SIGNIFICANT WAVE HEIGHT PREDICTION USING TRANSFER LEARNING

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INTRODUCTION

Wave prediction needed for maritime construction is generally performed by numerical models. This method, however, requires a high-performance computer and a large cost of computational resources. With the development of neural networks, which can compute at a low cost, the use of neural networks in wave prediction has recently been studied. However, because a large amount of training data is required for neural network tasks using scarce datasets, it is difficult to predict wave conditions accurately. Fan et al. (2020) reported that using LSTM model for prediction of significant wave height (H_s) was higher accuracy than conventional neural network model. Additionally, they recommended using at least 2 years of training data for 6h predictions, that is, an excessively small amount of data is not presumed to predict sufficiently H_s. Therefore, we propose a wave prediction method using transition learning. Transfer Learning is the method of transferring trained knowledge from one model to another. In this study, we investigate whether transfer learning can be used to improve the performance of H_s prediction by transferring the knowledge learned at Sakata port, which has a large amount of training data, to the coast of Yamagata, which has a scarce one.

METHODS

The transfer learning described in the introduction was used to predict the Hs. The input pre-training data for the training were obtained from the GPV-MSM (10 meters U and V wind component, wind speed, sea level pressure, and temperature at the surface) between October to April from 2006 to 2014, H_s data were obtained from NOWPHAS. The dataset used for transfer learning was the Sakata port as the source domain and the coast of Yamagata as the target domain in 2015. Using an LSTM model that can remember the previously inputted information, it was trained to predict H_s after 6, 24 hours on the coast of Yamagata. This overview flow is shown in Figure 1. Compilation used Adam as the optimizer and a mean square error loss function as the loss function. The learning rate in pre-training was set to 0.001. The learning rate in transfer learning was set to 0.00001 because of the role of adjusting the pre-training initial value. The number of epochs = 40, and batch size = 256, timestep = 12.

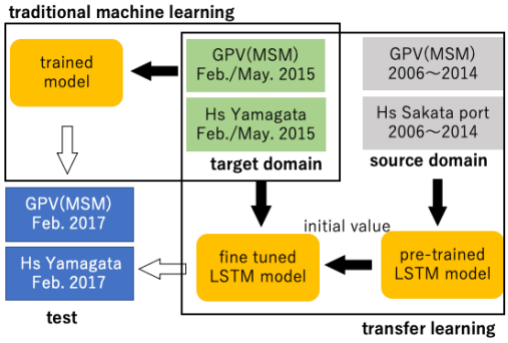

Figure 1 - Training process of using transfer learning and traditional machine learning.

RESULTS

To evaluate the performance of Hs prediction using transfer learning, wave height in February 2017 at the coast of Yamagata was used for verification. Two sets of training data for the target domain were prepared, one in February 2015 and the other in May 2015. First, the result without transfer learning is shown in Figure 2 (a). The best RMSE (6h) was 0.620, the worst one was 1.151. Next, the result using transfer learning at Sakata port as an initial value is shown in Figure 2 (b). The best RMSE (6H) was 0.460, the worst one was 0.474. Compared with the traditional trained model and the transfer learning model, the transfer learned model has smaller prediction errors in RMSE. This model also provided higher R^2 score of wave height predictions (Fig. 2). The result without transfer learning (Fig.2(a)) showed difference in accuracy depending on the month used for training (Feb. and May.), but the using transfer learning reduced the difference in accuracy (Fig.2(b)). This means that transfer learning is not dependent on the training data set in target domain.

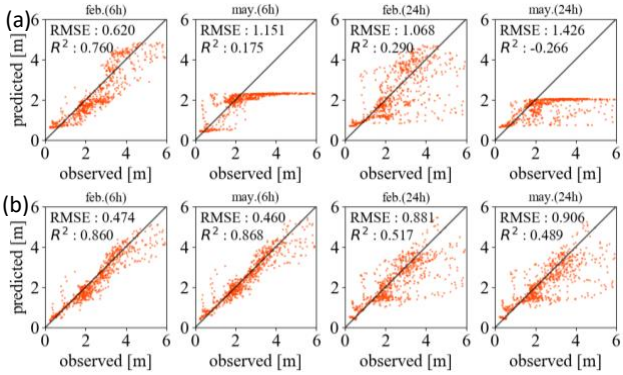

Figure 2 - Comparisons of scatter plot between using transfer learning(b) and not(a).

CONCLUSIONS

This study concluded with two major points. 1) Using transfer learning for wave prediction enabled highly accurate predictions even with a limited amount of training data. 2) The transfer learning model was found to be less dependent on the quality of training data in the target domain. In summary, the proposed wave transfer learning method has a better prediction effect and higher accuracy for wave height prediction.

REFERENCES

Shuntao Fan, Nianhao Xiao, Sheng Dong (2020) : A novel model to predict significant wave height based on long short-term memory network, Ocean Engineering, ELSEVIER, vol.205, Article 107298,