Surveying subsea cables and pipelines with non-ideal sonar

The imaging performance of a sonar depends on both mechanical and environmental properties. Examples of mechanical properties are deviations from specified requirements such as sensitivity, position, or orientation of elements during production or because of ageing. The marine environment can affect the image quality by, for example, marine growth on the sonar.

This project aims at testing sonar arrays sensitivity to calibration errors in the context of subsea cable and pipeline surveys. The project has two parts. We want to establish a baseline for standard imaging algorithms by analysing the performance using statistical analysis of the effect of calibration mismatches. Additionally, we want to quantify the sensitivity to calibration errors of adaptive array signal processing methods. This we will do by using simulated sonar recordings for many scenarios. Together, this would enable the consideration of robustness in the selection and pre-verification process of the adaptive DSP method before it would be used under field conditions.

Background

Safe and efficient transportation of offshore energy will always require well maintained **underwater infrastructure**, no matter if the energy source is fossil, wind, sun or wave. Subsea cables and pipelines can be efficiently surveyed using **sonar systems** mounted on surface or underwater vehicles.

Adaptive array signal processing methods are increasingly used to improve image quality in specific survey scenarios. In a previous study, we generated sonar data by **computer simulations** for many scenarios. These virtual recordings were used to benchmark adaptive array signal processing methods, which demonstrated significant improvement in the **imaging performance** under the assumption of an ideal sonar array. Field tests, however, show that adaptive methods can be quite sensitive to **array calibration errors**.

Interval analysis of sonar array beampatterns has proven to be an efficient method of analysing the worst-case effect of manufacturing tolerances, aging and environmental conditions[1]. The application of these analytical results on a specific use-case combined with **Monte-Carlo simulations** can be of significant practical use.

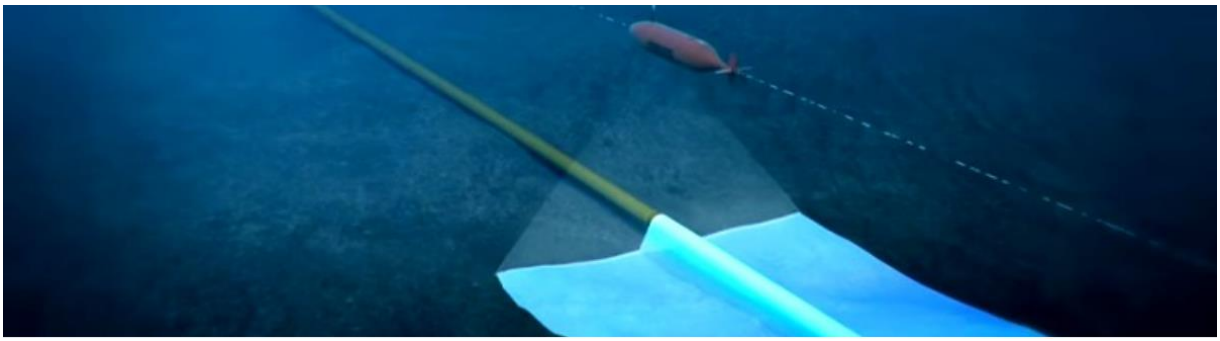

Figure 1: Hugin AUV inspecting an underwater pipeline (source: Kongsberg Maritime)

[1] Arnestad, Geréb, Lønmo, Kirkebø, Austeng, Näsholm. 'Sonar Array Beampattern Bounds and an Interval Arithmetic Toolbox'. *Proceedings of Meetings on Acoustics* 47 (2022). https://doi.org/10.1121/2.0001613.

About the DSB group

The project is hosted by the group for Digital Signal Processing and Image Analysis (DSB) at the Department of Informatics (Ifi). It has direct relevance to two **ongoing PhD projects** at the group, allowing the student to exchange ideas and technique, and work closely with PhD researchers.

The DSB group is participating – together with Kongsberg Maritime (KM) and the Norwegian Defence Research Establishment (FFI) – in the **Next generation echo sounder** industrial research project founded by the Research Council of Norway (RCN). The DSB activity within the project includes an ongoing PhD research (Gábor Geréb) and it builds on the results of two recently defended PhD theses from the DSB group (Tor Inge Birkenes Lønmo, Antoine Blachet). In addition, PhD student Håvard Arnestad is working closely together with Gábor on quantitative sensor array evaluation.

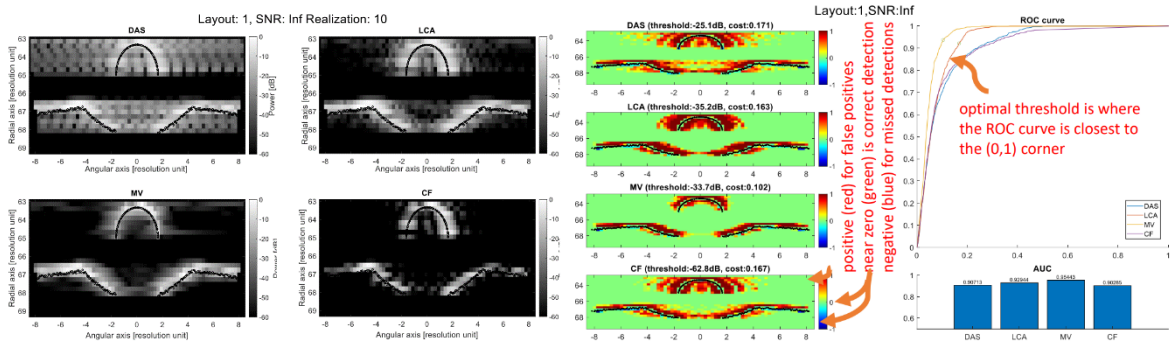

Figure 2: Beamforming simulated sonar data with various beamformers and then benchmarking the results

About the candidate

The project includes two positions.

- One student will **modify sonar data** simulated under the assumption of an ideal sonar array to contain realizations of random calibration errors (sensitivity, position, orientation, crosstalk, etc.). The student will establish a baseline for sonar performance. The results are to be interpreted using the Beampattern Interval Analysis Toolbox**.**
- The second students will have to **process sonar data** using multiple preselected calibration errors and adaptive array signal processing methods. The processing will be performed using the USTB Matlab package. **Quantitative evaluation** of the resulted images will be done using the Ultrasound Beamformer Benchmarking Framework.

The tasks involve numerical simulation and processing of sonar data using Matlab. We are looking for **enthusiastic and self-driven** candidates who has a passion for scientific computing, signal processing, and who would like to work with applications related to green energy.

You need to know how to perform experiments using Matlab libraries. Previous knowledge in **numerical modelling, signal processing and applied statistics** is an advantage (for instant having taken the courses IN3190/4190, IN5340, IN5450).

The timeframe is flexible but the project should be started before the summer vacations in July.

Contact persons

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