Area Explored by an AUV

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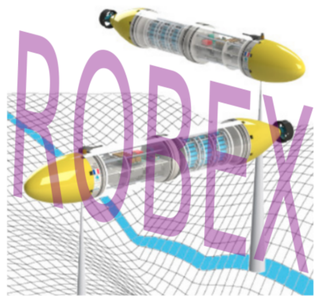
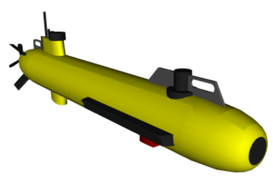


Problem Statement

We study the problem of an Autonomous Underwater Vehicle (AUV) exploring an unknown environment. The AUV has proprioceptive (IMU, DVL $\cdots$) and exteroceptive (sonar, cameras $\cdots$) sensors embedded.

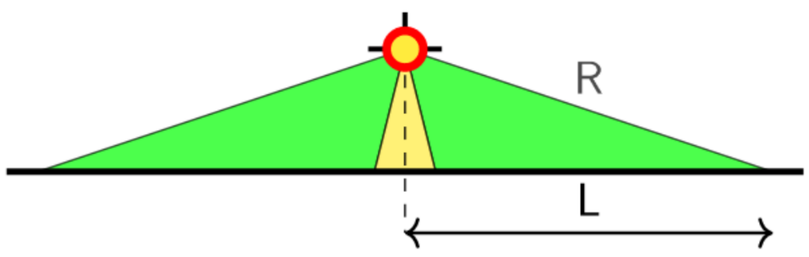
Objectives

Using only the robot's proprioceptive information we would like to compute in real time the explored area and how many times a point in the explored space has been seen by the AUV's exploration sensors.

