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

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ABSTRACT (BAHASA MALAYSIA)

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

Kajian ini adalah satu inisiatif ke arah menghasilkan model pengkomputan untuk pembuatan pemutusan kecemasan. Ciri-ciri persekitaran kecemasan menyerupai persekitaran pembuatan pemutusan naturalistik. Antara ciri-ciri persekitaran tersebut adalah tekanan dari segi masa untuk bertindak, tindakan yang segera, situasi yang tidak menentu, tinggi ketakpastian dan selalunya melibatkan ramai orang perseorangan dan pembuat pemutusan 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 pemutusan 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 pemutusan 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 Beneficient 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
Acc	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
Sn	Sensitivity
Sp	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

The contents of the thesis is for internal user only

REFERENCES

Allen, S.R. (2001). *Concern Processing in Autonomous Agents.* PhD Thesis. School of Computing Science, The University of Birmingham, England.

Allardice, R.R (1998). One Half Revolution in Orientation Implications for Decision-Making. Research Report. AU/AWC/044/1998-04. Air War College, Air University, Alabama, USA.

Antunes, C., & Oliveira, A.L. (2001). Temporal Data Mining: an Overview. In *Proceedings Of the Knowledge Discovery, & Data Mining KDD0.* Workshop on Temporal Data Mining, San Francisco, USA.

Bauer, B., Muller, J., & Odell, J. (2001). Agent UML: A Formalism for Specifying Multiagent Interaction. In P. Ciancarini, & M. Wooldridge (Eds), *Agent-Oriented Software Engineering* (pp91-103). Berlin: Springer-Verlag.

Beaudoin, L. (1994). *Goal Processing in Autonomous Agents.* PhD Thesis. School of Computing Science, The University of Birmingham, England.

Bergenti, F., & Poggi, A. (2001). Exploting UML in the Design of Multi-agent Systems. In *Proceedings Of the ECOOP-Workshop on Engineering Societies in the Agent's World 2000 (ESAW'00).* pp96-103.

Bienkowski, M.A., & desJardins, M.E. (1994). Planning Based Integrated Decision Support System. In *Proceedings Of the 2nd International Conference On AI Planning Systems.* Jun.Chicago, IL.

Bienkowski, M.A., desJardins, M.E., & Desimone, R.V. (1996). SOCAP; System for Operation Crisis Action Planning. In A. Tate (ed). *Advanced Planning Technology* (pp70-76). Menlo Park: AAAI Press.

Bigus, J., & Bigus, J. (2001). *Constructing Intelligent Agents using Java.* 2nd Edition. New York: John Wiley & Sons Ltd.

Bjorvard, A.T. (1996).*Time Series, & Rough Sets.* MS Dissertation. The University of Trondheim, Norway.

Bond, A., & Gasser, L. (eds) (1988). *Readings in Distributed Artifical Intelligence.* San Mateo, CA: Morgan Kauffman.

Bradshaw, J. (ed). (1997). *Software Agents.* Massachusets: AAAI Press/The MIT Press.

Brann, D.M., Thurman, D.A., & Mitchell, C.M. (1995). Case-based Reasoning as a Methodology for Accumulating Human Expertise for Discrete System Control. In *Proceedings of the 1995 IEEE International Confrence on Systems, Man, & Cybernetics.* Vancouver, Canada. pp4219-4223.

Breen, B. (2000). What's Your Intuition. *The Magazine.* [Online]. Retrieved 15 Jan 2002 from http://fascompany.com/online/38/klein.html

Broadstock, M. & Michie, S. (2000). Processes of Patient Decision-Making: Theoretical & Methodological Issues. *Psychology, & Health.* 15 (2), 191-204.

Burns, K. (2000). Mental Model & Normal Errors in Naturalistic Decision-Making. Paper presentation in the *5th Conference on Naturalistic Decision-Making.* Sweden. May 26-28.

Busemeyer, J.R. (1999). Dynamic Decision-Making. Technical Report #236. Cognitive Science Program, Indiana University.

