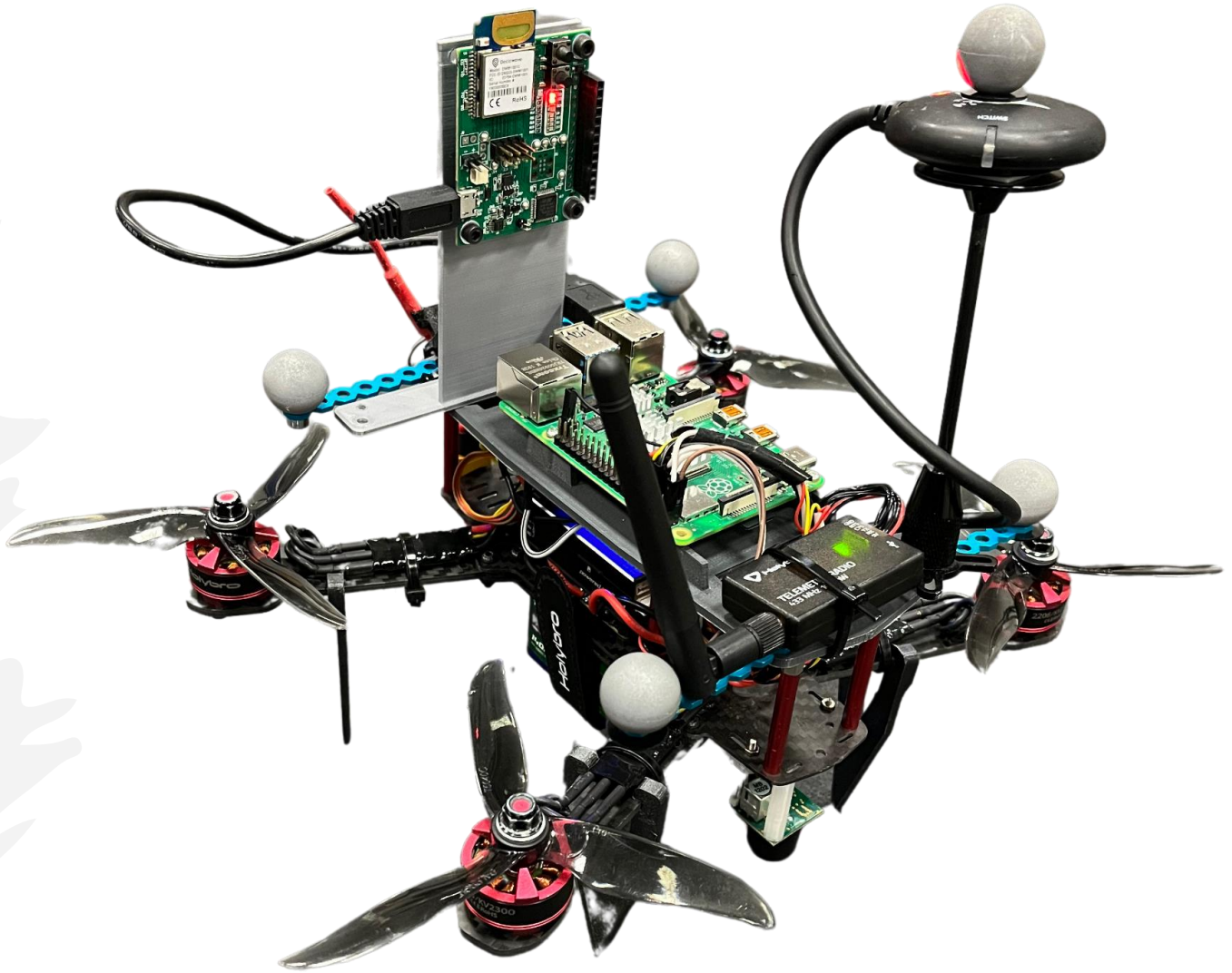
OFFBOARD DRONE APPLICATION USING DIFFERENT POSITIONING TECNIQUES



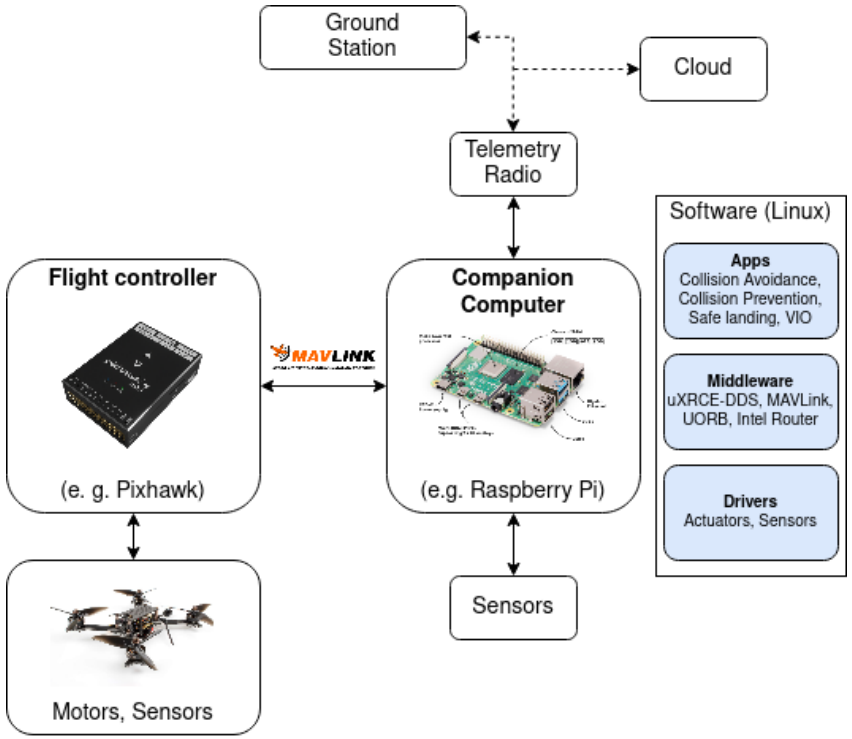
EMBEDDED SYSTEMS PROJECT

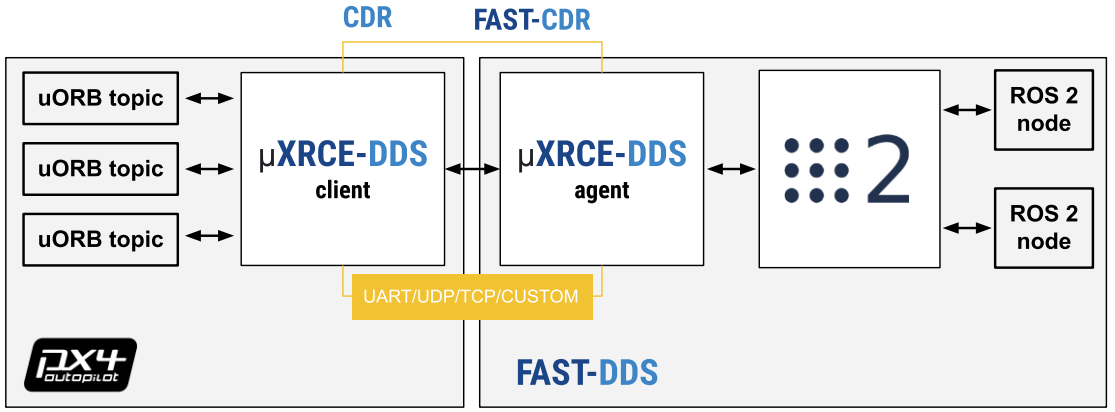
