International Conference on Hydroinformatics

2014

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INTEGRATION OF MULTI-OBJECTIVE GENETIC ALGORITHM AND SUPPORT VECTOR MACHINE FOR HOURLY TYPHOON RAINFALL FORECASTING

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Abstract

During typhoon periods, accurate hourly rainfall forecasts are extremely important. A new typhoon rainfall forecasting model that integrates multi-objective genetic algorithm (MOGA) with support vector machines (SVM) is presented in this paper. Apart from the rainfall data, the meteorological variables are also considered. An application to high- and low-altitude meteorological stations has shown that the proposed model yields the best performance as compared to other models. Results indicate that meteorological variables are helpful. The proposed model significantly improves hourly typhoon rainfall forecasting, especially for the long lead time forecasting. Moreover, the optimal combination of inputs is determined by the proposed model for each lead time forecasting. The use of the optimal combination of inputs yields more accurate forecasts than the use of all inputs. In conclusion, the proposed model is expected to be useful for effective hourly typhoon rainfall forecasting.

INTRODUCTION

Typhoon rainfall forecasting plays an essential role in these warning systems. More accurate typhoon rainfall forecasts are always required. However, it is difficult to construct a physically based model owing to the highly nonlinear and complex physical process. An attractive alternative to the physically based models is neural networks (NNs) because NNs have great ability to model nonlinear systems without assumptions. As to rainfall forecasting, applications of NNs have been presented (Luk et al. [5]; Chiang et al. [3]). NNs have been a well-known tool for hydrologists and water resources engineers. The ASCE Task Committee [1,2] and Maier and Dandy [6] have carried out comprehensive reviews of the applications of NNs in hydrology. To obtain effective forecasts of hourly rainfall, a model with good generalization ability is needed.

In many conventional NN dominated fields, support vector machines (SVMs) have emerged as an alternative data-driven tool. Lin et al. [4] compared the BPN-based and SVM-based models for hourly typhoon rainfall forecasting. They found that the SVM-based model is more accurate, robust, and efficient than the conventional model. Lin et al. [4] showed that SVMs have better generalization ability and the weights of the SVMs are guaranteed to be unique and globally optimal. Moreover, SVMs are trained much more rapidly. Therefore, the aforementioned advantages have prompted us to improve typhoon rainfall forecasting by using SVM-based models.

Besides typhoon rainfall, meteorological variables are viewed as key input to the rainfall forecasting models to further improve the long lead time forecasting. However, due to many meteorological variables and rainfall are used as input to models, the process of searching the optimal combination of inputs by manual methods, such as trial-and-error, is a time-consuming task. One of the optimization methods is multi-objective genetic algorithm (MOGA). In recent years, MOGAs have increasingly been applied to many water resources topics. Yapo et al. [7] demonstrated that MOGA is an effective and efficient search algorithm. Thus, MOGA was employed for finding an optimal solution in this paper.

The purpose of this paper is to propose a new hourly typhoon rainfall forecasting model with the optimal combination of input variables. For this purpose, forecasting models are constructed by integrating MOGA with SVM. Additionally, meteorological variables are added as key input to the proposed models to yield 1- to 6-h ahead forecasts. Actual applications are presented to clearly demonstrate the superior performance of the proposed model.

APPLICATION

The observed rainfall and meteorological variables from Biao-Hu and A-Li-Shan stations are used. The elevation of Biao-Hu station is 1163 m. This station is near the Tseng-Wen Reservoir, which is the largest reservoir in Taiwan. As to A-Li-Shan station, it is at an altitude of 2415 m. The main rainfall period for A-Li-Shan Range is between April and September. Typhoons usually bring heavy rainfall to A-Li-Shan Range.

The rainfall data and meteorological variables of the meteorological stations during 1996–2009 are collected from the Central Weather Bureau of Taiwan. The data of rainfall and meteorological variables are hourly, and typhoon events with meteorological variables and rainfall data available simultaneously are collected. A total of 16 typhoon events are used herein. The collected meteorological variables used herein include air pressure, air temperature, wind velocity, wind direction and duration of sunshine.

SUMMARY

The SVM-based model with meteorological variables is compared with that without meteorological variables to show the effect of meteorological variables. However, some meteorological variables still include relatively irrelevant information which adds noise to the model and weakens the forecasting performance. Thus, except adding meteorological variables, the new typhoon rainfall forecasting model is proposed to further improve hourly typhoon rainfall forecasting. In conclusion, suitable meteorological variables should be used as input to the typhoon rainfall forecasting models. The proposed model has the best forecasting performance regardless of high or low-altitude metrological station. In addition, the proposed model is able to determine the optimal combination of inputs for different stations. Therefore, the proposed model with the optimal combination of inputs is capable of providing more accurate hourly typhoon rainfall forecasts than the existing models. The proposed modeling technique is expected to be useful to other complex problems with numerous input variables, and recommended as an alternative to the existing model for disaster warning systems.

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