Caire, G., Leal, F., Chainho, P., Evans, R., Garijo, F., Gomez, J., Pavon, J., Kearney, P., Stark, J. & Massonet, P. (2000). *Agent Oriented Analysis using MESSAGE/UML.* AOSE. pp119-135. Retrieved 1 May, 2001, from http://citeseer.nj.nec.com/gomez01agent.html

Caglayan, A. & Harrison, C. (1997). *Agent Sourcebook: A Complete Guide to Desktop, Internet,, & Intranet Agents.* Canada: John Wiley & Sons Ltd.

Chan, N.W. (1997). Increasing flood risk in Malaysia: causes & solutions. *MCB Disaster Prevention, & Management*, 6 (2).

Chen, M., Han, J., & Yu, P.S. (1996). Data mining: An overview from database perspective. *IEEE Transactions on Knowledge, & Data Engineering.* 8(6), 866-883.

Coleman, H.J. (1999). What enables self-organizing behavior in businesses. *Emergence: A Journal of Complexity Issues in Organizations, & Management.* 1(1), 33-48.

Comfort, L.K. (1993). Integrating Information Technology into International Crisis Management & Policy. *Journal of Contigencies, & Crisis Management.* 1(2), 15-26.

Comfort, L.K. (1996). Self Organization in Disaster Response: The Great Hanshin, Japan Earthquake of January 17, 1995. Quick Response Report #78. Natural Hazards Center, University of Colorado.

Comfort, L.K. (2000). Disaster: Agent of Diplomacy of Change in International Affairs? *Cambridge Review of International Affairs*, Dec.

Comfort, L.K. (2001a). *Complex Systems in Crisis Management.* Transcript EIIP Virtual Library Presentation, Jan. 10. Retrieved 20 April 2001 from http://www.emforum.org/vlibrary/lc010110.htm

Comfort, L.K. (2001b). *Coordination in Complex System: Increasing Efficiency in Disaster Mitigation, & Response.* Political Research On-line. In

Proceedings of the 2001 Annual Meeting of the American Political Science Association.Retrieved 2 Mei, 2001, from http://pro.havard.edu/papers/024/024005ComfortLou.pdf.

Comfort, L.K., Metzler, D., Sungu, Y., Dunn, M., Selavo, L, Brown, K. & Myung, J. (1998). An Interactive Intelligent Spatial Information System (IISIS) for Disaster Management: A community model. *In Proceedings of the 18th Annual ESRI International User Conference.* July 27-31, San Diego, California.

Comfort, L.K., Sungu, Y., Huber, M., Piatek, J., Dunn, M., & Johnson, D. (1999). *Self Organization in Disaster Mitigation & Management: Increasing Community Capacity for Response.* Paper presented in TIEMS Conference, Washinton DC.

Comfort, L.K. & Sungu, Y. (2001). Organizational Learning from Seismic Risk: The 1999 Marmara & Duzce, Turkey Earthquakes. In U. Rosenthal, L.K. Comfort & A. Boin (eds). *From Crises to Contingencies: A Global Perspectives.* Chicago. Charles C. Springer. Inc. Forthcoming.

Craig, P.A. (1998). *Improving pilot decision-making situations of high stakes, high stress, & time pressure.* PhD Thesis. Tennessee State University.

Cuena, J., & Molina, M. (1999). A Multiagent Systems for Emergency Management in Floods. In *The Proceedings of the 12th International Conference on Industrial & Engineering Applications of AI and Expert System: Multiple Approaches to Intelligent System,* June. pp460-469

Cuena, J. & Ossowski, S. (1999). Distributed Models for Decision Support. G. Weiss (ed). *Multiagent Systems: A Modern Approach to Distributed Artificial Intelligence* (pp459-504). London: The MIT Press.

Currey, J., & Botti, M. (2003). Naturalistic Decision-Making: A Model to Overcome Methodological Challenges in the Study of Critical Care Nurses' Decision-Making About Patients' Hemodynamic Status. *American Journal of Critical care.* 12(3), 206-211.

Czerwinski, T. (1998). *Coping with Bound: Speculations On Non-linearity In Military Affairs.* USA: National Defense University.

Das, G., Lin, K., Mannila, H., Renganathan, G., & Smyth, P. (1998). Rule Discovery from Time series. In *Proceedings of the 4th International Conference on Knowledge Discovery, & Data Mining.*(KDD-98). AAAI Press.

