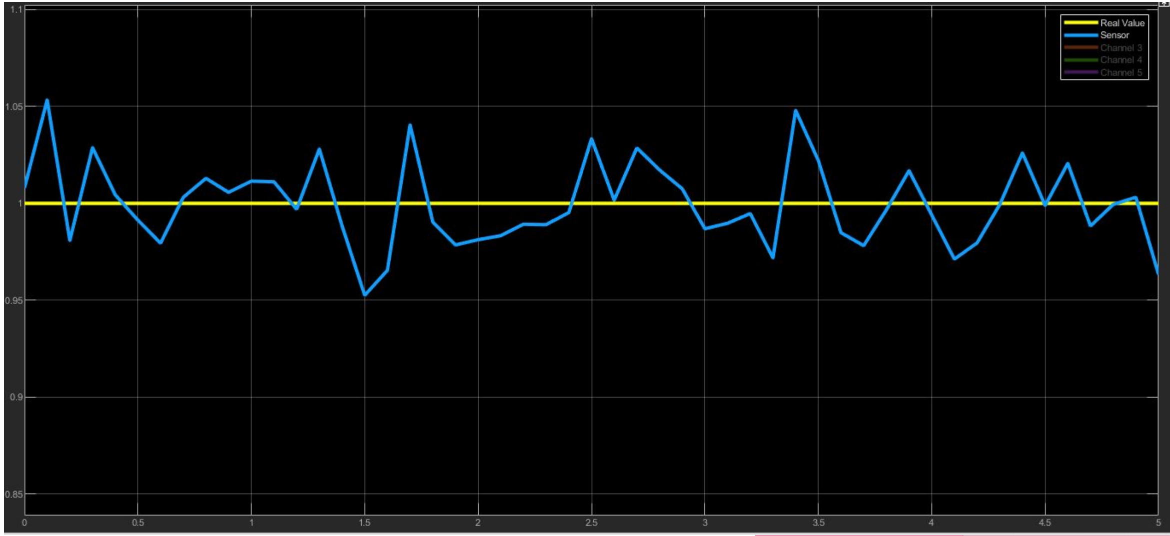
Basic Robotics Course

Class 4 - Sensor Fusion

Sensors are not perfect

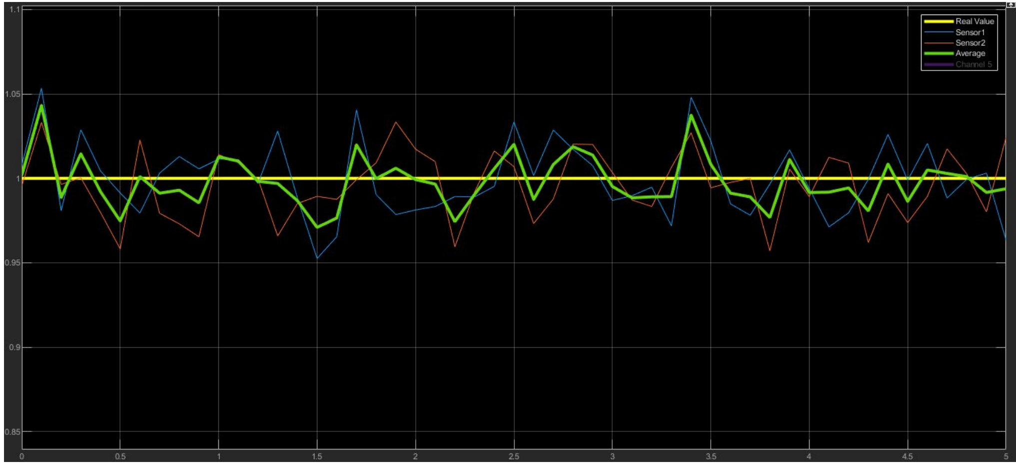
Sensors

- Sensors perceive some aspect of the real world.
- They have limited accuracy.
- They are affected by noise and interference.
- Example: the drone is 1m over the ground and the distance sensor has an accuracy of ±0.05m.



Sensor Accuracy

- There are situations when we can accept the accuracy of the used sensor, but there are situations when we cannot.
- On the prior example, a simple solution to improve the measure accuracy is to put another distance sensor and use the average of both measures.
- This is a very simple sensor fusion.



Sensor Fusion

- It is the process of combining different sensory data to better understand the observed world.
    - It can mean a more accurate, more consistent or more complete understanding.
- We can identify three ways of combining sensory data:
    - Redundant Sensors: All sensors give the same information about the world.
        - The former example of the distance sensors is in this case.

Sensor Fusion

- We can identify three ways of combining sensory data:
    - Complementary Sensors: The sensors provide independent types of information about the world.
        - Ex: The distance sensor provides the distance to the ground of the drone and the GPS provides the global position.
    - Cooperative Sensors: The information provided by the sensors is used to derive new information or to improve some former.
        - Ex1: the two images of a stereo camera are used to discover the deepness of the elements on the image.
        - Ex2: the IMU data is used to improve the GPS data on the drone.

