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# Estuarine morphodynamics forecast using a numerical model emulator based on deep learning methods. A first approach.

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Estuaries are transition zones between rivers and oceans that provide essential ecosystem services with high economic, environmental and social importance. These areas are exploited by fishing, maritime transportation and tourism industries, having banks usually highly urbanized and, thus, their waters are exposed to anthropogenic activities. They also serve as nursery areas for many fish and marine birds species, providing shelter and food in their early stages of life. Therefore, the preservation of the quality of estuarine natural resources is essential for all stakeholders, being of utmost importance to promote its sustainable use. However, the anthropogenic pressure threatens the availability of these natural resources, demanding a continuous monitoring effort.

Morphological conditions are determinants for most of the services provided by estuaries. Though its forecasting is a very challenging task due to the involved physical-process complexity. At the same time, its characteristic timescales demand long-term simulations with high computational costs to achieve relevant and accurate results. Anticipating the morphology evolution, allows, for

example, to optimize dredge operations to maintain navigation channels, being necessary for efficient flood management.

Available state-of-the-art physical-based numerical models can be applied to predict estuarine morphology. However, the sediment transport component usually requires additional computational resources, increasing the CPU time and limiting their application for short to medium-term forecasts. An artificial intelligence (AI) emulator based solely on the hydrodynamic component results could be a solution to minimize the total morphodynamic forecast CPU time.

This work implemented a convolutional neural network (CNN) to emulate the morphodynamic evolution of the Minho river estuary, located at the northern Portuguese coast. AI-based methods demand considerable time to be implemented, mainly during dataset preprocessing and training tasks, but their simulation performance could be superior when compared to numerical models if sufficient data are available for training the algorithm. In this proof of concept work, the CNN used the estuarine currents average velocity and direction and the bottom stress extracted from the Delft3D numerical model runs as input to forecast the accumulated sedimentation/erosion. The hydrodynamic numerical model was automatically calibrated using the OpenDA tool, determining the best value combination for the numerical parameters. Simulations were performed considering a 20-year return period flood event, with hourly generated outputs. The network was implemented using the TensorFlow open-source platform and was composed of an input layer, for reading the results of the hydrodynamic model, a filter layer, for simplifying the inputs, a hidden layer, for learning and processing the input information and, lastly, an output layer, for generating the accumulated erosion/accretion patterns within the estuary.

The results demonstrated the emulator’s capacity to reproduce the sandbar patterns inside the estuary, revealing to be a promising approach to forecast estuarine morphodynamics in a shorter computational time. The mean absolute percentage error of the CNN model was 0.80 during training and 0.77 during testing. While the numerical model requires 38 minutes to simulate a one-month simulation period, the emulator needed only a couple of seconds. Future works will analyze the networks hyperparameters, aiming to increase the emulator performance and accuracy.

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