6
Conclusions and Suggestions

6.1.
Conclusions

This work has contributed to elaborate a general technique that enables a robot to calculate its position relative to the environment through the use of a camera. The method has proven to achieve a fair accuracy in the experiments performed. The techniques used in this work are not specific for the TA-40 manipulator and can be applied to any manipulator.

Incorporating both calibration of the manipulator structure as well as the calibration of the manipulator base, this work includes the initial steps required to achieve a good absolute precision in the work environment. This can be used to give feedback to the operator in a virtual environment. In this virtual environment, work procedures and trajectories could be planned and programmed without the use of the manipulator.

When the manipulator has attained a good absolute precision and the absolute position of the base has been estimated, the inverse kinematic model could be used to perform preprogrammed trajectories. In this way, many of the operators' tasks could be automated.

All the kinematic models for the TA-40 manipulator have been developed. Experiments were performed using an x-y table and two cameras; a webcam and an underwater camera. The webcam achieved to estimate its position with an error less than 5mm RMS in all directions. The underwater camera achieved an accuracy of approximately 10mm RMS. The LMS algorithm gave the most accurate estimate of the relative orientation between two views and hence gave a more accurate position for both cameras.

6.2.
Suggestions for future work

During this project methods have been developed that allow a manipulator to estimate its relative position in a 3D environment. The method uses the SIFT algorithm which is a fairly new algorithm in computer vision. This work has used a Matlab implementation of the algorithm in the experiments. The algorithm is computationally heavy. In Matlab, estimating the SIFT keypoints for one image may take several minutes. When working in the laboratory this is not such big problem, but when the manipulator is to perform a real time base calibration, the process needs to be sped up. SIFT is subject for a lot of research, so some improvements to the algorithm can be expected.

In [25] several different region detectors were used to detect interest areas for the SIFT algorithm. The different region detectors proved to find the most likely areas to find robust keypoints, meaning that SIFT did not have to be computed on the whole image, making the computation faster.

When it comes to the use of underwater cameras in position estimation, there are a few problem areas that need to be solved. Due to the thick glass in front of the camera, the images will suffer from distortion. When the distortion is large, it might influence the recognition of SIFT keypoints. To investigate the potential use of the underwater camera in positioning, underwater tests need to be performed using objects of interest that are similar to the ones found in the manipulator's actual work environment. The resolution of the digital converter board should also be able to make use of the full resolution of the analog camera. It would also be advantageous if the images could be stored in a format without compression to avoid any distortion that a compressed image might have.