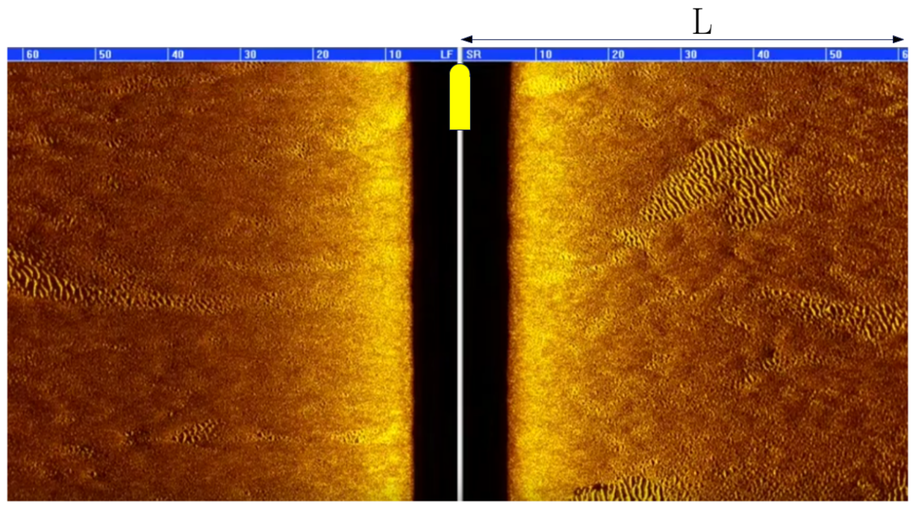


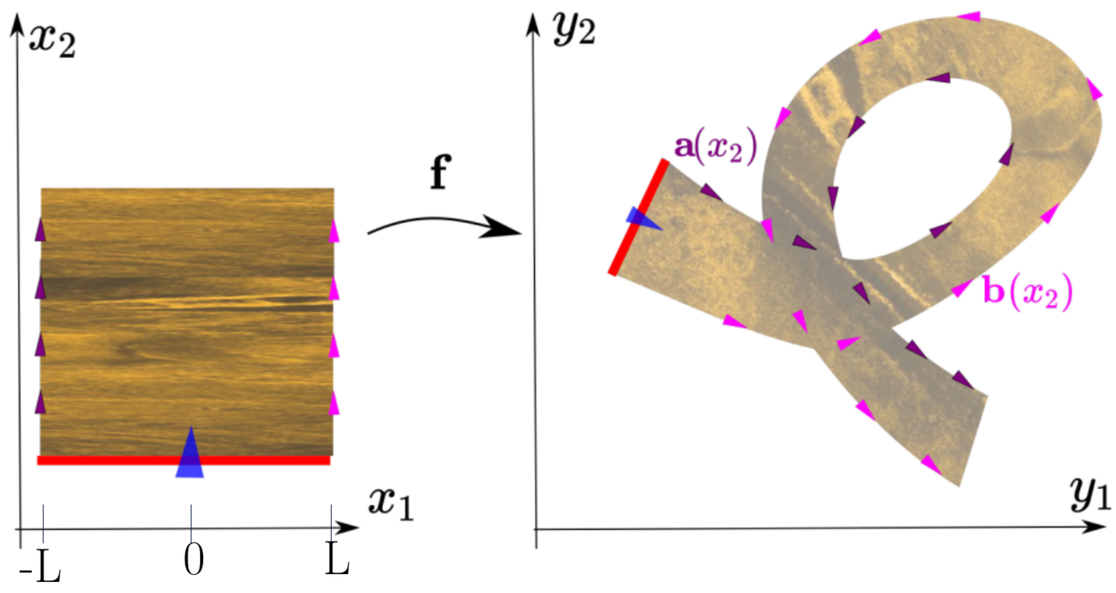
Context

We consider that the AUV has at each side a side scan sonar with a gap filler. At a first moment, for the sake of simplicity, we assume that the dynamics of the system are known and that the proprioceptive sensors are precise.



Side scan waterfall :





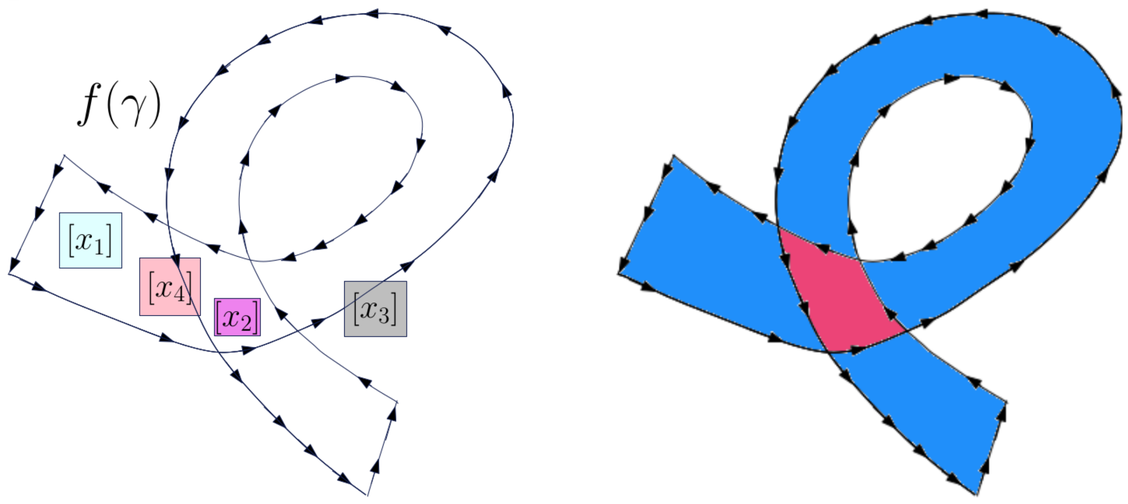
Contour

$$f(x_1, x_2) = a(x_2).\frac{(1 - \frac{x_1}{L})}{2} + b(x_2).\frac{(1 + \frac{x_1}{L})}{2}$$

The question "How many times has a point been seen by the robot ? " is equivalent to "How many times has a point been surrounded by the contour $f(\gamma)$?"

Winding Number

Winding numbers are an important concept in algebraic topology. The winding number of a closed curve with respect to a point is an integer that represents the total number of times the curve surrounds the point in a counterclockwise manner. A negative winding number counts clockwise turns around the point.



Conclusions

Using the properties of winding numbers and interval analysis we were able to compute in less than a second the area explored by an AUV in a simulated environment of $1250m^2$.

Future Work

- Add uncertainty to the robot's estimated trajectory
- Test the algorithm in real time in a a real environment

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