Development of continuous dynamic vertical reference for maritime and offshore engineering by using machine learning strategies

Summary

The PhD candidate shall develop a method that combines in-situ, hydrodynamic models and remote sensing data to develop continuous dynamic vertical reference. This development requires: (i) computing the sea level data from various sources and bringing them to a common vertical reference datum using the geoid; (ii) using machine leaning methods to merge the sea level and bathymetry data to enable adaptive routing and its error estimates; (iii) validation (with independent data sources (e.g. field experiments) and sensitivity analysis (e.g. RMS error, and scatter index (SI), error budget) and (iv) using all the sources (sea level, currents, bathymetry) along with the relevant data on the contributors to perform statistical and machine learning algorithm to and its associated uncertainty. The candidate is required to perform, statistical and computing techniques (in terms of RMS error, stand. dev, uncertainty estimates, error budgets, machine learning techniques etc.). From these results a specific model shall be developed that is essential for engineering and navigation purposes. The candidate is expected to assist in project related field campaigns.

Research field:	Building and civil engineering and architecture
Supervisors:	Prof. Dr. Artu Ellmann Dr. Nicole Camille Delpeche-Ellmann
Availability:	This position is available.
Offered by:	School of Engineering Department of Civil Engineering and Architecture
Application deadline:	Applications are accepted between June 01, 2023 00:00 and June 30, 2023 23:59 (Europe/Zurich)

Description

Background

Increased development in the marine areas has caused dramatical intensification of maritime and offshore engineering activities over the past years. This has become especially challenging for large ships (especially that of LNG and cargo) to sail shallow waters and enter ports due to limited manoeuvrability or under-keel clearance (UKC - vertical distance between the ship's keel and the sea bottom). Thus actual determination and forecasting of sea level and currents data becomes of utmost importance, where systematization of obtaining environmental information contributes to the increase efficiency and safety of navigation. Several sources are often used to obtain characteristics of the marine dynamics (e.g. tide gauges, hydrodynamic models (HDM), Global navigation satellite system (GNSS), marine buoys, satellites etc). Over the years GNSS applications has increased in accuracy and application and we now explore its capabilities in determining the adaptive routing in shipping. One of the key issues is solving realistic sea level and referring the marine data-sets to the physically meaningful reference datum. Such a geodetic vertical datum relates the GNSS obtained coordinates to contemporary nautical charts and enables the calculation of a vessel's height rigorously. The vertical datum is the zero level for the depths and heights in maritime and civil engineering applications. The geodetic and hydrographic communities have already adopted the concept of geoid-based vertical datum over marine areas. Access to an appropriate marine geoid model now enables providing the realistic sea level heights in the absolute sense (as opposed to sea level relative trends, which are used by different research communities, For the sea level analyses various sources such as tide gauges (TG), satellite altimetry (SA), shipborne and airborne GNSS profiles and hydrodynamic models (HDM) are often utilized. Advancements made in computing technology and artificial intelligence (machine and deep learning methods) allows a more strategic approach on synergizing the different data sets and a more accurate quantification to be performed in real-time. The focus of this study is that by combining different sources (hydrodynamic models, GNSS data, currents, waves, wind etc) for the development of continuous dynamic vertical reference that allows real time adaptive routing in shipping. This can be accomplished by the utilization of statistical and machine learning methods.

Tasks

The PhD candidate shall develop a method that combines in-situ, hydrodynamic models and remote sensing data to develop continuous dynamic vertical reference. This development requires: (i) computing the sea level data from various sources and bringing them to a common vertical reference datum using the geoid; (ii) using machine leaning methods to merge the sea level and bathymetry data to enable adaptive routing and its error estimates; (iii) validation (with independent data sources (e.g. field experiments) and sensitivity analysis (e.g. RMS error, and scatter index (SI), error budget) and (iv) using all the sources (sea level, currents, bathymetry) along with the relevant data on the contributors to perform statistical and machine learning algorithm to and its associated uncertainty. The candidate is required to perform, statistical and computing techniques (in terms of RMS error, stand. dev, uncertainty estimates, error budgets, machine learning techniques etc.). From these results a specific model shall be developed that is essential for engineering and navigation purposes. The candidate is expected to assist in project related field campaigns.

Requirements

The call is open for candidates that fulfil the following requirements:

- University degree (M.Sc.) in geodesy. Consideration will be given to applicants whose previous degrees are in appropriate related discipline, such as Earth Sciences, Marine Engineering, Mathematics or Physics.
- A clear interest in the research topic are preferred
- Advanced computer literacy and programming skills (e.g. Python, C++, MATLAB).
- Strong and demonstrable writing and analytical skills
- Skills in data analysis, mathematical and statistics (to be trained), machine learning methods (to be trained)
- Ability for independent research as part of a team, interest in the presentation and publication of scientific results.
- Good command of the English language (speaking and writing).

The shortlisted candidate may be required should submit a research plan for the topic. The candidate can expand on the outlined research scope.

We offer:

- 4-year PhD position (full time) in the Civil Engineering and Architecture that has a sound portfolio of ongoing European and national research projects
- An environment to perform excellent research and publications
- Opportunities for training relevant technical and transferable skills aiming academic or industrial careers
- Opportunities for conference visits, research stays and networking with globally leading companies, universities and research centres in the field of research

The candidate is obligated to participate and fulfil the requirements of Tallinn University of Technology PhD programme. Additional funds will be provided (and whence applicable the associated funding can be applied for) for research trainings, conferences and international mobility/stays abroad with durations of up to 3 months. The research group wishes to increase the number of women interested in Geomatics and Engineering. Qualified women are therefore also encouraged to apply. Do not hesitate to contact us for questions regarding the position. We look forward to receiving your application.

About the departments

Department of Civil Engineering and Architecture is an interdisciplinary teaching and research center of Tallinn University of Technology that focuses on various actual research issues. The department consists of several research groups. The geodesy research group has mainly been focused on the national geodetic infrastructure related research (modelling the gravity field and geoid, precise height network, GNSS positioning). Currently the TalTech geodesy group is participating in the international collaboration for implementing the Baltic Sea Chart Datum 2000 by improving the marine geoid modeling. Most of the Baltic Sea countries have agreed to adopt this new marine geoid based vertical datum as initial for the nautical charts, hence also for the maritime and offshore industry. The recent European

Space Agency sponsored international project Geodetic SAR for Baltic Height System Unification tested potential of the Interferometric Synthetic Aperture Radar (InSAR) of unification of across-ocean vertical datums. The group has relevant contractual research for industry, environmental and governmental agencies, for the details see A. Ellmann's (head of the group) ETIS account, https://www.etis.ee/CV/Artu_Ellmann/eng .

The Laboratory of Waves Engineering is part of the Department of Cybernetics at TalTech, the focus of this lab has been on complex and nonlinear phenomena in wave dynamics and coastal engineering, and the applications of mathematical methods in wave studies. Recent focus has been one the use of Lagrangian transport of different substances in marine environment for marine and maritime spatial planning, adequate description of hydrodynamic (wave and water level) extremes, and preventive methods for mitigation of marine-induced hazards. The geodesy group has participated in the wave dynamics for coastal engineering and management related large projects, for the details N. Delpeche-Ellmann's ETIS account https://www.etis.ee/CV/Nicole_Delpeche-Ellmann/eng/ These projects are relevant to the present research since the results and knowledge acquired contribute toward identifying and quantifying ocean dynamic processes.

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