Data-driven real-time bathing water quality monitoring system development

Summary

This PhD position, part of the UrbanSplash project within the Smart City initiative, aims to revolutionize the monitoring of bathing water quality (BWQ) by addressing critical limitations in current systems. Existing methods for detecting faecal indicator bacteria (FIB), such as E. coli and enterococci, are slow, often taking 18–72 hours or more, which delays risk mitigation and fails to protect public health effectively. The research focuses on developing innovative solutions combining low-cost sensors with advanced machine learning (ML) and physics-informed neural network (PINN) models to provide real-time, high-resolution BWQ data and spatial predictions. By integrating multiple data streams, including real-time sensor readings, meteorological forecasts, and hydrometric data, this work will enable rapid detection and forecasting of pollution events, improve public health safety, and promote sustainable use of urban water bodies.

Research field:	Information and communication technology
Supervisors:	Prof. Dr. Sadok Ben Yahia Dr. Uljana Reinsalu
Availability:	This position is available.
Offered by:	School of Information Technologies Department of Computer Systems
Application deadline:	Applications are accepted between January 01, 2025 00:00 and January 24, 2025 23:59 (Europe/Zurich)

Description

The research

The topic is part of the Smart City project UrbanSplash (One-stop shop for the management of outdoor bathing water quality). The UrbanSplash project aims to revolutionize the monitoring of Bathing Water Quality (BWQ) by addressing several deficiencies in data acquisition and communication found in current monitoring programs. The goal is to improve and accelerate the monitoring of bathing water quality. The current European Bathing Water Directive (BWD, Article 12) explicitly demands warning about present and predicted pollution events to prevent bathers from being exposed to contaminated water. In the EU the BWD proscribes monitoring of bathing waters with a new classification into: Poor, Sufficient, Good or Excellent. This classification is based on the enumeration faecal indicator bacteria (FIB), E. coli and enterococci. There is no fit-for-purpose solution that can provide microbiological water quality data in a time-frame that enables rapid decision-making and risk mitigation. Standard culture-based methods, although highly standardized are time-consuming and have a time to results ranging from 18 to 72 h, which makes same-day sampling and action impossible; in certain circumstances it could take up to 7 days for laboratory results, during which time users at risk. Low sampling frequency does not provide a representative picture of bathing water quality at sites that are frequently affected by pollution events and thus cannot provide public health protection.

The goal of the project is to develop and implement a comprehensive solution (addressing all limitations of current monitoring system) that can provide real-time, high-resolution data on bathing water quality, enable rapid response to pollution events, and identify the sources of contamination. This would protect public health, promote sustainable use of urban water bodies, and unlock the full economic and social benefits of these valuable assets.

The goal of this PhD project is to developed machine learning ML models providing the critical fix-point real-time FIB predictions using data inputs from low-cost sensor; while the physics informed neural network-based models PINN based models will be developed to provide spatial FIB predictions and forecast. A long-term solution will thus make use only of a limited number of low-cost sensors coupled with ML and PINN models. Besides providing real-time data of bathing water quality from low-cost sensors the forecast models would be developed making use of multiple data streams (real/near real-time in-situ data from sensors, real-time meteorological data and forecasts, hydrometric data, land-use etc).

Responsibilities and (foreseen) tasks

- Conducting a comprehensive literature review: The student will conduct a comprehensive literature review on existing approaches to provide real-time, high-resolution BWQ data and spatial predictions.
- Researching and developing algorithms for fix-point real-time FIB predictions using data inputs from low-cost sensor; spatial FIB predictions and forecast.
- Helping to conduct real-world data collection experiments.
- Testing and validating proposed methods in chosen pilot places.
- Collaborating with other researchers and companies to align research goals with practical applications in bathing water quality analysis.
- Documenting and publishing research findings in peer-reviewed journals and present at conferences.

Applicants should fulfil the following requirements:

- A master's degree in computer engineering or computer science
- A clear interest in the topic of the position
- Excellent command of English
- Strong and demonstrable writing and analytical skills
- Excellent programming skills (especially in Python)
- Capacity to work both as an independent researcher and as part of an international team
- Capacity and willingness to aid in organizational tasks relevant to the project

The following experience is beneficial:

- Previous work experience in the field of artificial intelligence, IOT
- Previous experience in working with physics informed neural network-based models PINNs
- Previous work experience in the field of bacterial analysis

We offer:

- Collaborate with a team of researcher in different fields on the development of revolutionized monitoring of Bathing Water Quality (BWQ) by addressing several deficiencies in data acquisition and representation.
- Access to research infrastructure (test basin), sensors, data etc.
- Opportunities for visiting conferences, research stays and networking with globally leading universities and research centers.

Employment:

The position is at the School of Information Technology at Tallinn University of Technology. The expected duration of doctoral studies is four years. Following the standard practice in the School of Information Technology, the contract will be made initially for one year, then extended after a successful progress review. The salary is according to the salary system of Tallinn University of Technology.

The position will be filled as soon as a suitable candidate is found. TalTech reserves the right for justified reasons to leave the position open or to extend the application period.

How to apply for a doctoral candidate position:

Please read the admission guidelines at https://taltech.ee/en/phd-admission.

Further information:

Job locations Tallinn, Estonia.

For additional information, please contact

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