Chapter 17

An Effective Hybrid Semi-Parametric Regression Strategy for Rainfall Forecasting Combining Linear and Nonlinear Regression

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ABSTRACT

Rainfall forecasting is an important research topic in disaster prevention and reduction. The characteristic of rainfall involves a rather complex systematic dynamics under the influence of different meteorological factors, including linear and nonlinear pattern. Recently, many approaches to improve forecasting accuracy have been introduced. Artificial neural network (ANN), which performs a nonlinear mapping between inputs and outputs, has played a crucial role in forecasting rainfall data. In this paper, an effective hybrid semi-parametric regression ensemble (SRE) model is presented for rainfall forecasting. In this model, three linear regression models are used to capture rainfall linear characteristics and three nonlinear regression models based on ANN are able to capture rainfall nonlinear characteristics. The semi-parametric regression is used for ensemble model based on the principal component analysis technique. Empirical results reveal that the prediction using the SRE model is generally better than those obtained using other models in terms of the same evaluation measurements. The SRE model proposed in this paper can be used as a promising alternative forecasting tool for rainfall to achieve greater forecasting accuracy and improve prediction quality.

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1. INTRODUCTION

Rainfall prediction is a challenging task in the climate dynamics and climate prediction theory. Accurate forecasting of rainfall information (including the spatial and temporal distribution of rainfalls) has been one of the most important issues in hydrological research, because it can help prevent casualties and damages caused by natural disasters (Wu, 2009; Lettenmaier & Wood, 1993). In general, rainfall forecasting involves a rather complex nonlinear pattern, for example pressure, temperature, wind speed and its direction, meteorological characteristics of the precipitation area, and so on (Luk, Ball, & Sharma, 2001; Kuligowski & Barros, 1998).

Over the past few decades, most of the research have used traditional statistical methods for rainfall forecasting, such as multiple linear regression, time series methods, and so on (Zwiers & von Storch, 2004). It is extremely difficult to capture the nonlinear characteristic by the traditional statistical methods. At present, although the climate dynamics approach for rainfall forecasting has developed, it is very difficult to describe and establish the forecasting model of rainfall, because the climate dynamic model involve many complex factors of weather and it is very difficult to solve (Druce, 2001).

Recently, artificial neural networks (ANN) techniques have been recognized as more useful than conventional statistical forecasting models. ANN is based on a model of emulating the processing of human neurological system to find out related spatial and temporal characteristics from the historical rainfall patterns (Hong, 2008). They are universal function approximations that can map any non-linear function without understanding the physical laws and any assumptions of traditional statistical approaches required. They have computationally robust, and has the ability to learn and generalize from examples to produce meaningful solutions to problems even when the input data contain errors or are incomplete. So it is widely applied to solve Climate Dynamical Systems problems including rainfall forecasting in comparison to traditional statistical models. French, Krajewski, and Cuykendal (1992) developed the first simulation scheme, whereby synthetically generated rainfall storms were used to both calibrate and validate ANN models. Kuligowski and Barros (1998) have applied an ANN approach for short term rainfall forecasting. Their model used feed-forward neural network (FFNN) architecture with upper atmospheric wind direction and antecedent rainfall data from a rain gauge network to generate a 0-6 h precipitation forecast for a target location. Luk et al. (2001) employed ANN to forecast the short-term rainfall for an urban catchment. Their model used among the ANN configured with different orders of lag and different numbers of spatial inputs. The experimental results shows that the ANN provided the most accurate predictions when an optimum number of spatial inputs was included into the network, and that the network with lower lag consistently produced better performance.

Currently, more hybrid forecasting models have been developed to improve rainfall prediction accuracy. Bowden, Dandy, and Maier (2005a, 2005b) have presented two methodologies, namely partial mutual information (PMI) and self-organizing map (SOM) integrated with a genetic algorithm and general regression neural network. The first method utilizes a dependent measure known as the partial mutual information (PMI) criterion to select significant model inputs. The second method utilizes a self-organizing map (SOM) to remove redundant input variables, and a hybrid genetic algorithm (GA) and general regression neural network (GRNN) to select the inputs that have a significant influence on the model's forecast. The results indicated that the two methods can lead to more parsimonious models with a lower forecasting error than the models developed using the methods from previous studies. Jain and Ku-

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