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Where's Wally?: Localization of acoustic landmarks using AUVs in a pose-graph framework

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***Abstract* – This work presents the implementation of an acoustic localization system that can work either with ranges or bearings. The algorithm is based on factor graphs and uses the information gathered from acoustic landmarks to estimate their position and the AUV pose without previous knowledge of their locations.**

***Keywords* -** *Acoustic localization, Autonomous Underwater Vehicle, pose-graph SLAM.*

I. INTRODUCTION

Although the problem of underwater acoustic localization has been studied in the past, either to locate landmarks or the AUV itself within a map, in most of them one of the two elements' positions is previously known, and the other is estimated in reference to it, such as LBL (Long BaseLine). In this work, the localization starts with neither the AUV nor the landmarks' position known. Thus, the main problem is to place both elements simultaneously on the map (i.e., simultaneous localization and mapping or SLAM). To achieve acoustic localization, a pose-graph algorithm is implemented. It utilizes acoustic signals from landmarks with data from the AUV internal sensors, to estimate both the landmarks positions and the AUV pose. This work is developed under projects PLOME [1] and BITER: the first uses static stations on the sea floor that help locate the AUV and afterward explore that area. These stations are deployed to gather local data to study the area and are equipped with acoustic modems that provide range information. After the AUV localizes itself in reference to these stations, the AUV will execute different missions such as acoustic mapping with a forward-looking sonar or a microbathymetry with a laser, to gather information from the area. BITER's main objective is to locate benthic fauna previously tagged with acoustic transmitters to study their behaviour. In this case, the AUV will receive bearing information (elevation and azimuth).

II. METHODOLOGY

Pose-graph SLAM (Simultaneous Location and Mapping) is an SLAM algorithm based on factor graphs [2] from which each node represents a pose of the robot or a landmark, and the edges of this graph are called factors and include information from sensors, i.e. acoustic, range and bearing, inertial data from a preintegrated IMU or internal from the vehicle like DVL velocities or depth from a pressure sensor). Factor graphs use least-squares optimization to estimate the robot's state at each newly added node.

To test the algorithm, we used the Girona1000 AUV [3], equipped with either a medium-frequency Evologics modem or a high-frequency Evologics USBL, depending on whether the acoustic information received will be ranges or bearings. The landmarks used were acoustic modems deployed in the area or part of the stations.

III. RESULTS

The experiments consisted of planned trajectories around the deployed landmarks to test the proposed localization graph. For better accuracy, the trajectories were mainly circular, since in the case of range information it has better observability [4]. Also, the depth was changed during the trajectory to reduce the uncertainty in the estimation of z.

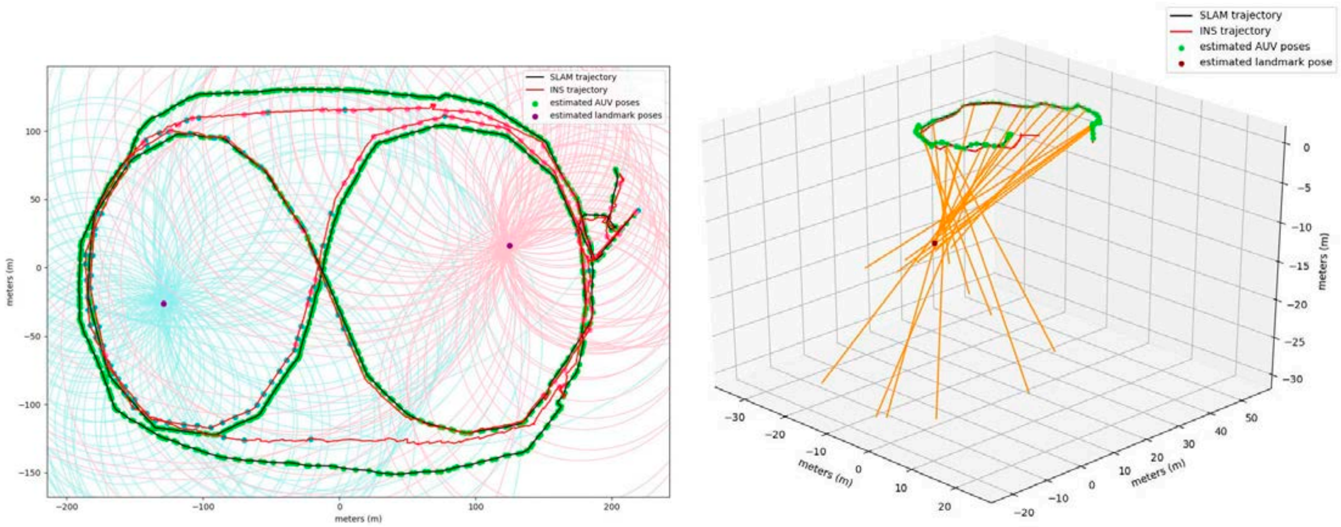

Fig 1. a)Acoustic localization of two stations by using ranges. Circumferences in blue and pink represent the rage received from each pose. b) Acoustic localization using bearings of an acoustic modem deployed at Sant Feliu de Guíxols harbor. The orange lines represent beams with the orientation of each bearing at the pose it was received.

Figure 1 presents the results of the localization algorithms. Figure 1 a) shows an acoustic localization of the static stations using ranges while Figure 1 b) presents the bearing-based localization of an acoustic modem that simulates the transmitters to be attached to benthic fauna.

IV. FUTURE WORK

Now that the localization has been achieved by using fixed trajectories, the next step in this project is the implementation of a path planning algorithm capable of optimizing the trajectories to reduce the localization time while improving the estimation of the landmarks. This optimization will be attained by implementing an informative path planning strategy that will take into account the observability of the landmarks and move the robot to maximize the information gain.

V. ACKNOWLEDGEMENTS

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