# Acoustic Detection of Underwater Obstacles

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This project investigated the use of an acoustic range and bearing system for echolocation. The acoustic system was originally developed for multi-vehicle coordination for underwater robots, consisting of an omnidirectional transmitter and up to 4 receivers. In this project we want to investigate if the same system can be used to detect nearby underwater obstacles, such as the lake bottom, rocks and walls.

The goal of this project is to investigate if the system used to localize each submarines inside the group can also be used to detect underwater obstacles, such as the lake floor, rocks... Ideally, the final range of detection should be at least 100 meters.

In the first part of the project some echoes were recorded, and target positions were estimated using the time of flight of the sound and the time difference of arrival between multiple receivers. All the processing was done offline.

After that, the approach of image reconstruction was taken, with all the processing done offline. This part should started with the visualization of the surrounding using each recording. Subsequently, recordings from different times and locations were fused into one global map.

During the project, several tools were developed to analyze the recording and try to detect obstacles. First, some basic tools were introduced to simulate and localize targets in ideal situations. These results were confronted with reality and the method had to be adjusted, since the reality is much different. The new method consists in computing the probability of a reflection for all the points in the horizontal plane, instead of focusing only on some specific points. Finally, a method was developed to merge information together in order to improve the results of a single pulse recording.

In chapter 3 interesting results were presented and some real obstacles were detected. Some additional tests should be performed in order to fully confirm those results, in a well-known environment for example. However, coming back on the initial goal of the project, these results are satisfying, as they offer the possibility to evaluate the capabilities of the system.

Depth of the water is easily detected using the first arrival of ground scattering which is clearly visible. It is also possible to roughly estimate distance to obstacles with local likelihood maps, and even the direction if multiple maps are fused together. Some features have been observed up to 30 meters away. These results could already be implemented on the real system for a very basic awareness of the environment.

In order to precisely localize obstacles and reconstruct their shapes, some improvements in the fusion process have to be made. Currently, only very distinctive targets can be detected. Thus, with some additional work, reliable detection of clear targets in a well-defined environment may be achieved.

Finally, the omni-directionality of the emitter creates difficulties, as many echoes are recorded. Considering this and the limited processing capabilities of the acoustic board, accurate mapping and imaging won't be possible.

In conclusion, basic obstacle detection is currently possible with serious limitations. Some of those limitations may be removed with additional work, but it is clear that this system is not suited for real mapping and imaging. It is also expected to obtain better results in deeper water, with well- defined obstacles.