

**COMPUTATIONAL RECOGNITION-PRIMED DECISION MODEL
BASED ON TEMPORAL DATA MINING APPROACH
IN A MULTIAGENT ENVIRONMENT
FOR RESERVOIR FLOOD CONTROL DECISION**

Norita Md Norwawi

**UNIVERSITI UTARA MALAYSIA
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BASED ON TEMPORAL DATA MINING APPROACH
IN A MULTIAGENT ENVIRONMENT
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**A thesis submitted to the Graduate Studies Unit, Academic Affairs Department in
full fulfillment of the requirements for the degree of**

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by

**Norita Md Norwawi
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Unit Pengajian Siswazah
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Jabatan Hal Ehwal Akademik
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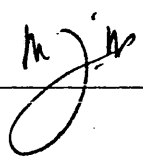
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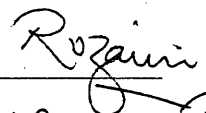
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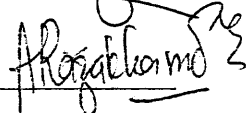
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ABSTRACT (BAHASA MALAYSIA)

Dalam keadaan kecemasan, pembuatan keputusan perlu dilaksanakan segera dan tepat. Setiap keputusan akan mempengaruhi keselamatan masyarakat awam dan harta-benda. Memandangkan kepada suasana yang cemas, satu model pembuatan keputusan yang pantas diperlukan yang akan meningkatkan keupayaan untuk bertindak segera dalam keadaan kecemasan. Model keputusan tersebut mestilah boleh menghasilkan keputusan yang tepat oleh kerana situasi yang tidak menentu dan tinggi ketidakpastiannya.

Kajian ini adalah satu inisiatif ke arah menghasilkan model pengkomputan untuk pembuatan keputusan kecemasan. Ciri-ciri persekitaran kecemasan menyerupai persekitaran pembuatan keputusan naturalistik. Antara ciri-ciri persekitaran tersebut adalah tekanan dari segi masa untuk bertindak, tindakan yang segera, situasi yang tidak menentu, tinggi ketidakpastian dan selalunya melibatkan ramai orang perseorangan dan pembuat keputusan yang sangat berpengalaman. Dalam situasi sebegini, pengalaman dan keupayaan untuk mengecam situasi yang sekan-akan serupa dengan peristiwa lampau adalah penting. Strategi pengcaman ini dapat membantu mempercepatkan respons kepada suatu kecemasan dengan membandingkan dengan peristiwa lampau. Gary Klein memperkenalkan satu model dikenali sebagai 'Recognition-primed decision' (RPD) bagi menerangkan proses pembuatan keputusan seorang yang sangat berpengalaman dalam persekitaran naturalistik.

Untuk sebuah sistem komputer, model pengkomputan ini perlu mempunyai keupayaan untuk belajar dari pengalaman dan mengecam situasi yang hampir serupa. Keperluan untuk 'belajar dari pengalaman' ini menyerupai prosidur pengkomputan pintar iaitu teknik perlombongan data. Kaedah ini boleh membantu memberikan keupayaan pembuatan keputusan berautonomi yang boleh membantu menghasilkan respons yang segera. Situasi kecemasan mempunyai ciri istimewa di mana suatu kejadian selalunya berlaku selepas beberapa tempoh masa dari mula wujudnya punca kejadian tersebut. Maka, situasi ini bergantung pada masa dan mesti mengikut turutan masa. Oleh kerana itu, kaedah perlombongan data perlu mengambil-kira faktor masa ini.

Tesis ini mengkaji keupayaan pendekatan perlombongan data temporal untuk menyokong model komputan RPD untuk digunakan dalam situasi naturalistik. Banjir adalah domain dalam kajian kerana kekerapan ia berlaku di Malaysia. Prosidur kawalan banjir empangan Timah Tasoh di Perlis adalah kes kajian untuk diuji model yang dibina. Data sebenar operasi empangan bagi kawalan banjir digunakan untuk menguji model. Satu sistem multiagen direkabentuk, prototaip diimplementasi dan diuji bagi memberikan keupayaan tambahan proaktif dan autonomi kepada sistem amaran kecemasan. Pendekatan agen dan perlombongan data temporal membolehkan respons yang berautonomi serta pantas pada kejadian kecemasan yang dijangkakan. Keupayaan model diuji dengan data operasi empangan dari tahun 1998 hingga 2002 dan didapati boleh meramal lebih dari 90% ketepatan dan kurang 10% amaran palsu.