Corradini Giacomo 236873

Pettene Mattia 239145

PX4 OVERVIEW

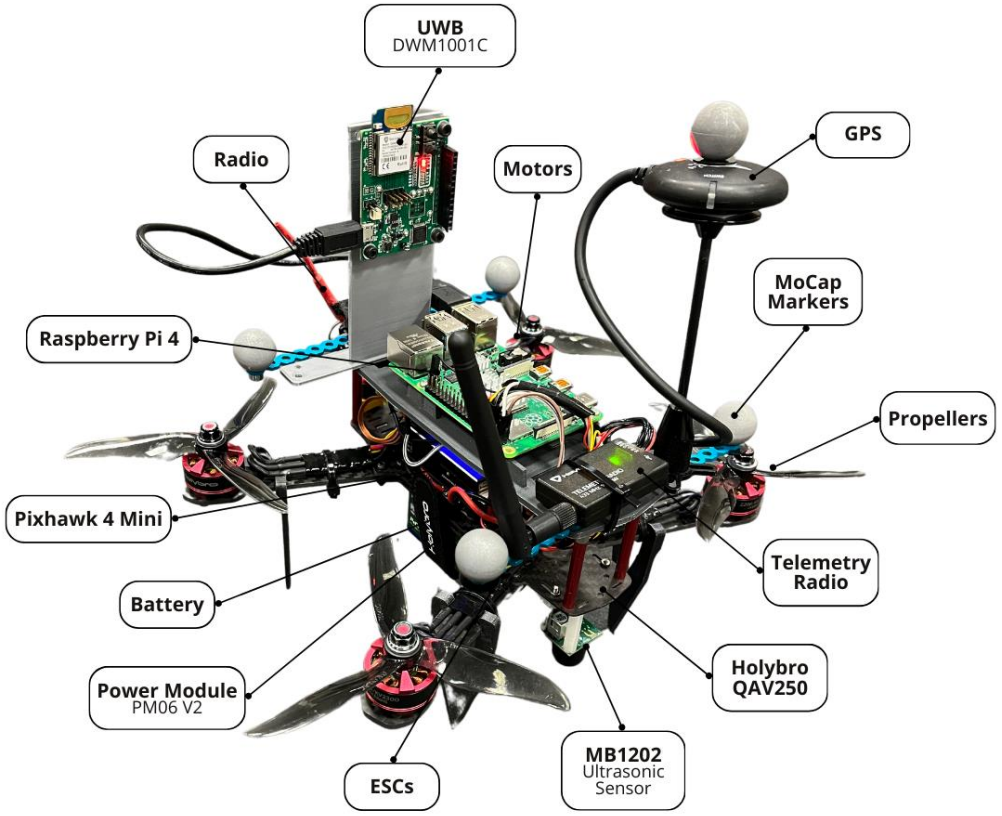
- Modular Architecture
- Open source
- Robust and deep integration with companion computer and robotics APIs
- uXRCE-DDS middleware