Dahm, P., & Bruckhoff, C. (1998). Autonomous Decision Making in Local Navigation. In *Animals to Animats: Proceedings of the 5th Intl. Conf. On Simulation of Adaptive Behavior* (SAB98), MIT Press.

Deitch, E.L. (2001). *Learning to Land: A Qualitative Examination of Pre-flight & in Flight Decision-making Process in Expert & Novice Aviators.* PhD Thesis. Faculty of Virginia Polytechnic Institute & State University.

Di Costanzo, G., & Gadomski, A.M. (1998). *Active DSS for Industrial Emergency Management Based on GIS.* International Conference & Exhibition on Geographic Information Congress Center of the International Fair, Lisbon. Sep 7-11

DID, Perlis. (1993). Timah Tasoh Dam Operation & Maintenance Manual. Drainage & Irrigation Department, Perlis, Malaysia.

DID, Perlis (2001). Kaedah Operasi Menghadapi Musim Banjir. Drainage & Irrigation Department, Malaysia.

DID, Perlis. (2002). Reservoir Level & Gate Operation Data (1998-2002). Drainage & Irrigation Department, Malaysia.

Doshita, S. (1996). *Research & Development of Intelligent Systems in Japan.* Paper Presentation at Seminar on Innovation with the Artificial Technology. Shah Alam, Malaysia.

Durfee, E.H., & Rosenschein, J.S. (1994). Distributed Problem-solving & Multiagent Systems: Comparison & Examples. In *Proceedings of the 13th International Distributed Artificial Intelligence Workshop.* July, Seattle, Washington. pp94-104

Electronic Flood Warning System for KL City Centre (8 October 2002). *New Straits Times-Management Times (Malaysia).* (EBSCO HOST Item No: 2W83515244984).

Etzioni, O., & Weld, D.S. (1995). Intelligents Agents on the Internet: Fact, Fiction, & Forecast. *IEEE Expert.* 10(4), 44-49.

Expanding Satellite Program to Track Natural Disasters (24 Jul 2001).. *New Straits Times (Malaysia)* (EBSCO HOST Item No: 2W820012001072421 41)

Faulty flood warning systems. (10 October 2003). *New Straits Times.* Retrieved 10 October, 2003, from htpp://www.nst.com

Ford, D., Dudley, M., & Marsha, H. (2002). Early warning. *Civil engineering.* 72(8), 62-67.

Forrest, S., & Jones, T. (1994). Modeling complex adaptive systems with echo. R.J. Stonier & X.H. Yu (eds). *Complex Systems: Mechanism of Adaptation* (pp3-21). Amsterdam: IOS Press.

Frawley, W., Piatetsky-Shapiro G., & Matheus, C. (1992). Knowledge Discovery in Databases: An Overview. *AI Magazine*, Fall 1992, 213-228.

Gadomski, A., Balducelli, C., Bologna, S., & Di Costanzo, G. (1998). Integerated Parallel Bottom-up & Top-down Approach to the Development of Agent-based Intelligent DSSs for Emergency Management. In *Proceedings of the International Emergency Management Society Conference TIEMS'98: Disaster, & Emergency Management.* Washington.

Gervasio, M., Iba, W., Langley, P., & Sage, S. (1998). Interactive Adaptation for Crisis Response. In *Proceedings of the AIPS-98 Workshop on Intercative, & Collabirative Planning.*

Green, S., Hurst, L., Nangle, B., Cunningham, P., Somers, F., & Evans, R. (1997). Software Agents: A Review. Intelligent Agent Group Report, Dept. of Comp. Sc., Trinity College Dublin.

Grzymala-Busse, J.W., Zheng,X., Goodwin, L.K., & Grzymala-Busse, W.J.(2000). Comparing Different Strategies in Using Rules Induced from Pre-term Birth Data. *In Proceedings of the Information Processing, & Management of Uncertainty in Knowledge Based System*, Madrid, Spain, July 3-7, pp388-394.

Guilfoyle, C. (1995). *Vendors of Agent Technology.* UNICOM Seminar on Intelligent Agents & Their Business Applications. 8-9 Nov., London. pp135-142

Guralnik, V., & Srivasta, J. (1999) Event Detection from Time Series Data. *In Proceedings of the 5th ACM SIGKDD International Conference on Knowledge Discovery, & Data Mining.* San Diego, CA. Aug15-18. pp33-42

Handmer, J. (2000). Are Flood Warnings Futile? Risk communication in emergencies. *The Australasian Journal of Disaster, & Trauma Studies.* 2000-02.

