AUV Localization as an Optimization Problem

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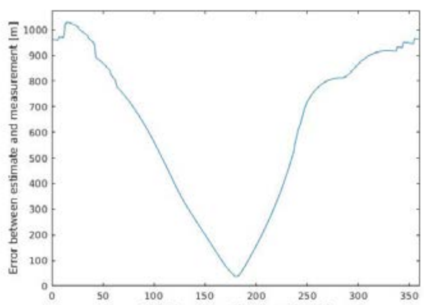
One of the major problems limiting research progress in submarine robotics, is the difficulty of underwater localization. Indeed, water has the particularity of greatly reducing the electromagnetic waves, preventing the use of localization systems such as GPS and radio communication. It is in this context that the DISAL laboratory initiated this project. The solution proposed is an Underwater acoustic positioning system that consists of surface-side and AUV-side acoustic transceiver devices. Knowing the position of multiple transmitting beacons, it is possible to triangulate the position of the AUV. However, multiple kind of errors can distort position estimates from inertial navigation such as bad calibration and/or wrong initial value for, vehicle mass, thrust constants, compass etc… For this project, the studied parameter was the initial heading angle.

$$E_{total} = \sum_{k=1}^{n} e(k) \qquad e(k) = |r_{measured}[k] - r_{predicted}[k]|$$

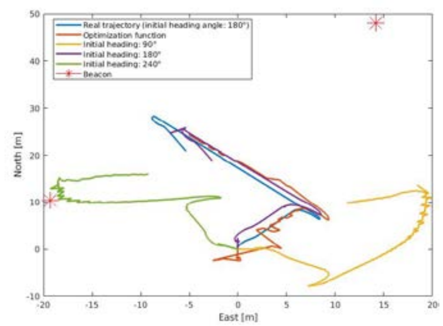
An error is associated to each angle, the angle with the smallest associated error will be considered as the initial heading for the next position estimation. This error is calculated as the sum of the differences between the range measured by the beacon and the estimated range. A new error is added and a new estimate of the initial heading is made at each range reception.



Accumulated error in function of initial heading.

Tests have shown that the smallest error is close to the real angle. The error in function of the heading angle is convex and has one minimum, but it's not exactly symmetrical and centered on the real heading. This is due to different phenomena such as water velocity, viscous drag, buoyancy or even the gyroscope drift.

The efficiency of the optimization was also tested against different constant angles. Optimization has overall better results, but under certain conditions a constant angle can be better. It especially need to be very close to the real angle. But after a certain travel time, the optimization function has anyway better results because it has enough data to get a good angle estimation and it can also adapt to noise that changes the ideal angle over time.



Trajectory comparison between the optimization and constant angles.

The time taken by the optimization to converge on an angle depends strongly on the trajectory, but a convergence between 30 and 40 seconds can be expected in a lot of cases.

A last point to consider is the very long computation time of the algorithm. On the current system, it takes about 1.2 seconds for each angle estimate. This could become a limiting factor if nothing is done in the future.

Globally the optimization seems to offer promising results and in a next project, It will be time to extend the optimization to other parameters such as vehicle mass or thrust constant. This is without forgetting the computation time which must be taken care of.