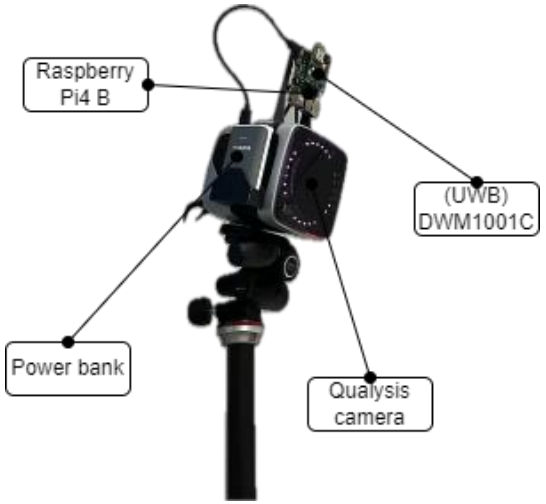


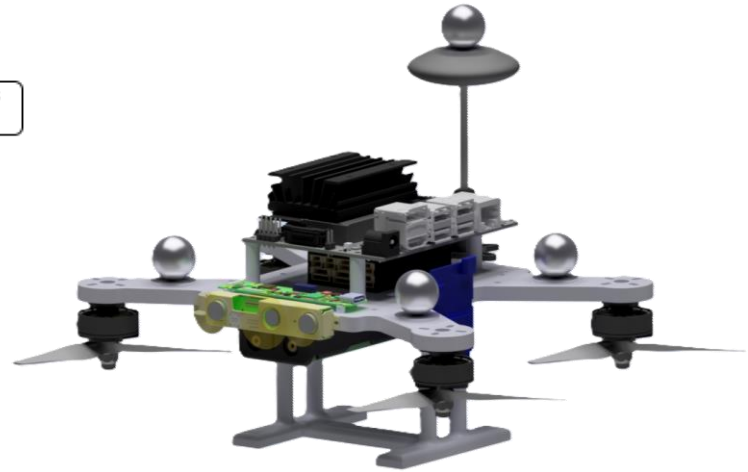


HARDWARE DESCRIPTION

- Holybro QAV250
- Pixhawk 4 mini
- Raspberry Pi 4
- Qualysis camera
- DWM1001C (UWB)
- MB1202 (Sonar)
- Communication
- Custom airframe

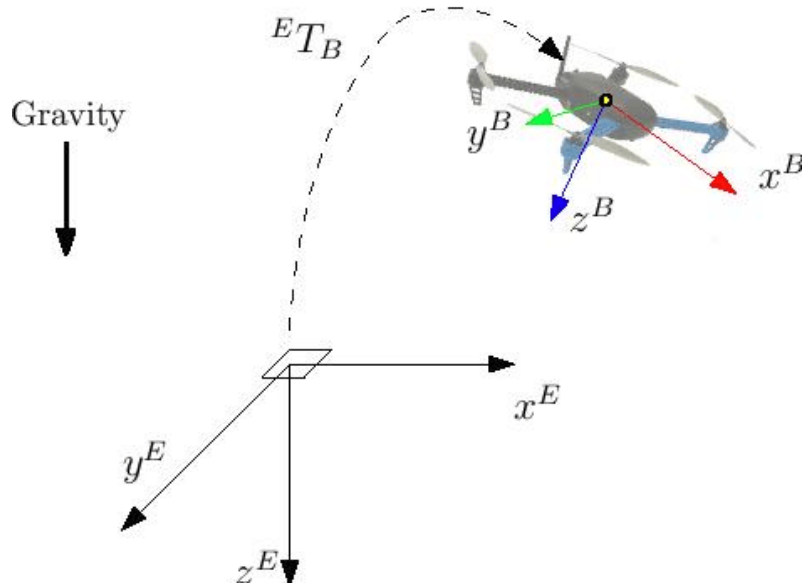






BRIDGES

- External position estimation
- Reference frame trasformation for correct data fusion
- Publish in vehicle_visual_odometry




```
# Vehicle odometry data. Fits ROS REP 147 for aerial vehicles
uint64 timestamp                # time since system start (microseconds)
uint64 timestamp_sample

uint8 POSE_FRAME_UNKNOWN = 0
uint8 POSE_FRAME_NED     = 1 # NED earth-fixed frame
uint8 POSE_FRAME_FRD     = 2 # FRD world-fixed frame, arbitrary heading reference
uint8 pose_frame            # Position and orientation frame of reference

float32[3] position         # Position in meters. Frame of reference defined by local_frame. NaN if invalid/unknown
float32[4] q                # Quaternion rotation from FRD body frame to reference frame. First value NaN if invalid/unknown

```

PROGRAM STRUCTURE

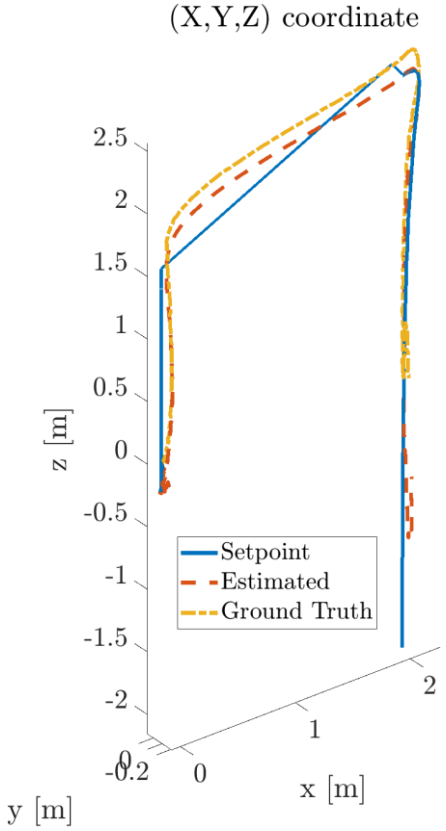
- timer_callback()
- publish_trajectory_setpoint()