Hedberg, S.R. (1995). Intelligent agents: The First Harvest of Softbots Looks Promising. *IEEE Expert.* 10(4), 6-9.

Heintze, C., Papasimeon, M., & Goss, S. (2000). Specifying agent behavior with Use cases. In *Proceedings of Pacific Rim Workshop on Multi-Agent (PRIMA),* Melbourne, Australia.

Hevner, A.R. and March, A.T. (2003). The Information System Research. *IEEE Computer.* Nov. 36(11). pp 111-113

Hoyman, K.H. (2000). *Nursing Team Recognition of Pressure Ulcer Risk.* PhD Thesis. University of Minnesota. (UMI ProQuest Digital Dissertation Publication No. AAT 9972969).

Huget, M. (2002a). An Application of Agent UML to Supply Chain Management. Technical Report ULCS-02-015. Department of Computer Science, University of Liverpool.

Huget, M. (2002b). Agent UML Class Diagram Revisited. Technical Report ULCS-02-013. Department of Computer Science, University of Liverpool.

Huget, M. (2002c). Extending Agent UML Protocol Diagrams . Technical Report ULCS-02-014. Department of Computer Science, University of Liverpool.

Huget, M. (2002d). A Language for Exchanging Agent UML Protocol Diagrams. Technical Report ULCS-02-009. Department of Computer Science, University of Liverpool.

Iba, W., & Gervasio, M.T. (1999). Adapting User Preferences in Crisis Response. *In Proceedings of Intelligent User Interface.* Pp87-90. [Electronic Retrieved 21 Mac, 2001, from, http://citeseer.nj.nec.com/iba99adapting.html.

Iba, W, Gervasio, M.T., Langley, P., & Sage, S. (1998). Evaluating Computational Assistance for Crisis Response. In *Proceedings of the 20th Annual Conference on the Cognitive Science Soc. (Cog-Sci98).*

Iglesias, C., Garrijo, M., & Gonzalez, J. (1999). A Survey of Agent-oriented Methodologies. J. Muller, P.S. Munindar(eds). In *Proceedings of the 5th International Workshop on Agent Theories, Architectures, & Languages (ATAL98).* Lecture Notes in Artificial Intelligence. Heidelberg: Springer-Verlag. pp317-330

Janca, P.C. (1995). Pragmatic Application of Information Agents. BIS Strategic Report.

Jennings, N.R. (1996a). Applying Agent Technology. Plenary presentation at *Practical Application of Agent & Multiagent (PAAM 1996) Conference.*

Jennings, N.R. (1996b). Coordination Techniques for Distributed Artificial Intelligence. In G.M.P. O'Hare & N.R. Jennings (eds). *Foundation of Distributed Artificial Intelligence.* (pp187-210). London: Wiley..

Jennings, N.R. (2001). An Agent-based Approach for Building Complex Software Systems. *Communications of the ACM.* 44(4), 35-41.

Jennings, N.R., & Wooldridge, M. (1998). Applications of Intelligent Agents. In N.R. Jennings & M. Wooldridge (eds). *Agent Technology, Foundations, Applications, & Markets.* Springer Verlag.

Jennings, N.R., Sycara, K., & Wooldridge, M. (1998). A Roadmaps of Agent Research & Development. International Journal of Autonomous Agents & Multiagent Systems. 1, 275-306.

Kadous, M.W. (2002). *Temporal Classification: Extending the Classification Paradigm to Multivariate Time Series.* Phd Thesis. University of New South Wales, Sydney, Australia.

Kamel, M., & Ghenniwa, H. (1994). Coordination of Distributed Intelligent Systems. In F. Aminzadeh & M. Jamshidi (eds). *Soft Computing: Fuzzy Logic, Neural Networks, & Distributed Artificial Intelligence* (pp229-260). USA: Prentice Hall.

Karimi, K., & Hamilton,H.J (2002). Discovering Temporal Rules from Temporally Ordered Data. In H. Yin, N. Allinson, R. Freeman, J. Keane, S. Hubbard(eds). *Lec. Notes on Computer Science* (pp25-30).Vol 2412. Springer.

