RESERVOIR WATER RELEASE DYNAMIC DECISION MODEL BASED ON SPATIAL TEMPORAL PATTERN

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Abstrak

Keputusan pelepasan air bagi takungan serba guna memerlukan pakar bagi membuat keputusan dengan menghimpunkan maklumat pemutusan kompleks yang wujud secara masa nyata. Keputusan perlu mengambil kira lebihan air takungan yang mencukupi bagi mengekalkan fungsi serba guna takungan dan menyediakan ruang yang mencukupi untuk hujan lebat dan aliran masuk air. Amat penting juga, pelepasan air tidak boleh melebihi tahap maksimum sungai di hilir supaya ia tidak akan menyebabkan banjir. Hujan dan paras air adalah maklumat kabur, oleh itu model keputusan memerlukan keupayaan untuk mengendalikan maklumat yang kabur. Tambahan pula, hujan yang direkodkan di lokasi yang berbeza mengambil masa berbeza untuk sampai ke dalam takungan. Situasi ini menunjukkan terdapat hubungan ruang masa yang tersembunyi di antara setiap stesen pengukur dan takungan. Oleh itu, kajian ini mencadangkan model keputusan pelepasan air takungan dinamik yang menggunakan kedua-dua maklumat ruang dan masa dalam corak input. Berdasarkan kepada corak berkenaan, model ini akan mencadangkan bila air takungan perlu dilepaskan. Model ini menggunakan Penyesuaian sistem inferens neuro-kabur (ANFIS) untuk mengendalikan dengan maklumat yang kabur. Data yang digunakan dalam kajian ini diperolehi daripada Jabatan Pengairan dan Saliran Perlis. Algoritma *Sliding Window* yang telah diubahsuai telah digunakan bagi membentuk corak masa bagi hujan, manakala maklumat ruang telah diperolehi melalui simulasi corak hujan dan paras air takungan yang telah dipetakan. Prestasi model telah diukur berdasarkan *Root Mean Square Error* (RMSE) dan *Mean Absolute Error* (MAE). Hasil daripada kajian ini menunjukkan ANFIS menghasilkan RMSE dan MAE paling rendah apabila dibandingkan dengan model *Autoregressive Integrated Moving Average* (ARIMA) dan *Backpropagation Neural Network* (BPNN). Model ini boleh digunakan oleh operator takungan bagi membantu pembuatan keputusan dan menyokong operator takungan baharu sewaktu ketiadaan operator yang berpengalaman.

Kata Kunci: Penyesuaian sistem inferens neuro-kabur (ANFIS), Kepintaran pengkomputan (CI), Pembuatan keputusan dinamik, Pembuatan keputusan pelepasan air takungan, Perolehan data ruang masa.

Abstract

The multi-purpose reservoir water release decision requires an expert to make a decision by assembling complex decision information that occurred in real time. The decision needs to consider adequate reservoir water balance in order to maintain reservoir multi-purpose function and provide enough space for incoming heavy rainfall and inflow. Crucially, the water release should not exceed the downstream maximum river level so that it will not cause flood. The rainfall and water level are fuzzy information, thus the decision model needs the ability to handle the fuzzy information. Moreover, the rainfalls that are recorded at different location take different time to reach into the reservoir. This situation shows that there is spatial temporal relationship hidden in between each gauging station and the reservoir. Thus, this study proposed dynamic reservoir water release decision model that utilize both spatial and temporal information in the input pattern. Based on the patterns, the model will suggest when the reservoir water should be released. The model adopts Adaptive Neuro-Fuzzy Inference System (ANFIS) in order to deal with the fuzzy information. The data used in this study was obtained from the Perlis Department of Irrigation and Drainage. The modified Sliding Window algorithm was used to construct the rainfall temporal pattern, while the spatial information was established by simulating the mapped rainfall and reservoir water level pattern. The model performance was measured based on the Root Mean Square Error (RMSE) and Mean Absolute Error (MAE). Findings from this study shows that ANFIS produces the lowest RMSE and MAE when compare to Autoregressive Integrated Moving Average (ARIMA) and Backpropagation Neural Network (BPNN) model. The model can be used by the reservoir operator to assist their decision making and support the new reservoir operator in the absence of an experience reservoir operator.

Keywords: Adaptive Neuro-Fuzzy Inference System (ANFIS), Computational intelligence (CI), Dynamic decision making, Reservoir water release decision, Spatial temporal data mining.

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Table of Contents

List of Tables

List of Figures

List of Appendices

List of Abbreviations

ANFIS	Adaptive Neuro-Fuzzy Inference System
ANN	Artificial Neural Network
CI	Computational Intelligence
CBR	Case Based Reasoning
CDM	Classical Decision Making
GA	Genetic Algorithm
MFs	Membership Function
NDM	Naturalistic Decision Making
NN	Neural Network
RPD	Recognition Primed Decision
SW	Sliding Window

CHAPTER ONE
INTRODUCTION

This chapter provides an overview of this study, which includes research background, problem statement, research objectives, scope of study, research significance and organization of the thesis.

1.1 Research Background

Emergency situation is one of the complex situations that require fast and accurate decisions, since the decision is very crucial to save human lives. Emergency situations can be identified by a few characteristics such as dynamic (Philips-Wren, 2009), complex (Norwawi, 2004) and action dependent (Feigh and Pritchett, 2006). Naturally, decisions that are made by people during these situations are based on instances and their past experiences. According to this view, the concept of new theory for understanding how people make decisions are important to illustrate that decisions which have been made do not only depend on a set of alternatives, but also based on their experiences. A decision is defined as the choice of one among a number of alternatives (Bohanec, 2001; Beach & Mitchell, 1978; Hersh, 1999). Naturalistic decision theory is one of the decision making approaches that defined how humans naturally make decisions in urgency and complex environments (Klein & Klinger, 1991). Decision makers have applied this theory during emergency situation such as fire fighting (Hersh, 1999). In emergency situations, typically, decisions are made under dynamic situations and also can be referred as dynamic decision making. Dynamic decision making can be defined as a series of decision that occurs in situations that change over time, where the future decision depends on

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