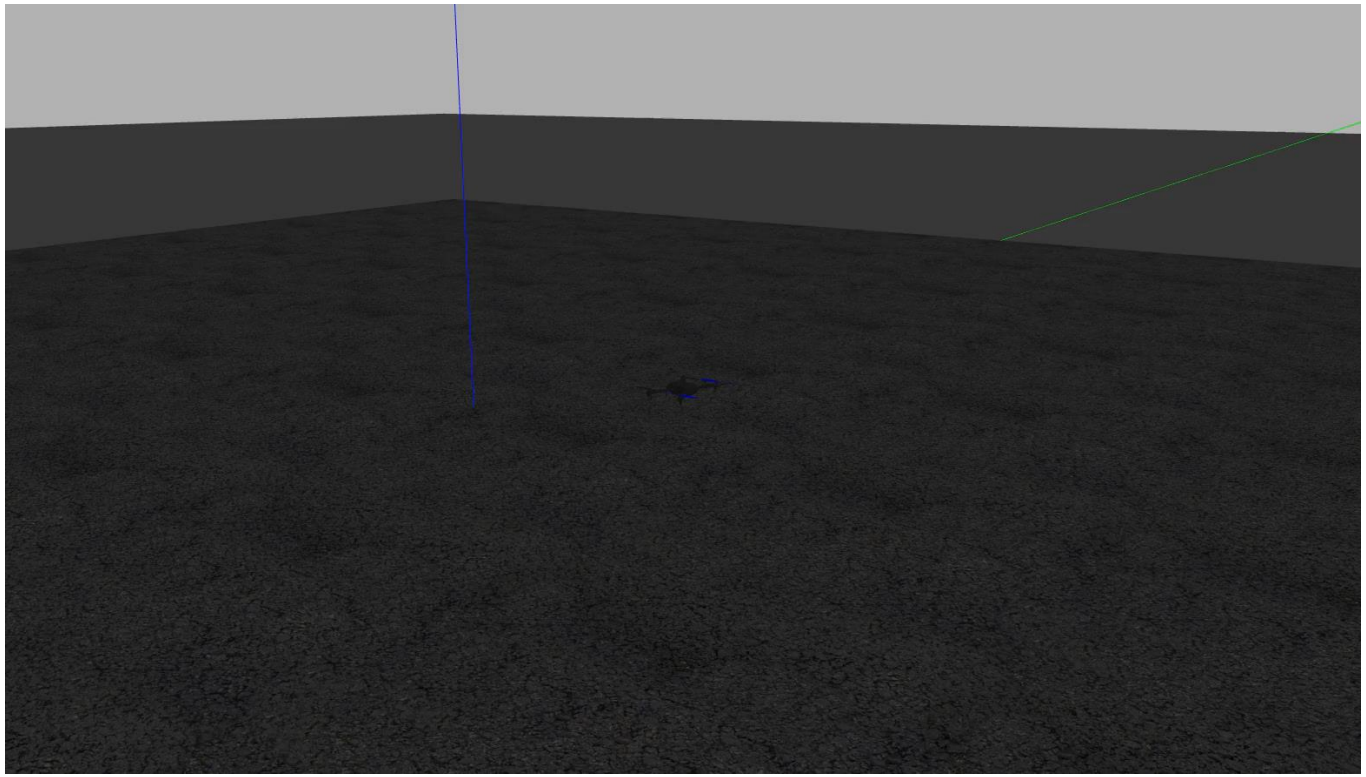
Algorithm 1: timer_callback()

```
// Arm and takeoff
if offboard_setpoint_counter_ == 0 then
    arm()
    takeoff()
end
// Trajectory setpoint
if takeoff_finished == 1 and len(point_list)! = 0
 then
    publish_vehicle_command(VehicleCommand.
      VEHICLE_CMD_DO_SET_MODE, 1., 6.)
    publish_offboard_control_mode()
    publish_trajectory_setpoint()
end
// Land (when the list is empty and
    all points are reached)
if len(point_list) == 0 then
    land()
end
// Disarm
if landing_flag == true then
    disarm()
end
offboard_setpoint_counter_+ = 1
```

Algorithm 2: publish_trajectory_setpoint()

```
msg = TrajectorySetpoint()
point = self.point_list
range = self.range
// check the list is not empty
if len(point) > 0 then
    msg.position = [point[0].x, point[0].y, point[0].z]
    msg.velocity = [self.velx, self.vely, self.velz]
    // point is reached
    if self.distance(point[0]) <= range then
        // delete the reached point from
           the list
        point.pop(0)
    end
end
msg.timestamp =
  int(Clock().now().nanoseconds/1000)
self.trajectory_setpoint_publisher_.publish(msg)
```