Keogh, E. (2001). Tutorial on Indexing & Mining Time Series Data. ICDM '01. The *2001 IEEE International Conference on Data Mining*, Nov. 29, San Jose.

Keogh, E., & Kassetty, S. (2002). On the Need for Time Series Data Mining Benchmarks: A Survey & Empirical Demonstration. In *Proceedings of the 8th ACM SIGKDD International Conference on Knowledge Discovery, & Data Mining*. Canada. pp102-111

Keogh, E., Chu, S., Hart, D., & Pazzani, M. (2001). An online algorithm for segmenting time series. In *Proceedings Of the IEEE International Conference On Data Mining.* pp289-296

Killion, T.H. (2000). Decision-making & the Levels of War. *Military review.* US Army Command & General Staff College, 1XXX(6), 666-70.

Kim, S.H. (1994). Learning & Coordination: Enhancing Agent Performance through Distributed Decision-making. Neteherlands: Kluwer Academic Pub.

Kiss, G. (1996). Agent Dynamics. In G.M.P O'Hare & N.R. Jennings (eds) *Foundations of Distributed Artificial Intelligence* (pp247-267). USA: John Wiley & Sons.

Klein, G., & Klinger, D. (1991). Naturalistic Decision-Making. *Human Systems* IAC Gateway. 11(3), 16-19.

Klein, G. & Weick, K.E. (2000). Decisions: Making the Right Ones. Learning from the Wrong Ones. *Across the Board, June 2000.* Retrieved 10 January 2002 from http://www.conference-board.org/atb/article/kleinJun.cfm,2000

Kobus, D.A., Proctor, S., Bank, T.E., & Holste, S.T. (2000). Decision-making in a Dynamic Environment: The Effects of Experience & Information Uncertainty. Technical Report 1832, SPAWAR Systems Center, San Diego, United States Navy.

Kusiak, A. (2001). Feature Transformation Methods in Data Mining. *IEEE Transactions on Electronics Packaging Manufacturing*. 24(3), 241-221.

Kusiak, A. (2002). Data Mining & Decision-Making. In B.V. Dasarathy (ed). *Proceedings Of the SPIE Conference on Data Mining & Knowledge Discovery: Theory, Tools, & Technology IV* (pp155-165). 4730. Orlando, Florida.

Kusiak, A., Kern, J. A., Kernstine, K.H. & Tseng, B.T.L. (2000). Autonomous Decision-making: A Data mining approach. *IEEE Transactions on Information Technology in BioMedicine*. 4(4), 274-284.

Lane, T., & Brodley, C.E. (1999). Temporal Sequence Learning, & Data Reduction for Anomaly Detection. *ACM Transactions on Information & System Security. (TISSEC)* . 2(3), 150-158.

Lassila, O., Becker, M., & Smith, S.F. (1995). An Explanatory Prototype for Reactive Management of Aeromedical Evacuation Plans. Technical Report CMU-RL-TR-96-03. The Robotics Institute, CMU.

Last, M., Klein, Y., & Kandel, A. (2001). Knowledge Discovery in Time Series Databases. *IEEE Transactions on System, Man,& Cybernetics*. Part B Cybernetics, 1-9.

Lee, H.Y. (1999). How Practical are Current AI Systems. In *Proceedings of the 1st National Conference on Artificial Intelligence Applications in Industry*. Kuala Lumpur. Malaysia. pp102-113.

Lee, C., Lin, C., & Chahn. M. (2001). Sliding Window Filtering: An Efficient Algorithm for Incremental Mining. In *Proceedings of the 10th Intnl. Conference On Information, & Knowledge Management*. Atlanta, Georgia, USA. pp263-27

Lesnick, L. L., & Moore, R.E. (1997). *Creating cool intelligent agents for the Net*. Foster City, CA, IDG.

Liang, Y., Fugere, B.J., & Ackles, K.N. (2000). Towards a Naturalistic Broad Agent Design. . In *Proceedings of the 9th Computer Generated Forces*. May 16-18. Florida.

