# Building a Platform for Testing Underwater Navigation Based on Environmental Sensor Data

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## SUMMARY

Autonomous underwater vehicles (AUVs) holds a significant promise for hydrography and deep-sea exploration. The CIAM research project (Comprehensive Integrated and Fully Autonomous Subsea Monitoring), funded by the German Ministry of Economy, is dedicated to developing various AUVs for monitoring critical infrastructure, particularly deep-sea pipelines. These vehicles are equipped with a range of acoustic and optical sensors to monitor pipeline conditions, enabling the detection of damages and leaks. Employing a port-to-port concept allows for additional cost savings by directly following the pipeline without the need for a mothership. Traditionally, AUV navigation leans on inertial navigation, but to enhance long-term stability, updates are incorporated from a surface accompanying leading vessel or a network of installed underwater beacons providing extrinsic pose estimation through acoustic modems. However, this method is considered costly and under certain circumstances less robust due to expensive technology and the challenges posed by error-prone acoustic communication technology. The CIAM project investigated how sensors actually intended for monitoring pipelines can be used to support inertial navigation. The research in this paper focuses on the development of an Extended Kalman Filter (EKF) integrating Inertial Navigation System (INS) sensor data for navigation using a-priori knowledge as well as visual and acoustic odometric methods. Recognizing the expensive and labor-intensive nature of underwater testing, a test platform has been created to evaluate these algorithms on land, utilizing sensors with specifically transferable characteristics to underwater environment. This platform includes a camera-based solution capable of identifying continuous features and computing velocity. Identified landmarks by the camera serve as references for updating the position estimation; potentially involving unmistakable geometries, labels, or purposefully placed markers, providing distinctive references with absolute coordinates to reinforce inertial navigation. Utilizing a line-laser-camera triangulation scanner, the study reconstructs the point cloud that is generated underwater with a multibeam echosounder carried by an AUV. The

analysis of this point cloud occurs a few seconds after data capture, introducing temporal discontinuity, which aids the pose estimation in a closed-loop or cascaded EKF.

This approach develops the possibility of guaranteeing not only precision but above all robustness. It further aims to improve navigation accuracy in challenging underwater environments and forms a basis for further advancements in this field.