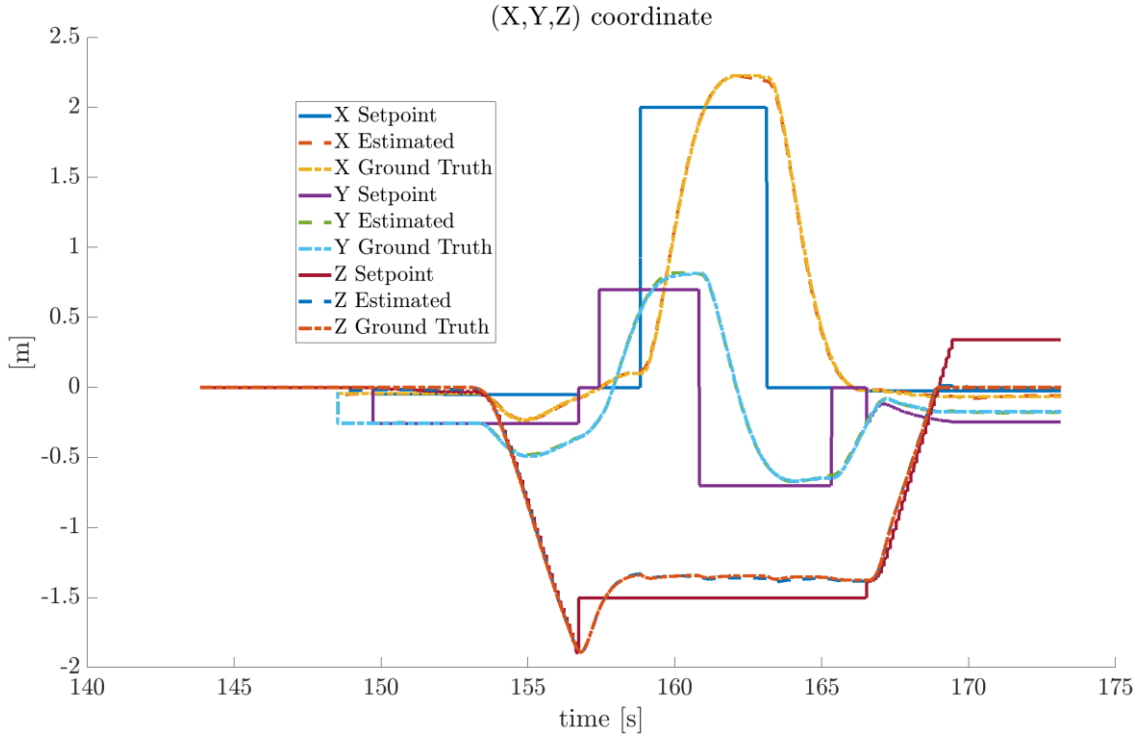


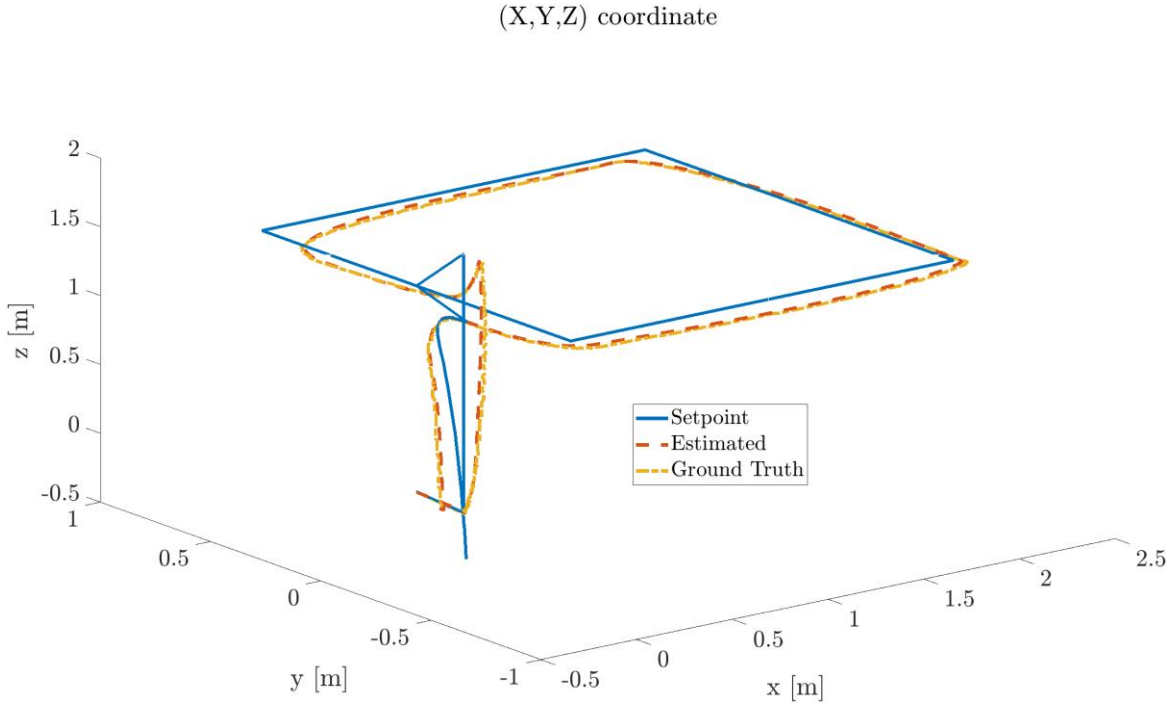
SIMULATIONS - GPS

- Gazebo environment
- GPS plugin

SIMULATIONS - MOCAP

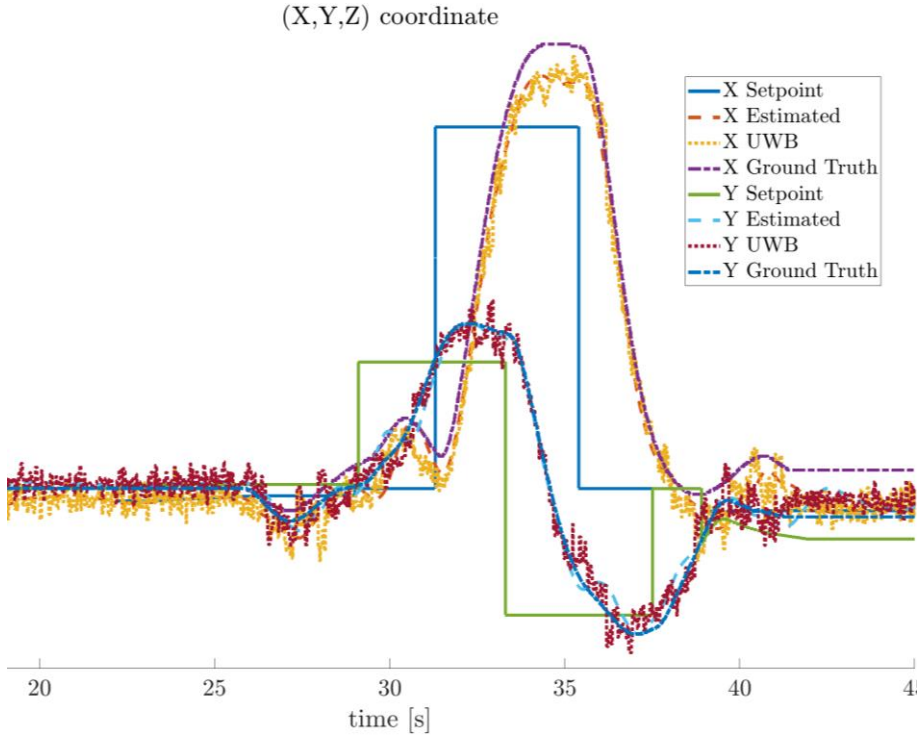
- External position estimation
- No outdoor sensors (GPS, barometer)
- Noisy Position Gazebo plugin

