Motion Planning of Robotic Watercraft with LOS Control

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Abstract

Smooth movement is necessary for robotic watercraft to do water data collection, bathymetric mapping and environmental Monitoring. To achieve the smooth movement, two things need to be done. First, gradient descent optimization technique and the Quick Hull algorithm are used to coerce randomly-set waypoints into a smooth spiral trajectory. Second, the proposed control strategy for the motion planning is based on a modified Line-of-Sight (LOS) guidance law with integral action and a pair of adaptive feedback controller.

Background

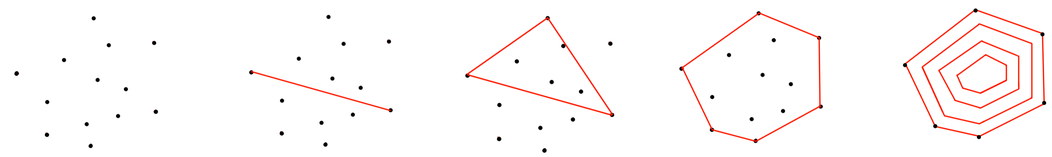
The boat model used in this project is based on The Lutra Prop, a small robotic boat developed by Platypus LLC.

The Lutra Prop

Methods

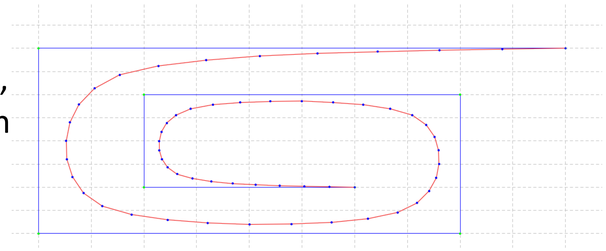
Step 1 Find the Convex Hull

To calculate the convex hull of a random waypoints set, the Quick Hull algorithm is one of the easiest to implement and has a reasonable running time of *O(n log n).*

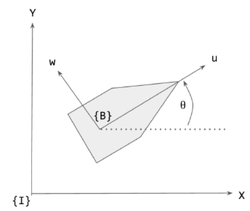


Step 2 Optimize

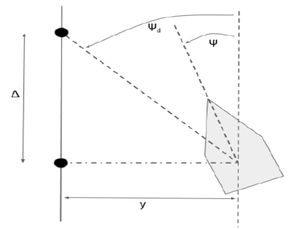
Optimization algorithm optimizes the data points in the crude spiral path to create a smooth trajectory. The optimization uses gradient descent. The smoothness of the trajectory is controlled by two parameters, one controls how close to the original path we wish the smooth way points to be, the other controls how curvy we wish the smooth trajectory to be.



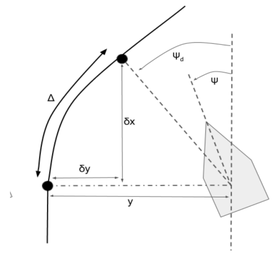
Step 3 Implement LOS control



Individual boat state geometry



LOS control for a straight line

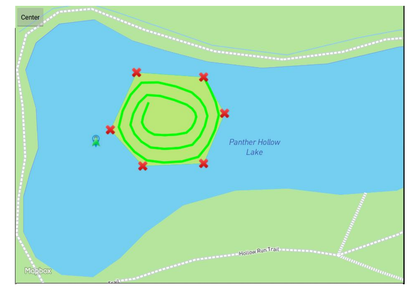


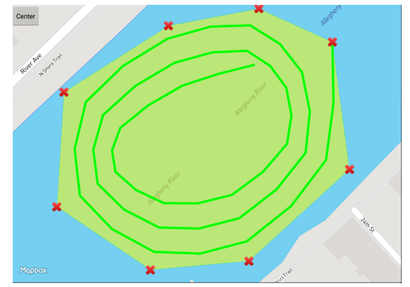
LOS control for a curve

Line-of-sight control is described as aiming the vehicle at some points lying on the desired path, usually at some fixed look-ahead distance relative to the vehicle's current position. Without considering the water flow disturbance, we can get the equation for the linear path: $\psi_d = -\tan(\frac{y}{\Delta})^{-1}$, the equation for the curve: $\psi_d = -\tan(\frac{y-\delta_y}{\delta_x})^{-1}$.

Preliminary Results

The spiral trajectory is shown on a Tablet. User can set some points on the map as the boundary and a smooth spiral path will be generated .





Future Directions

1. When the boat drives on ocean or river, we need to develop an improved LOS design that handles ocean currents by automatically creating the reference heading angle that produce the necessary side-slip.
2. Sometimes the spiral trajectory could converge, we will fix this problem.

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References

1. Jason Blum. Connecting Run-Time Metrics Outcome Performance of Team Attack and Defense. Master thesis, Pittsburgh, Pennsylvania. Carnegie Mellon University, 2016.
2. Borhaug E, Pavlov A and Pettersen KY. Integral LOS control for path following of underactuated marine surface vessels in the presence of constant ocean currents. In: *Proceedings of the 47th IEEE conference on decision and control*, Cancun, Mexico, 2008.
3. Platypus LLC. 2010 Smallman Str., Pittsburgh, PA 15222. senseplatypus.com.

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