Liang, Y., Robichaud, F., & Fugere, B.J. (2001). Implementing a Naturalistic Command Agent Design. *In Proceedings of the 10th Computer Generated Forces*, Norfolk, VA., 15-17 May 2001. pp379-386

Lin, W. Orgun, M., & Williams, G.J. (2002). An Overview of Temporal Data Mining. In S.J. Simoff, G.J. Williams & Hegland, M. (eds), *The 1st Australasian Data Mining Workshop, ADM02* (pp83-90), University of Technology, Sydney.

Lind, J. (2000). MASSIVE: Software Engineering for Multiagent Systems. In J. Bradshaw & Arnold, G. (eds), *Proceedings of the 5th International Conference On the Practical Application of Intelligent Agents, & Multiagent Technology* (PAAM 2000) (pp339-354).

Lipshitz, R., Klein, G., & Orasanu, J. (2000). Taking Stock of Naturalistic Decision-making. Center for Study of Organization & Human Resource Management. Retrieved 20 January, 2002, from, http://organizations.haifa.ac.il/raanaan-taking.doc

Lu, H., Han, J., & Feng, L. (1998). Stock Movement Prediction and n-Dimensional Inter-transaction Association Rules. *In Proceedings ACM SIGMOD Workshop on Research Issues on Data Mining, & Knowledge Discovery* (pp1-12).Seattle, Washington.

MacIntyre, D.J. (2002). Are Marines Soft-pedalling Maneuver Warfare? In *Proceedings of the United States Naval Institute,* Feb. 128(2), 72-75.

Maes, P. (1994). Agents that Reduce Work & Information Overload. *Communications of the ACM.* 37(4), 31-40.

Malaysia Country Report (1999). Crisis & Disaster Management Unit, Division for National Security, Prime Minister Department, Malaysia.

Matthews, R. (2001). Complex Adaptive Systems Co-operative Games & Strategic Issues. *Eastern Academy of Management.* May. New York.

McCoy, L.C., & Gillies, D. (1998). Architecture for Emergency lane on the NII: Crisis Information Management. White Paper on *The Unpredictable, Uncertainty* (pp364-373). National Academy Press: USA..

McCoy, L.C., Harrald, J.R., McManis, D.Y., & Tuttle, J.O. (1999). Crisis Management as a Function of Information Exchange. A White Paper on *Emergency Information & Communication.* National Institute for Urban Search & Rescue.

Moore, C., Baek, S., & Liebowitz, J. (1998). Intelligent Agent-based Information Warfare Advisor ("Bob-in-a-box"). *Kybernetes.* 27(1), 38-53. MCB University Press.

Morrison, J.G., Kelly, R.T., & Hutchins, S.G. (1996). Impact of Naturalistic Decision Support on Tactical Situation Awareness. In *Proceedings Of the 40th Human Factors, & Ergonomics Society Annual Meeting.*, Philadelphia. PA. Sep 22-26.

Morris, J.G., & Mitchell, C.M. (1995). A Designer Associate for Command and Control Software Development. In *Proceedings of the 1995 IEEE International Conference on Systems, Man & Cybernetics*, Oct. Vancouver, BC.

Mitroff, I.I., & Pearson, C.M. (1993). *Crisis Management: A Diagnostic Guide for Improving Your Organization's Crisis Preparedness.* San Francisco: Jossey-Bass Pub.

Mulgund, S., Rinkus, G., Illgen, C., Zacharis, G., & Friskie, J. (1997). OLIPSA: On-line Intelligent Processor for Situation Assessment. Paper presented at the *2nd Intnl. Annual Symposium & Exhibition on Situational Awareness in the Tactical Air Environment*, Patuxent River, MD.

Mylopoulos, J., Kolp, M., & Castro, J. (2001). UML for Agent-oriented Software Development: The Tropos Proposal. In *Proceedings of the 4th International Conference On UML, UML'01.*

National Research Council (1996). *Computing, & Communications in the Extreme: Research for Crisis Management, & Other Application.* Computer Science & Telecommunication Board. Washington: National Academy Press.

National Research Council (1999). *Summary of Workshop on Information Technology Research for Crisis Management.* Computer Science & Telecommunication Board. Washington: National Academy Press.

National Science & Technology Council (2000). Effective Disaster Warnings. Report by Working Group on Natural Disaster Information System, Natural Disaster Reduction.

