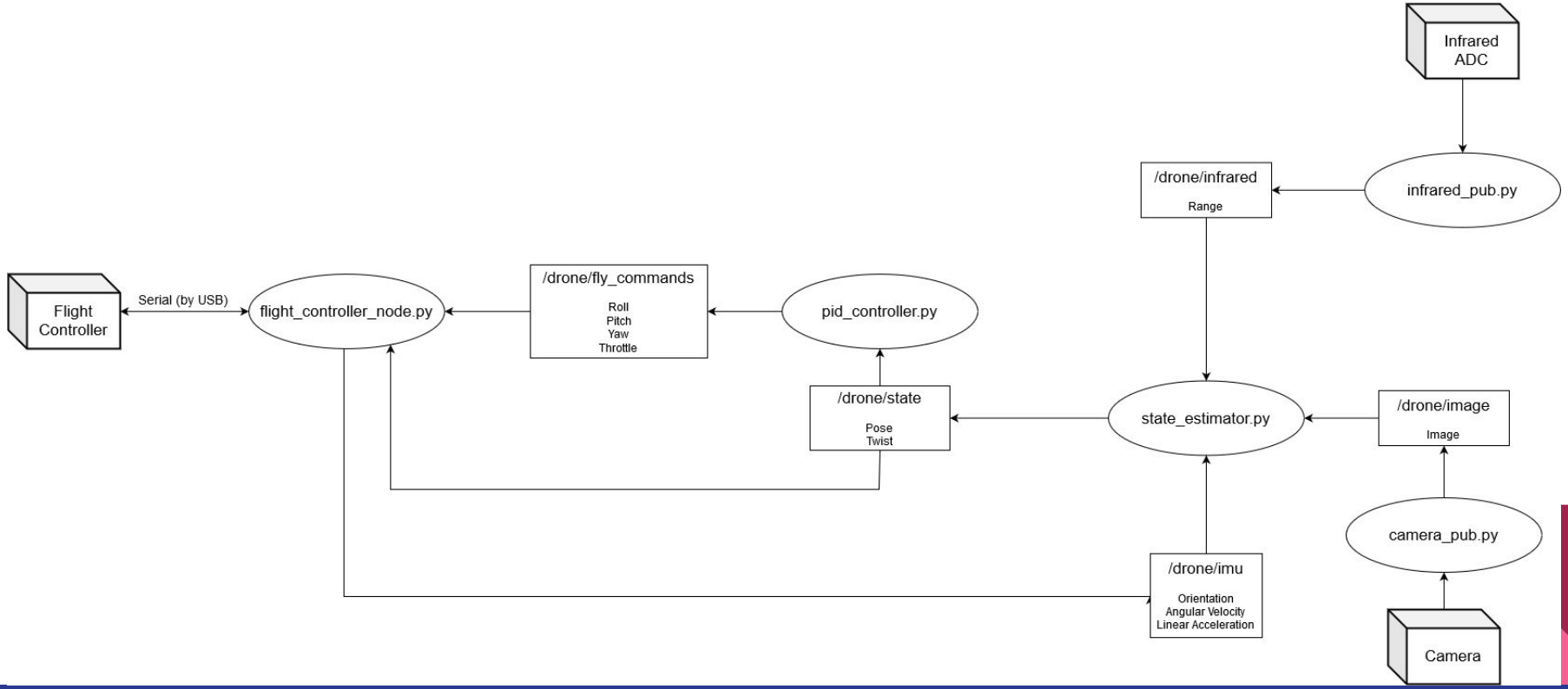
ROS - Drone


Flight Controller
Serial (by USB)
flight_controller_node.py
/drone/fly_commands
Roll
Pitch
Yaw
Throttle

