Foras na Mara
Marine Institute

Cullen Scholarship: Machine learning assisted detection and prediction of climate change related anomalous events in complex marine systems (PhD Award)

Background

The commercial aquaculture sector is vulnerable to mass stock mortality events when marine environmental conditions rapidly change without warning. For example, a sudden decline in dissolved oxygen or the onset of a marine heat wave, depending on severity, can have detrimental effects on fish health, which in turn impact the yield and quality of the harvest. Farm managers need actionable information to support their decision-making processes in an effort to alleviate large financial loss when such events occur. Monitoring essential ocean and climate variables (EOVs and ECVs) at aquaculture sites and using these in prediction of short-term future change (hours to days rather than months to years) is, therefore, critical to support farm management best practices related to feeding and fish health. Work produced in the project will serve to assist the EuroSea project reporting needs.

Proposal

We propose a structured four-year PhD on a full-time basis to create short term forecasts of anomalous marine environmental events using in-situ data of EOVs and ECVs collected by sensors deployed in the marine environment (e.g. data buoys, coastal observatories, etc.). It is envisaged that the project will first make use of the continuous data streams provided by the EuroSea project and from the SmartBay observatory in Galway Bay. The broad goals of this project are to:

1. Explore suitable machine learning approaches and test method capabilities to forecast anomalous and extreme marine events with data from marine sensors measuring water properties at selected ocean observing sites off SW and W Ireland.
2. Test if the machine learning process to develop a short-term forecast model can be reused across different sites when given equivalent marine data collected at these sites (e.g. the SmartBay Observatory site in Galway Bay).

Proposed objectives are to:

1. Determine the temporal variability of dissolved oxygen, temperature, pH and salinity at the selected sites using machine learning to develop data pattern recognition that can reliably be applied in the early warning of extreme marine events.
2. Publish machine learning model outputs and appropriate derived products for use in applications by the MI.
3. Link findings to existing national and international ocean observing efforts (e.g. activities carried out by NOAA) and determine scalability and applicability of the models.
4. Produce a priority list of measurements used by a forecast model based on a measurement's influence on the model's predictive skill.

Specific research questions to be addressed:

1. Is there a qualitative value to Machine Learning approaches to modelling biogeochemical predictions in comparison with more traditional numerical modelling approaches? This will be addressed through skill comparison of observed data with both the Machine Learning model and an in-house numerical model for the same parameters the Machine Learning model will predict.
2. What is the quantitative skill a Machine Learning model developed for a particular site can bring to another geographic location? This will be tested through initial focus and calibration at a specific area and then application of the model in a new geographic domain.

Outcome

The expected outcome of the project is the application of a short-term forecasting model to underpin an early warning system of anomalous and/or extreme marine events that are of relevance to the aquaculture industry. The short-term forecasting model will be driven by the real-time inclusion of a subset of priority EOVs/ECVs (temperature, salinity, oxygen and pH).

It is expected that the student will publish at least three peer-review papers. It is also expected that the methodologies (principles, tools and practices) and transferable framework developed in the project will be used in future national and international projects.

Project outputs should inform the EU Water Framework Directive (2000/60/EC) and Marine Strategy Framework Directive (2008/56/EC) monitoring programmes. Results should be relevant to the UN Sustainable Development Goals 13 "Climate Action" and 14 "Life below water" and Action 13a of Harnessing Our Ocean Wealth – An Integrated Marine Plan for Ireland, which stresses the need to maintain and expand key marine observations for essential climate variables, endorsed by the UNFCCC Global Climate Observing system (GCOS). Outputs from the project should also support improved regional climate modelling, scenario development, forecasting and climate impact risk assessment.

Links to MI strategy

While this proposal is clearly linked to the strategic initiative of "forecasting ocean and climate change" under Strategic Focus Area 2 of the Marine Institute's Strategic Plan; as it will build localised operational forecasting capability; it will also support decision makers in terms of aquaculture sites and fish farms at those localised sites and is therefore tied to Strategic Focus Area 2. It will also advance the data analytics capacity of the Marine Institute through bringing Machine Learning expertise into the Institute and strengthening relationships with established researchers in this field thereby supporting the strategic enabler focussed on Data & IT.

Specific Requirements

The scholar should have a minimum of a 2:1 Honours undergraduate degree in Information Technology or an equivalent discipline and have an interest in marine/environmental sciences. It would be advantageous to have an MSc in Artificial Intelligence / Machine Learning or in Environmental Data Analytics.

Financial Details

Scholarships will be up to €25,000 per annum (maximum funding of €100,000 over four years). This amount comprises a maintenance award of €16,000 (Irish Research Council rate) to the student as well as payment of fees to the host higher education institution (HEI). The maximum fees payable to the HEI will be €6,000 per annum. The scholarship award also includes a budget of up to €3,000 per annum for eligible research costs (travel & subsistence, publication costs, consumables and other costs e.g. laptop) for the sole use of the student, and are payable on a reimbursement basis direct to the host institution where the postgraduate student (scholar) is registered. There are no overheads payable on the scholarship. Publication costs are intended to cover publications on which the scholar is listed as first author and are published under Open Access.

Marine Institute Co-Supervisor(s)

Dr. Adam Leadbetter, Ocean Science and Information Services (adam.leadbetter@marine.ie)

Given the cross cutting disciplinary nature of the proposed PhD project, the Marine Institute propose set-up an advisory panel to include national/international experts who can advise and assist the student during the project.