Machine Learning Based Modelling of the Surface Conditions of Coastal Seas

Summary

This study explores the use of statistical machine learning and deep learning techniques in conjunction with Synthetic Aperture Radar (SAR) data to estimate wave density spectra in the Baltic Sea. Traditional in situ wave buoys for measuring waves on a large scale are impractical due to high maintenance costs. SAR, offering a spatial overview independently of daylight or cloud coverage, is a viable alternative. The objectives include assessing the success of previous experiments, identifying key success factors, determining optimal SAR and spectra processing practices, and establishing the capabilities required to estimate wave spectra from various SAR data sources. The end goal is an operational software system for the estimation of wave spectrum.

Research field:	Earth sciences
Supervisors:	Sander Rikka
	Dr. Sven Nõmm
Availability:	This position is available.
Offered by:	School of Science
	Department of Marine Systems
Application deadline:	Applications are accepted between January 01, 2024 00:00 and January 22, 2024 23:59 (Europe/Zurich)

Description

The research

Coastal seas are of high importance for human society for providing medium for economic, social, and recreational activities. For providing safety on the sea, measuring surface waves is necessary to avoid needless risks. It is also clear that using in situ wave buoys on such large scale is not feasible because of high maintenance costs. Another way of measuring surface waves is using satellite Synthetic Aperture Radar (SAR) which data is shown to have link with sea state. SAR is great technology that provide spatial overview of large area independently from day light or cloud coverage. It can therefore be used to provide spatial overview of surface waves with high frequency.

Various algorithms have been developed for SAR for estimating both 1D or 2D wave spectra or bulk wave parameters. Sequential AI models such as long short-term memory (LSTM) and Deep Learning Transformers (originally developed as large language models in natural language processing) have demonstrated promising results. Proposed PhD project aims to establish solid frameworks answering the following goals:

- Find the limits for application statistical machine learning techniques for spectra estimation.
- Develop novel Transformer models for the task.
- Explore the possibility to enhance prediction quality using multi modal approaches integrating the data from the additional sources.

Specifically, the aim is to explore the possibility of training the model on one satellite data and application of the model for other ongoing and past SAR missions. Another point of interest is the interoperability of the models built for Baltic Sea in other seas and lakes that are similar in scale. The secondary goal is to provide software system for operational application.

The thesis should address the following questions:

1. How successful have been the previous or ongoing experiments for estimating wave spectra in the coastal seas?
2. What are the main lessons about the success factors?
3. What are the best SAR and spectra processing practices that leads to the most accurate wave spectra estimations from SAR data?
4. Which capabilities are needed to estimate wave spectra from past and other ongoing SAR data?

Supervisors

Main supervisor: Dr. Sander Rikka

Co-supervisor: Prof. Sven Nõmm

Responsibilities and (foreseen) tasks

- Compile datasets for SAR, in situ, and wave model spectra
- Train and validate neural network model
- Support teaching activities of Dr. Sander Rikka and Prof. Sven Nõmm

Applicants should fulfil the following requirements:

- A master's degree in one of the following subjects: Natural Sciences (Earth Sciences, Oceanography, Physics etc.) or Computer Science.
- A clear interest in the topic of the position
- Good skills in one of the following computer languages – Python, MatLab, R.
- Excellent communication of English
- Strong and demonstrable writing and analytical skills
- Capacity to work both as an independent researcher and as part of an international team

The following experience is beneficial:

- Knowledge about Linux/Unix systems, High Performance Computing (HPC) environments.
- Previous experience with data bases (i.e., Copernicus), data mining, implementation of machine learning methods.
- Previous experience in analyzing geospatial data (remote sensing imagery, structured- and unstructured model fields).
- It is desirable if candidate can share some of their GitHub projects to demonstrate programming skills.

The candidate should submit a research plan for the topic, including the overall research and data collection strategy. The candidate can expand on the listed research questions and tasks, and propose theoretical lenses to be used.

We offer:

- 4-year full time (fully funded) PhD position in an outstanding Baltic Sea research institution with a large portfolio of ongoing pan-European and national public sector applied research projects.
- Opportunity to participate in applied research projects funded by European Commission (e.g. LIFE program), European Space Agency (ESA)
- Opportunities for conference visits, research stays and networking with globally leading universities and research centers in the fields of applications of machine learning, satellite data processing and oceanography.

About the department

Tallinn University of Technology (TalTech), the only technological university in Estonia, is the flagship of Estonian engineering and natural sciences. Here the synergy between different fields (technological, natural, exact, economic and health sciences) is created and new ideas are born.

The Department of Marine Systems at TalTech is a leading oceanographic and meteorological R&D unit in the Baltic Sea region. We focus (1) on oceanographic process research based on scientific analysis to find cause-and-effect relationships and (2) on developing marine monitoring and forecasting services. The implemented methods include machine learning based algorithms for satellite image processing and for model data analysis as well as development of innovative (operational) methods for monitoring the marine environment and analyzing the changes. We have long-term experience in developing applications and methods for operational oceanography, the outputs of which are information products provided to the general public and to various authorities on water level variability, ice conditions and other parameters of marine physics. We are contributing significantly to the pan-European Copernicus program (CMEMS) and Destination Earth (DestinE) initiative.

Additional information

For further information, please contact Sander Rikka (sander.rikka@taltech.ee) or Sven Nõmm (sven.nomm@taltech.ee).

To get more information or to apply online, visit https://taltech.glowbase.com/positions/725 or scan the the code on the left with your smartphone.