DIKE BREACH FLOOD PREDICTION OF AN LSTM COMPARED TO THE HAND.FLOW MODEL FOR REAL-TIME FLOOD FORECASTING

The most common method to model flood dynamics is using two-dimensional depth-averaged hydrodynamic models. However, their long computation times make them unsuitable for scenario analysis in a real-time flood forecasting system after a warning for an incoming discharge wave. The aim of this study is to identify which surrogate model is the most promising for real-time flood forecasting in case of a dike breach: a new conceptual HAND.FLOW model or a data-driven LSTM neural network.

The Long Short Term Memory (LSTM) neural network was used in this study, as it is suitable for predicting time series due to its ability to store information and to learn long-term dependencies in data. It was trained using 58 simulations of a 1D-2D hydrodynamic HEC-RAS model by Bomers (2021). The original HAND model requires only the Digital Elevation Model (DEM) of the area, but it is not suitable for dike breaches in flat delta regions like the Netherlands. Therefore, the HAND.FLOW model was created to model flood propagation from the breach into the hinterland.

Both the LSTM and HAND.FLOW model were compared to the results of 15 simulations of the HEC-RAS model. The LSTM was very accurate in predicting water depth, with an error of just 3% compared to the reference floods. The CSI metric for comparing the inundation areas was on average 0.94, which is near the maximum of 1. The HAND.FLOW model was less similar to the HEC-RAS water depths, due to a terrain feature not modelled in HEC-RAS. In a single corrected simulation, the average water depth error was 15% and the CSI was around 0.7.

All in all, the LSTM can predict the flood event near instantly and very accurately. However, it has to be re-trained for a change in the hinterland or for another breach location, which requires simulating new training data (taking 800 hours for Bomers (2021)). The HAND.FLOW model has a much shorter set-up time of around 30 minutes, so it is much more flexible for changes in the hinterland, simulating other breach locations or adapting spatial/temporal resolutions. Additionally, the simulation time was only 1.5 minutes on the HEC-RAS/LSTM resolution, so it is suitable for flexible use in a real-time flood forecasting system. In conclusion, the HAND.FLOW model quickly offers a reasonable insight in how a dike breach flood will propagate in the hinterland, and with further development might be suitable for actual real-time flood forecasting.

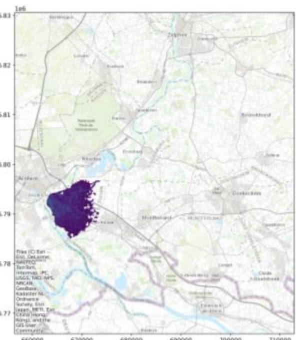

Figure 1: LSTM prediction of first time step after breach

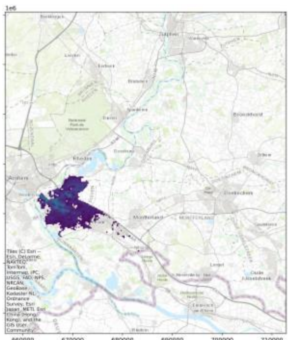

Figure 2: HAND prediction of first time step after breach.

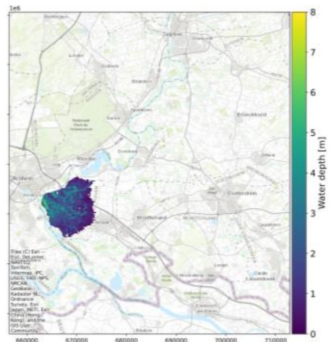

Figure 3: Reference HEC-RAS simulation in first time step after breach

Bomers, A. (2021). Predicting Outflow Hydrographs of Potential Dike Breaches in a Bifurcating River System Using NARX Neural Networks. Hydrology, 8(2), 87

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