Low-Cost Underwater Localisation

Design and development of a device for the dynamic acquisition of SONAR measurements

Graduate

Michael Scherrer

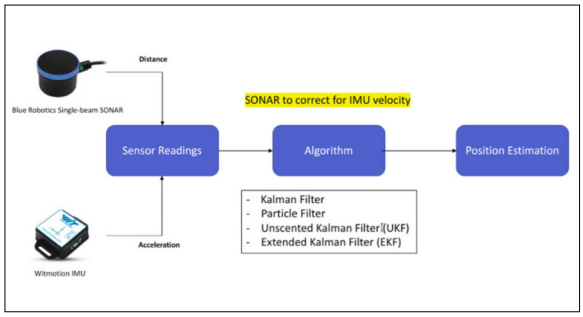
Problem: The project aims to develop a robot that can navigate and move around underwater. With an IMU, an attempt is made to measure the displacement of the robot in space and to localise its position on the basis of the measured values. However, since an IMU always involves a certain drift, an additional measurement system is needed to support the IMU. SONAR is a measuring method that can measure the distance to other solid bodies using the travel time of sound waves in water. Such a specific sensor is available at the beginning of this thesis. However, in order to integrate it into the system, the knowledge of how its measurement behaviour is exactly and what contribution it can make is not yet available.

Approach: In order to characterise the given sensor, a setup should be developed that allows measurements to be taken in a pool. The sensor will be mounted 1 m under water on a floater that simulates the robot and has the necessary equipment to record the sensor's measurements. This floater is now to be set in motion at a constant speed so that the distance to the pool wall can be measured at the same time. In parallel, there is an optical distance sensor on the floater, which is mounted above the water surface and is used as a ground-truth reference. The resulting measurement series are to be processed and interpreted. The measurement is successful if the measurement series have a linear course corresponding to the movement and the difference to the measurement series of the optical distance sensor is small.
First, the Rope-Pulley-Machine is modelled and then manufactured. It contains a stepper motor that drives a pulley. A rope can now be wound on this pulley, which is tied to the rig and thus set it in motion. An Arduino Uno is used for control so that a constant speed is achieved. This will be used to execute the first experiment and record the measured values.
The next step is to improve the stability of the movement. For this purpose, the system is extended with another rope, which is directed at a pulley at the other side of the pool and guides the rig from the other side at the same time. With this, the second experiment is carried out and the measured values are processed with Python.

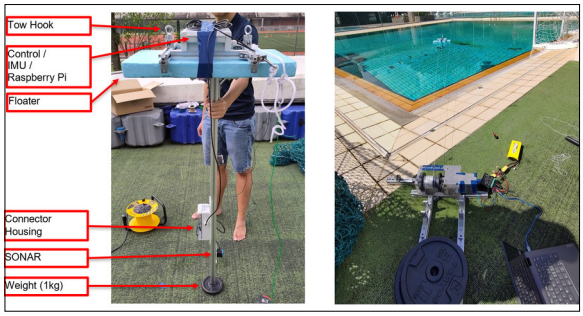
Result: Localisation is possible with the SONAR sensor. The course of the measured values of the SONAR mainly corresponds to the TOF values. However, individual measurement errors are detected, the cause of which is not fully known. In addition, the measured values are output by the sensor with a delay. The resulting error can be reduced by reducing the ping time, but cannot be completely eliminated. The developed measuring setup achieves an accuracy of 4.28% and a reproducibility of 3.82%.
In order to pursue the goals of the project, 2 of the SONAR sensors should next be tried simultaneously.

The data obtained can then be used to simulate the localisation. To achieve this, a pragmatic approach is recommended. It is not absolutely necessary to know the exact cause of the recorded measurement errors.

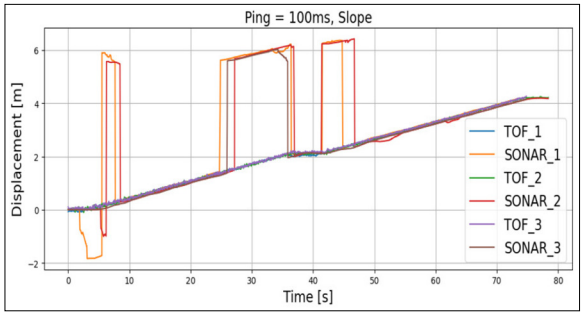
Acquisition of position data
Own presentment



Rig and experimental setup
Own presentment



Data analysis, systematic error
Own presentment



Advisor
Prof. Michael Hubatka

Co-Examiner
Dr. Antje Rey, Zürich, ZH

Subject Area
Automation & Robotics, Mechatronics and Automation Technology, Sensorics

Project Partner
Nanyang Technological University, Singapore