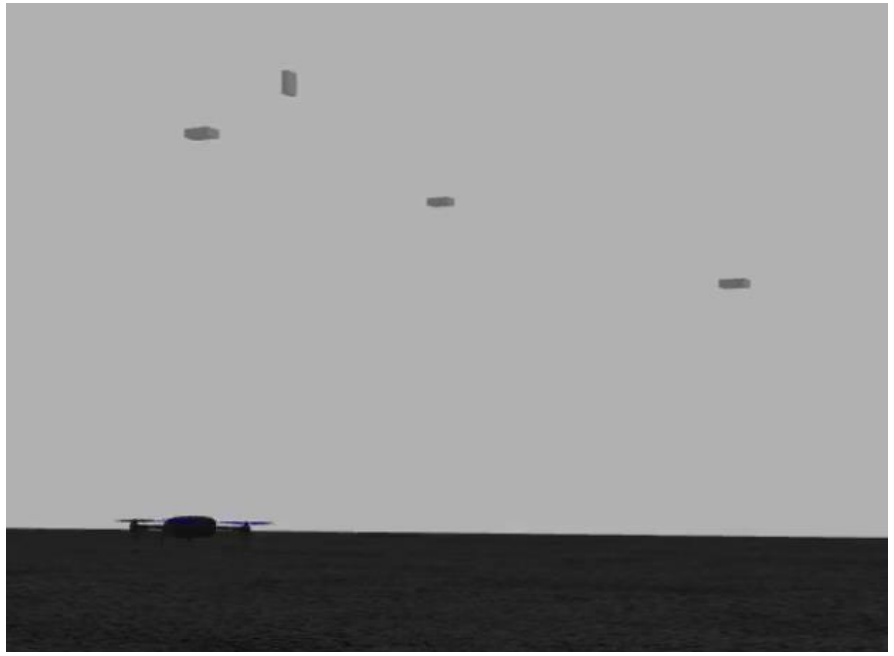




SIMULATIONS - UWB

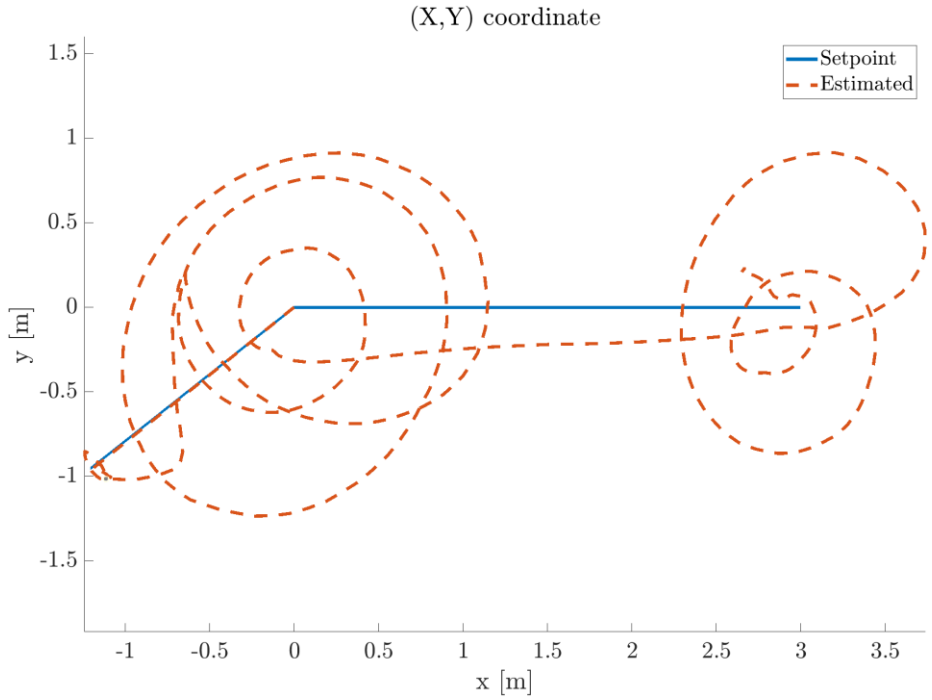
- External position estimation
- Noisy UWB Gazebo plugin
- Multilateration algorithm