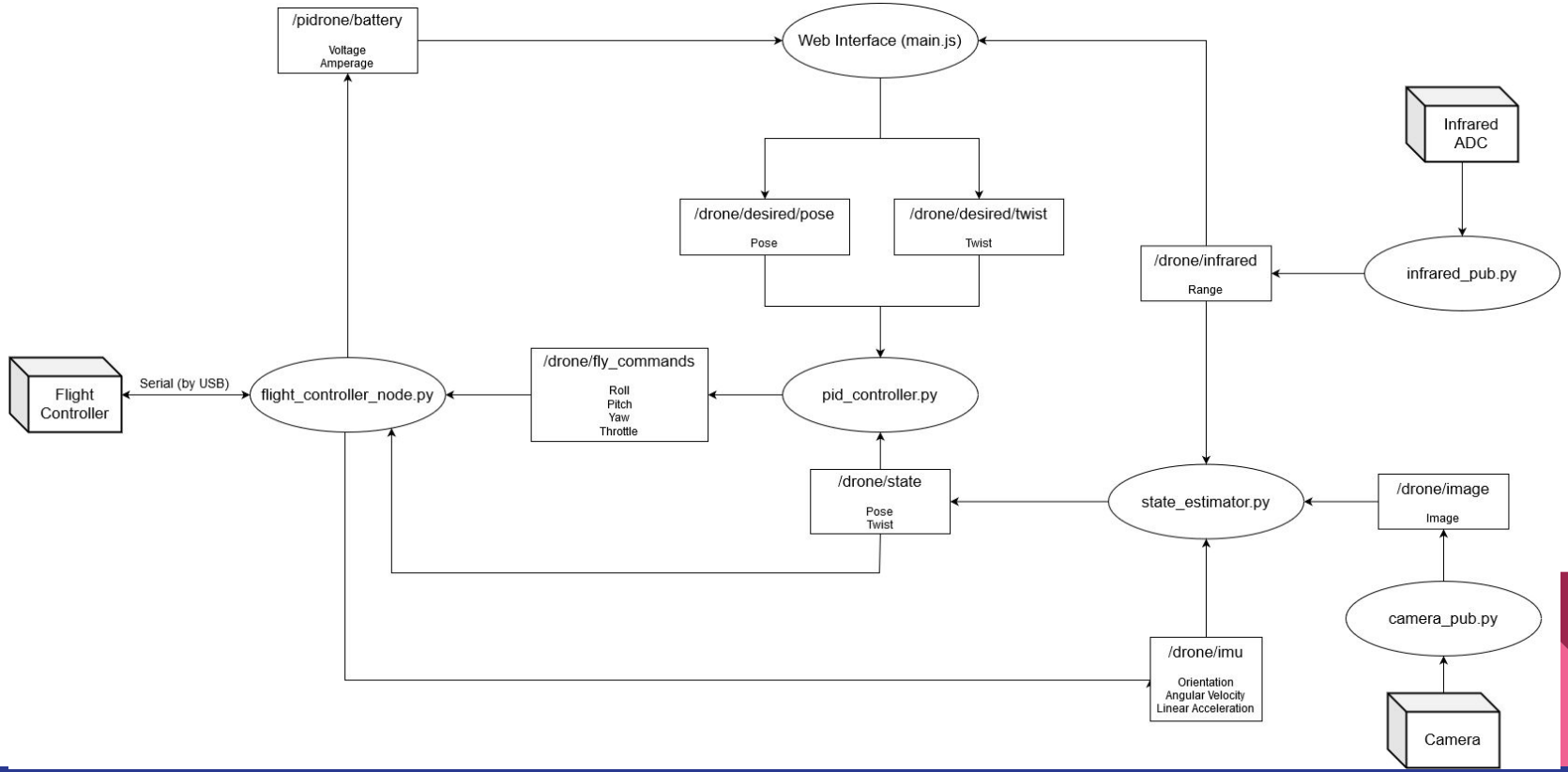
ROS - Drone


Flight Controller
Serial (by USB)
flight_controller_node.py
/drone/fly_commands
Roll
Pitch
Yaw
Throttle
pid_controller.py
/drone/state
Pose
Twist

ROS - Drone


Infrared ADC
/drone/infrared
Range
infrared_pub.py
Flight Controller
Serial (by USB)
flight_controller_node.py
/drone/fly_commands
Roll
Pitch
Yaw
Throttle
pid_controller.py
/drone/state
Pose
Twist
state_estimator.py
/drone/image
Image
camera_pub.py
/drone/imu
Orientation
Angular Velocity
Linear Acceleration
Camera

ROS - Drone


/pidrone/battery
Voltage
Amperage
Web Interface (main.js)
Infrared ADC
/drone/desired/pose
Pose
/drone/desired/twist
Twist
/drone/infrared
Range
infrared_pub.py
Flight Controller
Serial (by USB)
flight_controller_node.py
/drone/fly_commands
Roll
Pitch
Yaw
Throttle
pid_controller.py
/drone/state
Pose
Twist
state_estimator.py
/drone/image
Image
camera_pub.py
/drone/imu
Orientation
Angular Velocity
Linear Acceleration
Camera