Automated Calibration Algorithm for a 3D Infrared Relative Localization Sensors for Quadrotors

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Relative localization for UAVs is a central element of several multi-drone missions, such as formation control, optimal exploring or inter-drone collision avoidance. In comparison with centralized localization, the onboard computing of the relative pose makes swarms much more robust to the failure of a single computer, hence allowing a much greater scaling potential. Additionally, infrared-based systems present several unique advantages with respect to popular vision-based systems, such as the ability to work in the dark and much cheaper computational requirements. However, in order to correctly interpolate a position and orientation from processed infrared measurements, we need an accurate estimate of the function that converts the position and power of the beacons to an RSS signal. This estimate is obtained through the process of calibration.

The first objective of this project was to design, manufacture and assemble a separate experimental setup on which the full sensor modules (receivers, emitters, onboard computer, battery, electronics) could be mounted as if it was a true UAV. This setup is necessary because it allows the sensor calibration process to be decoupled with real drones. This way we can easily produce and test many new setups at a relatively much lower cost.

Two assembled setups with the sensors mounted

Additional requirements to the design of these setups included :

- Being able to easily swap the emitters (ping-pong balls in the image)
- Have many spare area to place Motion Capture System (MCS) markers over the 3 dimensions

Once minimum two setups were complete, the calibration process could be performed in two steps :

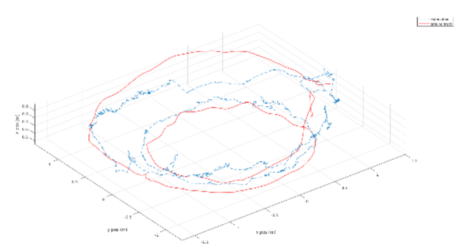
1. Receiver calibration

The aim of this step is to estimate all the parameters linked to the variation of the signal strength depending of the receiver-emitter angle, as well as all parameters originating from the processing of the raw signal. The output function to be estimated is a piecewise quadratic function with different parameters in 5 different areas of the function. The process here is to gather many datapoints of across many various distances and orientation, then minimize the squared error between observations and predictions with the matlab function *lsqcurvefit* for all 16 receivers on a module, we find 2 + 3*5*16 = **242** parameters.

2. Emitter calibration

This step's aim is the find the relative gain factors between the different beacons of one module. They are found by comparing the strength of different emitters from a same known distance, then normalizing them to the same value.

Finally, we perform a dynamic test with ground truth to evaluate the performance of the position estimate.



Dynamic 3D relative position test with the ground truth (red) and the estimate (dashed blue)