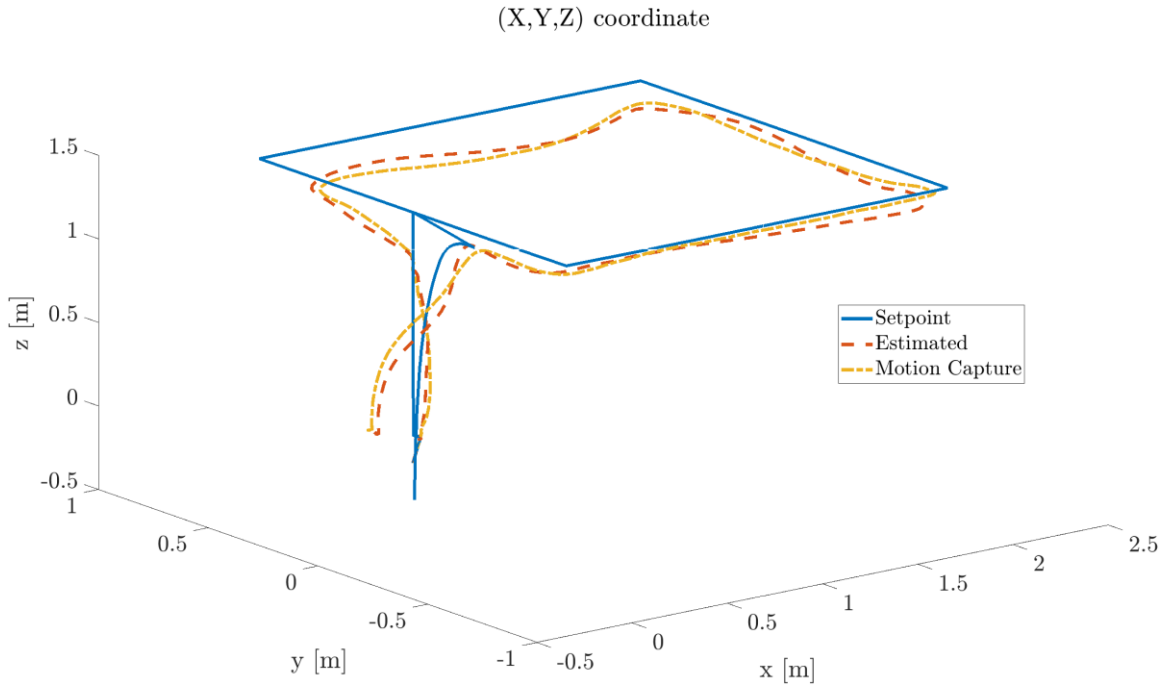
EXPERIMENTAL RESULTS - GPS

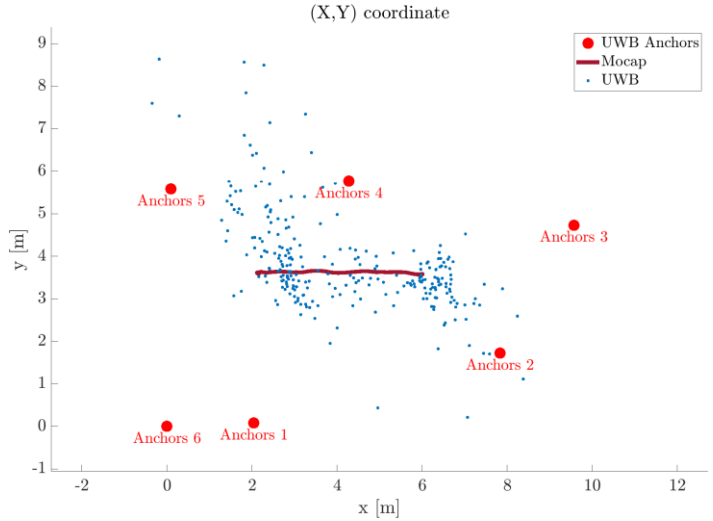
- Safety conditions
- Turns around set points
- Starting point

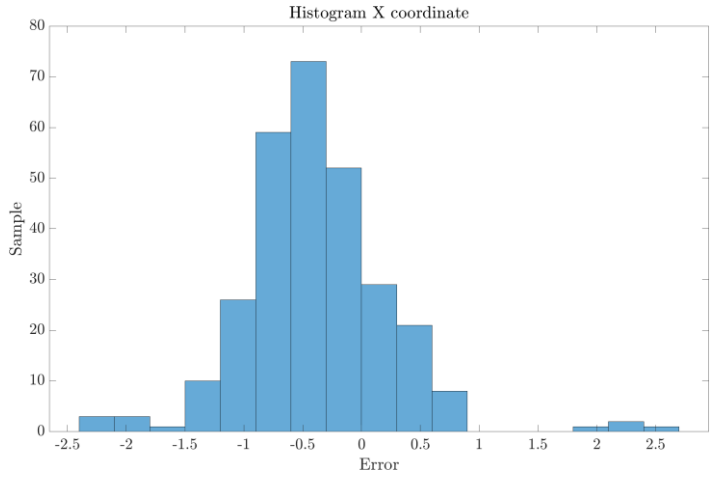


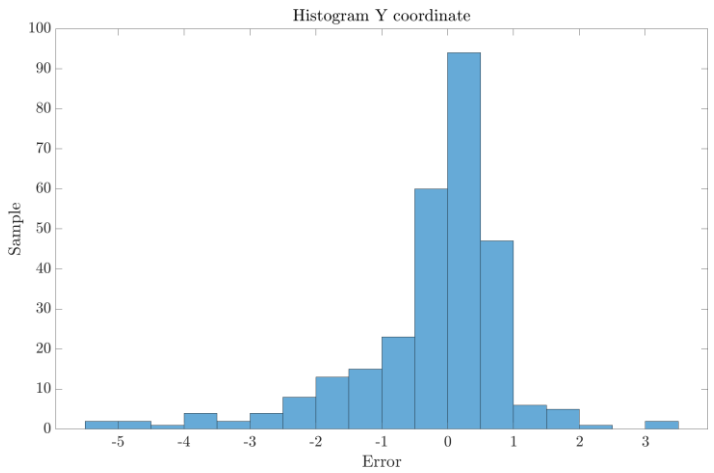
EXPERIMENTAL RESULTS - MOCAP

- External position estimation
- Motion capture to PX4 bridge
- Accurate and precise positioning system



