Lighthouse Positioning System: Dataset, Accuracy, and Precision for UAV Research

Authors
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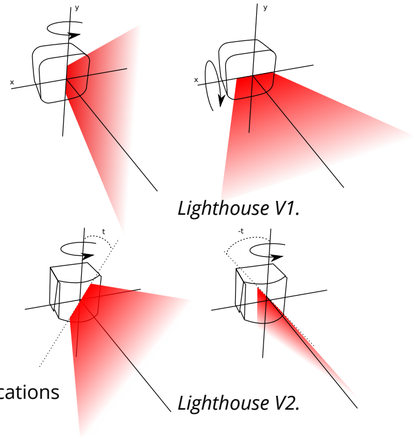
Introduction

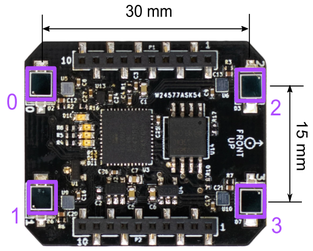


Lighthouse (LH) vs. Motion Capture (MoCap):
+ Significantly cheaper
+ Fully distributed operation
- Accuracy, precision not quantified for robotics applications

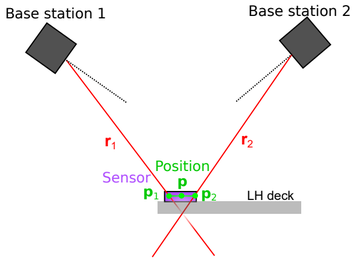
This paper presents:
- a Crazyflie-captured dataset of the LH system
- an analysis of the accuracy and precision vs MoCap

Positioning Methods

The system consist of two parts:
1. Two LH basestations:
   - V1 - 2 rotating drums with each one plane
   - V2 - 1 rotating drum with 2 planes on different angles
2. Sensor array on the Lighthouse positioning expansion deck for the Crazyflie.

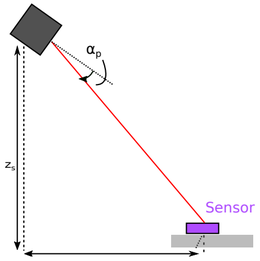


Lighthouse positioning deck.



Crossing Beam Method (C.B.)
- Two LH Base Stations
- Intersection of both light planes

$$\boldsymbol{p}_{1,s}, \boldsymbol{p}_{2,s} = \underset{\boldsymbol{p}_1 \in \boldsymbol{r}_{1,s},\ \boldsymbol{p}_2 \in \boldsymbol{r}_{1,s}}{\arg\min} \|\boldsymbol{p}_1 - \boldsymbol{p}_2\|_2$$



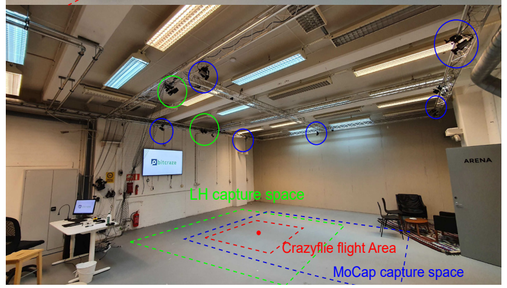
Extended Kalman Filter (EKF)
- Input raw IR light planes
- Measurement model

$$\alpha_p = \arctan\frac{y_s}{x_s} + \arcsin\frac{z_s \tan t_p}{r_s},$$
$$\text{where } r_s = \sqrt{x_s^2 + y_s^2}.$$

Test Setup

Flight arena:
- Mocap (7x7x3m; 6 Qualysis miques m3)
- Lighthouse (1.5x1.5x1.5m; V1 and V2)

UAV:
- Crazyflie 2.1
- Lighthouse deck
- Active Marker Deck
- µSD-card deck

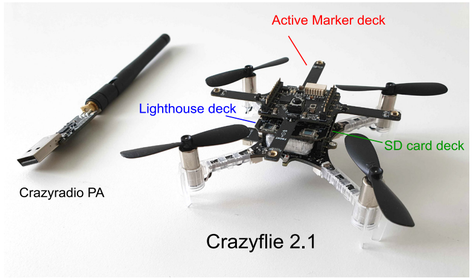


Data Collection

The data was collected in two ways:
- External Motion: Movement of the Crazyflie on long rod
- Flight: The crazyflie in flight with a sweeping pattern and randomly sampled way-points

The type of data logged on the µSD-deck:
- Synchronized 100 Hz: Gyroscope and Acceleration
- Event-based streams: raw LH Angles and position by C.B. and EKF

Data was excluded when either events occurred:
1. No Lighthouse data was received by the lighthouse deck
2. No tracking by the MoCap system



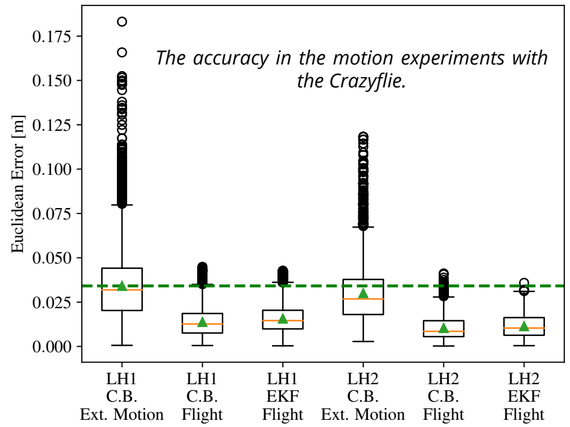
Hardware used for data collection.

	LightHouse 1		LightHouse 2		MoCap
	C.B.	EKF	C.B.	EKF	
Freq. [Hz]	30 ± 2.4	N.A.	34 ± 18	N.A.	300 ± 0.1
Jitter [mm]	0.6	3.9	0.3	0.7	0.1

Sample frequency and jitter for a stationary setting.

Results

Observations:
- The sample frequency STD is higher for C.B. for LH2 because of the plane interference.
- The mean and median Euclidean error are in all experiments about 2 - 4 cm.
- External motion outliers of 18 cm were observed for the external motion due to faster motions and worse observability.
- Outliers during flight is 5 cm.
- The two methods C.B. and EKF have a similar accuracy.
- LH2 has higher accuracy compared to LH1.



Resources and References

The Lighthouse positioning system's Base Stations are developed by Valve:
www.valvesoftware.com/en/index/base-stations
The dataset and code used in the test can be found: www.github.com/bitcraze/positioning_dataset
The Crazyflie and its accessories are from Bitcraze AB: www.bitcraze.io
The MoCap cameras are from Qualysis: www.qualisys.com/cameras/miqus
Original C.B. method is inspired by the work of: www.github.com/ashtuchkin/vive-diy-position-sensor

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