ABSTRACT (ENGLISH)

In an emergency, decisions have to be made fast and accurate. Each decision has an influence to the safety of the public and properties. Due to the time pressure of the situation, a rapid decision model is required which will increase the speed of responding to an emergency situation. The decision model must be able produce accurate decisions due to the unpredictability and uncertainty of the situation that develops.

This study is an initiative towards developing a computational model for emergency decision-making. The characteristics of an emergency environment resembles naturalistic decision-making environment. Among the properties of this environment is time pressure, urgent, unpredictable, high uncertainty, high stakes, usually involved multiple players and experienced decision-maker. In a situation such as this, experience and able to recognize a similar situation with the past is essential. This recognitional strategy helps reduce time taken in making decisions by comparing to previous decision patterns. Gary Klein introduced such a model called Recognition-prime decision (RPD) to describe experienced decision makers thinking processes.

For a computer system, the computational model should be able to learn from experience and recognize a similar situation. The 'learning from experience' requirement resembles a computational intelligence procedure called data mining. It can provide an autonomous decision-making capability that can facilitate shorter response time in decision-making. Emergency situation has special characteristics where events are usually an effect of a cause after some considerable delay. Hence the situation is time dependent and strictly time ordered. Therefore the data mining approach need to be able to handle this time factor.

This thesis, explored the feasibility of using temporal data mining approach to support computational RPD model to be used in a naturalistic situation. Flood emergency is taken as domain to be studied due to its common occurrences in Malaysia. Reservoir flood control at Timah Tasoh dam in the State of Perlis is taken as case to test the model developed. Real operation data were used to validate the model. A multiagent system was also designed, prototype implemented and tested to also provide autonomous and proactive capability to the emergency warning system. Agent based approach and temporal data mining provide faster response to impending emergency situation. Performance of the model was measured against real operation data from 1998 to 2002 and was found to predict with more that 90% accuracy with less than 10% false alarm.

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DEDICATION

In the name of Allah Most Beneficent Most Merciful

Al Fatehah

*To my late father Md Norwawi Idris
To my late daughter Musfirah Masruhan
To family and friends who believe in me*

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LIST OF ABBREVIATIONS

Acronym	Meaning
ABC	Agent Based Computing
<i>Acc</i>	Total prediction accuracy
AI	Artificial Intelligence
ANN	Artificial Neural Network
BDI	Belief, Desire, Intention
CAS	Complex Adaptive System
CBR	Case-based Reasoning
CDM	Classical Decision-Making
COA	Course of Action
CSTB	Computer Science and Telecommunication Board
DAI	Distributed Artificial Intelligence
DBA	Design Based Approach
DID	Drainage and Irrigation Department
DIS	Distributed Intelligent System
DPS	Distributed Problem-Solving
EOC	Emergency Operation Center
IBL	Instance Based Learning
JESS	Java Expert System Shell
KDTD	Knowledge Discovery in Temporal Databases
MAS	Multiagent system
NDM	Naturalistic Decision-Making
OOP	Object-oriented Programming
RPD	Recognition-Primed Decision
SA	Situation Assessment
SABBA	Sistem Amaran Banjir Berbilang Agen (Multiagent Flood Warning System)
SMS	Short Messaging Services
<i>Sn</i>	Sensitivity
<i>Sp</i>	Specificity
UML	Unified Modeling Language
WWW	World Wide Web

CHAPTER 1

INTRODUCTION

Natural disaster like earthquake, typhoon, flood or man-made disaster such as terrorist attacks and industrial accidents are instances of emergency situations. These are complex, dynamic and highly uncertain environments with extreme peril to the safety of human and properties. In this thesis, decision-making in an uncertain and dynamic environment is investigated from the perspectives of emergency management, naturalistic decision-making (NDM) and complex adaptive system (CAS). This is an attempt to develop a decision-making model suitable for complex and dynamic environment with autonomous decision-making capability. This decision-making model must be able to support rapid, right on time and accurate decision.

This chapter will give a brief overview of emergency management, NDM, CAS, intelligent agent technology and problem encounters. Research objectives, motivation, scope and the significance of this study will also be introduced.

Failed management in emergency response effort due to inefficient and ineffective operation influences the adoption of information and communication technology. A decision-centered approach is much more beneficial to decision-makers rather than a technology-driven orientation (Allardice, 1998) because it is a flexible and natural approach to design that enables reduction of the long-term cost. This approach requires “how human decides and how decision-makers fit into complex system” to be understood.

The profile of an emergency situation has a strong resemblance with NDM environment properties. Dynamic, uncertain, high stakes, time stress, multiple

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