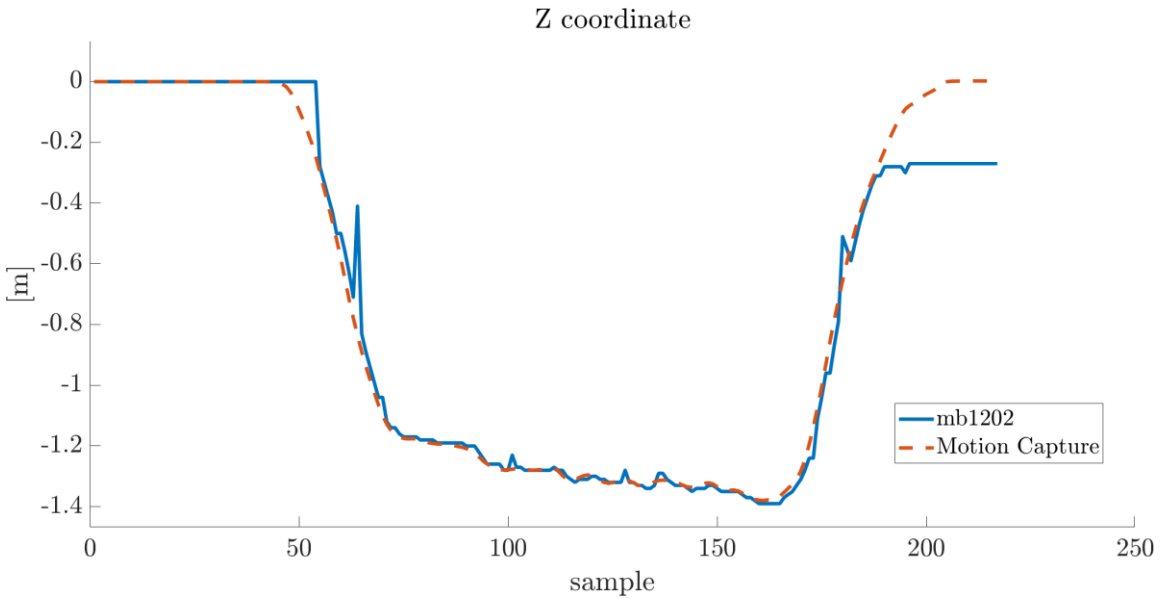


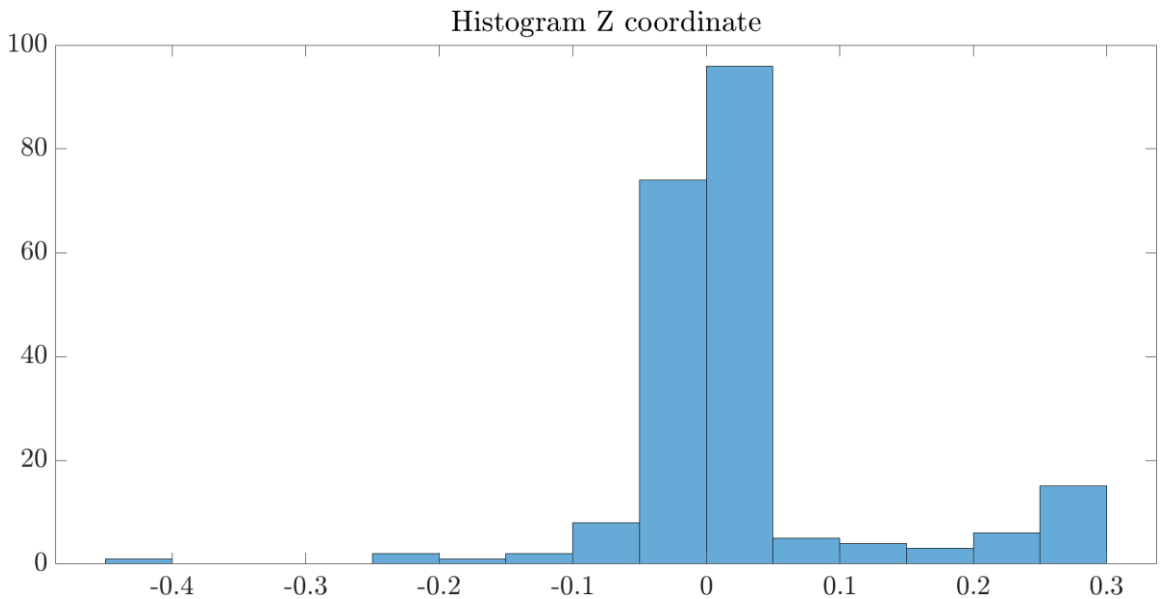




EXPERIMENTAL RESULTS - UWB

- External position estimation
- UWB to PX4 bridge
- DTDOA algorithm





EXPERIMENTAL RESULTS - SONAR

- Height position estimation
- MB1202 bridge
- Initial and final steps
- Maximum error

CONCLUSIONS

- Positioning techniques comparison
- Possible future implementations

GPS

Difficult to control in position

RTK module to improve precision

MOCAP

Accurate and precise

Usefull as ground trouth

High cost positioning technique

UWB

Low cost promising positioning technique

Improve the UWB infrustructure accuracy

Outliers rejection is mandatory

SONAR

Good low cost height estimate

Outliers rejection is mandatory