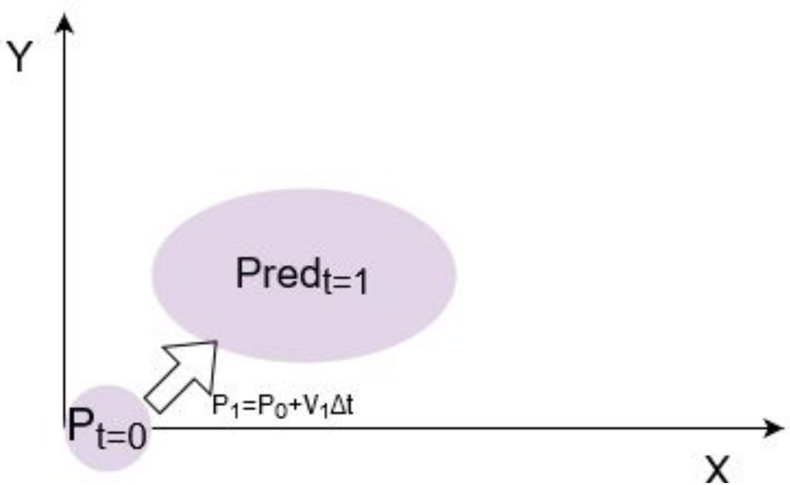
Kalman Filter

- One of the main algorithms for Sensor Fusion.
- For this algorithm:
    1. We build a model of our system for the data we want to control.
    2. With this model and the previous estimates, we predict future data.
    3. With new measurements from our sensors, we update our prediction to generate a new estimate.
    4. We repeat steps 2 and 3 over time and expect our predictions to become better with the time.

Kalman Filter - Example

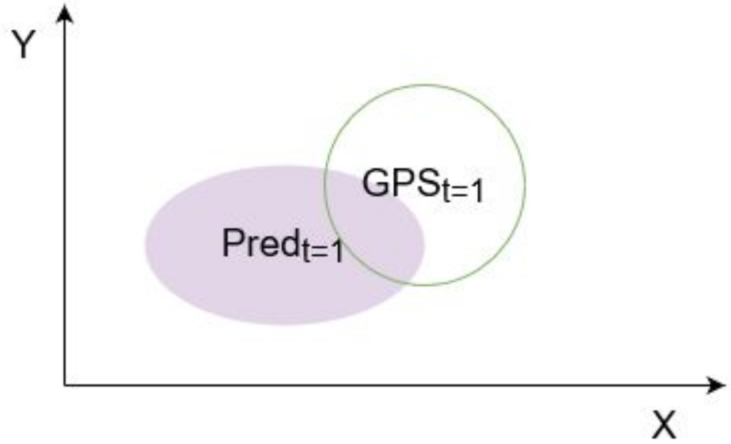
- We have our drone with a GPS with a 10m accuracy.
- We have estimates of the drone velocities with precision range.
- We want to know the drone position.

- A very simple model to estimate position having velocities is $P_T = P_{T-1} + V_T \Delta t$.

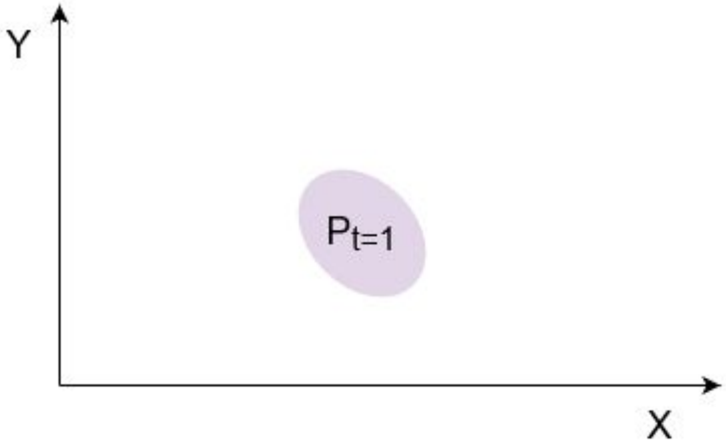


Having the position and velocities in t=0, we predict the position in t=1.

Kalman Filter - Example

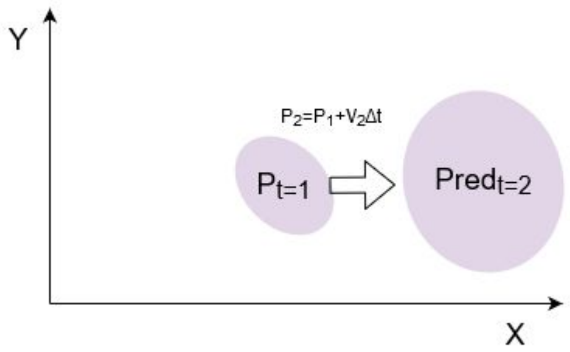


We receive a position measure from GPS in t=1

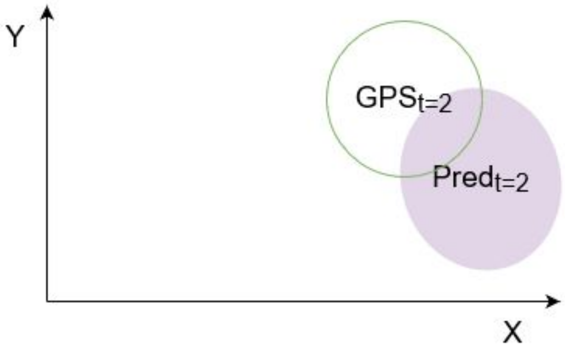


We use the measure to update the prediction and estimate the position

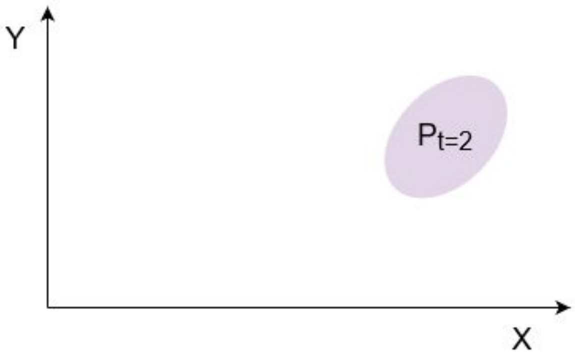
Kalman Filter - Example



Predict in t=2



Measure in t=2



Update in t=2

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.

Battery Safety