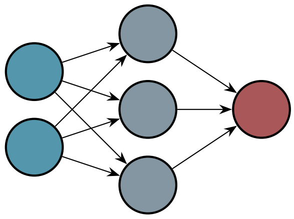

Project or Master thesis

Deep learning for the prediction of wave surface elevation from remote measurements

The phase-resolved prediction of water waves is a major challenge due to their complex spatio-temporal dynamics. Forecasts are usually performed by feeding initial conditions to numerical wave models which then predict the wave evolution over time. Stationary buoys are a well-established method to gather data by measuring the surface elevation at fixed locations over time. Figure 1 a shows a square domain with an array of stationary buoys each recording the surface elevation over time, cf. Figure 1 b.

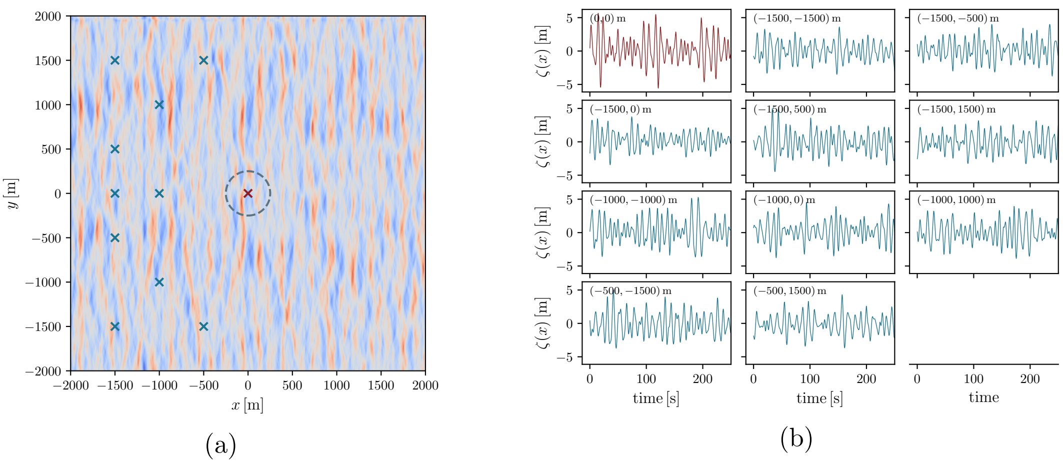

Figure 1: The blue markers show the locations of gauges where the wave surface elevation is measured over time. Waves travel in positive x-direction.

This thesis aims at exploring the potential of machine learning (ML) for the prediction of the surface elevation at the center of the domain based on time-series data from surrounding buoys. The training data is generated using the high-order spectral method (Dommermuth & Yue, 1987; West et al., 1987) which models nonlinear patterns up to fourth-order, yielding physically highly accurate wave simulations. The ML task which arises from the setup is a multivariate time-series regression, cf. Figure 2. After finding a suitable ML method for the task, an optimal array of buoys, i.e. the necessary and sufficient information for the ML model to accurately predict the surface elevation at the center of the domain, is to be determined.

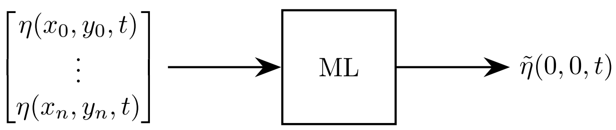

Figure 2: Schema of multivariate time-series prediction. The input containing multiple time-series $\{\eta(x_i, y_i, t)\}$ is mapped to the time-series of the surface elevation at the center of the domain $\eta(0, 0, t)$.

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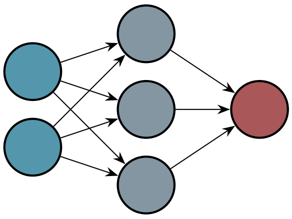

The scope of this work covers the following tasks:

- Literature review of state of the art, choice of suitable ML method,
- Application and evaluation of chosen method,
- Optimization of buoy array.

Prerequisites:

- Knowledge of neural networks and basic wave dynamics,
- Demonstrated programming experience in Python and a neural network library of your choice, e.g. TensorFlow, PyTorch or Flax,
- Curiosity, excellent skills in independent work and communication.

The extent of this work may be adjusted to fit either a project- or a master thesis.

References

Dommermuth, D. G., & Yue, D. K. P. (1987). A high-order spectral method for the study of nonlinear gravity waves. *Journal of Fluid Mechanics*, *184*, 267–288. https://doi.org/10.1017/S002211208700288X

West, B. J., Brueckner, K. A., Janda, R. S., Milder, D. M., & Milton, R. L. (1987). A new numerical method for surface hydrodynamics. *Journal of Geophysical Research: Oceans*, *92*(C11), 11803–11824. https://doi.org/10.1029/JC092iC11p11803

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