Validation – Mapping of Ancient Water Storage Systems with an ROV for Visualization – An Approach Based on Fusing Stationary Scans within a Particle Filter

William McVicker*, Christopher M. Clark*
*California Polytechnic State University
San Luis Obispo, CA 93407 USA
Email: wmcvicke@calpoly.edu

I. Validation

The algorithm developed in my thesis localizes and maps underwater water storage systems found mainly in Malta. The algorithm uses sonar data that is gathered while the underwater robot remains stationary. This method removes the motion model, which in turn eliminates the common odometry uncertainty errors found in SLAM applications.

To increase the likelihood of localizing the robot within a map, a weighted least squares approach is taken with the cost function aimed to reduce the distances between the positions of the robot for each sonar scan (1) where i and j represent the two scans attemping to align with one another and n equalling the type of measurement taken where there are four different types of measurements: 1) the measured distance between the originally loaded scan and the converged particles' location, 2) the measured distance explained in 1) where scan j is loaded first as opposed to scan i being loaded first, 3) a pseduo measurement calculated from the previous 2 measurements, and 4) another pseudo measurement.

$$S = \sum_{i}\sum_{j}\sum_{n=1}^{4} w_{ij\_\mu\_n}(d_{ij} - \hat{d}_{ij,n})^2 \,, \tag{1}$$

To validate our algorithm, we cannot easily compare our results to truth vales because the sites explored are underground and inaccessible for us to manually measure. To accommodate for this, we mapped a swimming pool that could be used to compare dimensions of the generated map to the true dimensions of the swimming pool. Additionally, in situations where the truth values are not available, mosaics were manually created to be used as a suppliment to the truth values. These mosaics are considered to be extremely accurate.

In comparing the truth values or mosaics to the dimensions of the generated maps, we calculated a standard deviation using these measured differences. The standard deviation represents how accurate our scan matching algorithm aligns the collection of sonar scans.

The validation process was executed for three different sites: a Mdina private home, the Mdina Cathedral Sacristine, and a swimming pool. Table I shows how well the algorithm worked for these three different sites.

TABLE I: Mean Dimension Differences (Grid vs. Mosaic)

Site Name	Width (m)	Length (m)
Mdina Home (Site 8)	0.000	-0.022
Mdina Sacristine	-0.027	-0.04
Swimming Pool	0.105	-0.025