

Analysis and modelling of flood risk assessment using information diffusion and artificial neural network

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ABSTRACT

Floods are a serious hazard to life and property. The traditional probability statistical method is acceptable in analysing the flood risk but requires a large sample size of hydrological data. This paper puts forward a composite method based on artificial neural network (ANN) and information diffusion method (IDM) for flood analysis. Information diffusion theory helps to extract as much useful information as possible from the sample and thus improves the accuracy of system recognition. Meanwhile, an artificial neural network model, back-propagation (BP) neural network, is used to map the multi-dimensional space of a disaster situation to a one-dimensional disaster space and to enable resolution of the grade of flood disaster loss. These techniques all contribute to a reasonable prediction of natural disaster risk. As an example, application of the method is verified in a flood risk analysis in China, and the risks of different flood grades are determined. Our model yielded very good results and suggests that the methodology is effective and practical, with the potentiality to be used to forecast flood risk for use in flood risk management. It is also hoped that by conducting such analyses lessons can be learned so that the impact of natural disasters such as floods can be mitigated in the future.

Keywords: artificial neural network, information diffusion, flood, risk analysis, assessment

INTRODUCTION

Natural disasters are increasing alarmingly worldwide. Flooding is a common natural disaster which often causes loss of property and human life. Recent flooding disasters have shown the vulnerability of the so-called developed and developing countries to such events. In China, flood disasters occur frequently, and about two-thirds of the country's area is facing the threat of different types and degrees of floods, as a result of both natural and unnatural influences, such as social and economic factors (Chen, 2010). Natural disasters present a great challenge to society today. Flood risk assessment for an area is important for flood disaster managers to be able to implement a compensation and disaster-reduction plan. As severe floods occur frequently, flood risk assessment and management play an important role in guiding governments in making timely and effective decisions for disaster rescue and relief.

Risk management for the operation of an existing flood protection system is the sum of actions for a rational approach to flood disaster mitigation. Its purpose is the control of flood disasters, in the sense of being prepared for a flood, and acting to minimise its impact. It includes the process of risk analysis, which forms the basis for decisions on maintaining and improving the system.

Risk analysis is a challenging task at the present. Assessing flood risk is difficult because of the lack of objective measures of acceptable risk, scarcity of data, and an abundance of unknown probability distributions. Flood risk analysis methods progressed from the direct integral method, Monte Carlo method,

and mean first-order-second-moment method, to advanced first-order-second-moment method, second-order-method and JC method (design point in first-order second-moment method). Theories and methods of flood risk analysis have been established based on the work of several authors: e.g. Ang and Tang (1984), Ashkar and Rousselle (1981), Diaz-Granados et al. (1984), Kuczera (1982), Stedinger and Taylor (1982), Todorovic and Rousselle (1971), Todorovic and Zelenhasic (1970), Wood and Rodríguez-Iturbe (1975). Recently, many risk analysis approaches have been based on using linguistic assessments instead of numerical values. Using fuzzy sets theory (Zadeh 1965), data may be defined in vague, linguistic terms, such as low probability, serious impact, or high risk. These terms cannot be defined meaningfully with a precise single value, but fuzzy sets theory provides the means by which these terms may be formally defined in mathematical logic.

In traditional flood risk analysis, the probability statistics method is usually used to estimate hydrological variables' exceedance probability, because it is based on a mature basic theory and has easy application. However, problems exist in the feasibility and reliability of the method's outcomes, without considering its fuzzy uncertainty. Especially in the case of small samples, results based on the classical statistical methods are usually unreliable. It is also rather difficult to collect long sequence flood data and the sample is usually small. Information diffusion theory can be applied enabling as much useful underlying data as possible to be extracted from the sample and thus improving the accuracy of system recognition (Huang, 2002; Palm, 2007).

Information diffusion is a fuzzy mathematic set-value method for samples, which considers optimising the use of fuzzy information of samples in order to offset the information deficiency. In order to map the multi-dimensional space of a disaster situation onto a one-dimensional disaster space

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