TEST OF LSTM NETWORKS IN LONG-TERM BEACH MORPHOLOGICAL CHANGES

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INTRODUCTION

In the prediction of beach profile changes, for example, the long-term calculation of daily changes can only provide sufficiently reliable reproduction results for a few years. One of the reasons is that actual morphological change is caused by the superposition of complex processes that are unknown. The prediction of time-series data by data-driven models in contrast to physical models has been applied to various fields in recent years with the spread of deep learning and is expected to be used as a tentative solution for problems that cannot be adequately predicted by physical modeling. Recurrent neural networks are being applied to predict shoreline change over several years (Montaño et al., 2020), but application to spatial morphological changes, such as beach profile changes, is rarely investigated due to the limitations of the large amount of observation data required for learning. Here, we used the LSTM (Long Short-Term Memory) network, one of the recurrent neural networks, and long-term beach profile data observed at the Hasaki coast, Japan for learning and prediction of beach profile changes.

DATA AND METHOD

Hasaki coast is a microtidal barred beach located in eastern Japan facing the Pacific Ocean. Daily beach profiles were measured at 5 m intervals in a 500 m cross-shore section along a pier on the Hasaki coast from 1986 to 2011 (Banno et al, 2020). We used 9,061-day profile data linearly interpolated for the missing data such as weekends (Figure 1). Other input variables were daily mean offshore wave energy flux, daily mean water level, and daily tidal difference.

The number of LSTM layers ranged from 1 to 10, and the number of hidden units in each LSTM layer ranged from 200 to 4000. Dropout layers (dropout rate 0.1) were inserted after each LSTM layer to prevent overlearning. The networks were trained by inputting the first 75% over 18 years of the data as a single time-series sequence and outputting time-series data of the corresponding beach profiles for the next day. The number of training epochs was set to a sufficient number of more than 300. The second 25% over 6 years of the data were used for validation, and the output beach profiles were used for the next-time input.

RESULTS AND CONCLUSION

Although the LSTM networks were able to predict long-term plausible morphological changes for over 6 years with robustness, the prediction accuracy of longshore bar morphology was not necessarily good enough. Some LSTM networks were able to predict foreshore beach morphology with high accuracy after a series of low waves and immediately after high waves, i.e., when the foreshore morphology was considered to be asymptotically close to the equilibrium profile (Figure 2). This may be because the LSTM network had sufficiently learned the equilibrium profile from the observation data. There was no clear relationship between the prediction performance and the number of layers and hidden units, however, the LSTM network with the careful design of the architecture may provide better predictive performance than existing beach profile change models. Data that are difficult to obtain over time, such as changes in sediment grain size, are not used as input data in either the existing beach profile change model or the LSTM network used in this study. Because non-explicit information is carried over in time by the state of the hidden units in the LSTM layer, it is expected that the LSTM network can estimate the non-explicit effects such as those caused by changes in sediment grain size from observed data and reproduce beach morphological changes caused by processes that are not well understood.

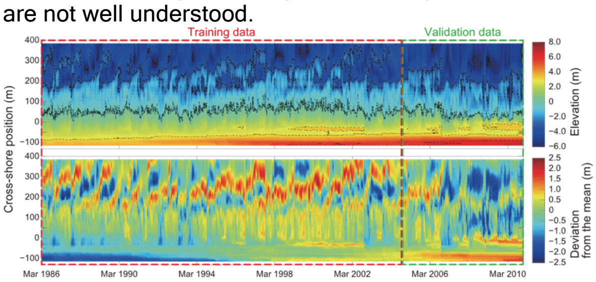

Figure 1 - Beach profile measured from 1986 to 2011

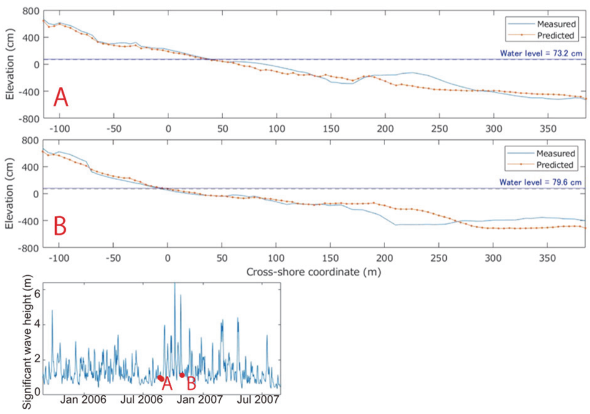

Figure 2 - Snapshot of beach profile predicted by trained network (hidden units: 2000, LSTM: 2 layers)

REFERENCES

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