WS 2018-2019, SMT, DISAL-SP125 Project Summary

Underwater AUV localization

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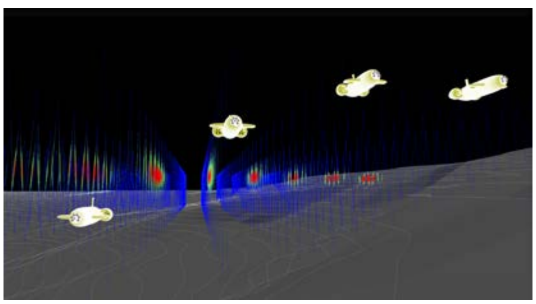
The water world still has a lot of secrets to reveal and to discover. Recent technologies allowed us to develop autonomous underwater vehicles (AUVs) to help us explore and monitor water mediums. Along with DISAL laboratory, the startup Hydromea has developed such vehicles. Compare the AUVs on the market, Hydromea's Vertex AUV claims to be smaller, lighter and at lower cost. These AUVs were taken on experimental missions in Lake Geneva last summer and we were able to use the data from it to make our experiments.

The AUV mission is to make measurements under water (Temperature, pH, pressure…) and reveal them on a 3D map. Also, it will be able to work as a swarm to make measurements at many positions at the same time.



AUV Swarm making a 3D map of collected data

In order to map the , an AUV should be able to know where it is. An inertial model alone is not sufficient for localization in water. However, because of the electromagnetic absorption of water, GPS cannot be used underwater but only on its surface. To overcome that effect, we need to use acoustic signals. Using acoustic signals raises many issues that we are trying to solve.

The AUV receive acoustic signals from beacons located on the surface. The beacons are themselves localized with the help of GPS sensors. The AUV is using tiny sensor nodes and gets noisy acoustic signals and they are converted to a position onboard. We are working on small AUVs that cannot embed heavy computers. A Raspberry Pi Zero with a 1GHz one-core CPU was chosen for this task.

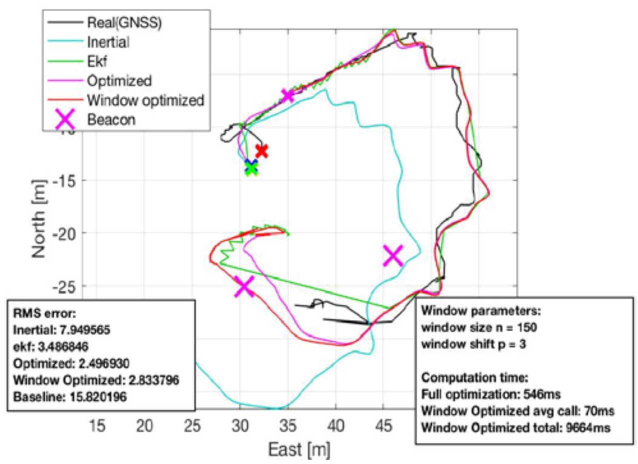
The inertial estimates and the measurements are fused together by an Extended Kalman Filter. However, EKF suffers from the Markov chain assumption, marginalizing the last poses for every update.

Our problem can be experimented in 2D because the depth component can easily be measured with a pressure sensor. For testing, we make the AUVs navigate at the surface and equip them with a GPS system. This allows us to compare our results with "real" position data.

As we can observe on the graph below, the position estimation from EKF has a lot of discontinuities. The purpose of this work was to optimize this result and implement so it can be done in real time. To get an optimized position estimation, we are using a factor graph representation of our positions. The graph is then a non-linear least square problem to solve. Among others solvers like Google Ceres or g2o, we decided to use GTSAM as it was the best turn-key solution, coming with many examples that we could use as models.

Firstly, we can perform a full trajectory optimization in post-processing using the inertial and measurements recorded during a mission. This is computationally efficient with GTSAM and results in a smooth path that can be used afterwards to map correctly the data acquired in water.

For the optimization to work in real time, the algorithm is called regularly (every p estimations) and ran over the n-last position estimations. Working like a sliding-window, this allows the AUVs to have a corrected position estimation every p pose.



Results of localization optimizations

Computation time tests were realized on a computer and the results are promising. The program still has to be ran on a Raspberry Pi and tested in real conditions for validation. This is planned to be done in a future work.