Norling, E., Sonenber, L., & Ronnquist, R.(2000). Enhancing Multiagent Based Simulation with Human-like Decision-making Strategies. In S. Moss, & P.Davidson (eds) *Multiagent based Simulation: Proceedings of the 2nd International Workshop MABS2000* (pp214-228). Boston: Springer.

Norling, E. (2001). *Learning to Notice: Adaptive Models of Human Operators.* In Doina Precup & Peter Stone. (eds). *Agents-2001.* Workshop on Learning Agents, Montreal, Canada.

Norman, D.A. (1994). How Might People Interact with Agents. *Communication of the ACM.* 37(4).

Nunamaker, J.F., Chen, M. and Purdin, T.D.M. (1991). System Development in Information Systems Research. *Journal of Management Information Systems.*, 7 (3). pp 89-106.

Nurbianto, B. (17 Oct 2003). Officials must provide early warning on floods. *Jakarta Post.* (EBSCO HOST Accession No. 2W83134359047).

Nwana, H.S. (1996). Negotiation Strategies: An Overview. BT Labs Internal Report. In G.M.P. O'Hare & N.R. Jennings (eds). *Foundations of Distributed Artificial Intelligence.* USA: John Wiley & Sons.

Nwana. H.S., & Ndumu, D. (1999). A Perspective on Software Agents Research. *Knowledge Engineering Review.* 14(2), 1-18.

Nwana, H.S., Lee, L., & Jennings, N.R. (1994). Coordination in Software Agents System. BT Laboratories Internal report.

Odell, J., Parunak, H.V., & Bauer, B. (2000). Extending UML for Agents. In *Proceedings Of Agent-Oriented Information Systems Workshop*, pp3-17.

Odell. J., Parunak, H.V., & Bauer, B. (2001). Representing Agent Interaction Protocols in UML. In P. Ciancarini & W.ooldridge, M. (eds) *Agent-Oriented Software Engineering* (pp121-140). Berlin: Springer-Verlag.

Officials blamed for not issuing flood warning. (2 Jul 2003). *Jakarta Post (Indonesia)*. (EBSCO HOST Accession No: 2W83454953488)

O'Hare, D. (1992). The "Artful" Decision maker: A Framework Model for Aeronautical Decision-making. *The International Journal of Aviation Psychology*. 2(3), 175-191.

Orasanu, J., & Martin, L. (1998). Errors in Aviation Decision-Making: A Factor in Accidents & Incidents. In *Proceedings of Human Error, Safety, & System Development* (HESSD'98) (pp100-107). Seattle, Canada.

O'Shaughnessy, J. (1999). Sources of Power: How People Make Decisions. [Review of the Book]. *Journal of Macromarketing*. Jun.

Otsu, N. (1999). Real World Intelligence: A New paradigm of Artificial Intelligence. *In proceedings of the 1st National Conference on Artificial Intelligence Applications in Industry*. Kuala Lumpur, Malaysia. p1-8.

Ovum Report (1994). Intelligents Agents: The new revolution in software.

Paton, D., & Flin, R. (1999). Disaster Stress: An Emergency Management Perspective. *Disaster Prevention, & Management*. 8(4), 261-267.

Paton, D., Johnston, D., & Houghton, B. (1998). Organisational Response to A Volcanic Eruption. *Disaster Prevention, & Management.*7, 5-13.

Papasimeon, M., & Heinze, C. (2001). Extending the UML for Designing Jack Agents. In *Proceedings of Australian Software Engineering Conference (ASWEC2001)*. Aug. Canberra, Australia.

Park, S., Kim, J., & Lee, S. (2000). Agent-oriented Software Modeling with UML Approach. *IEICE Trans. Information, & Systems*. E83-D(8), 1631-1641

Parker, D.J., & Handmer, J.W. (1998). The Role of Unofficial Flood Warning Systems. *Journal of Contingencies, & Crisis Management*. 6(1), 45-60.

Parunak, H.V.D., & Odell, J. (2001). Representing Social Structures in UML. In *Proceedings Of International Conference On Autonomous Agents '01*, May28-June 1. Montreal, Canada.

Peterson, B., Stine, J.L., & Darken, R.P. (2000). Eliciting Knowledge from Military Ground Navigators. The *5th Naturalistic Decision-making Conference*, Tammsvik, Sweden. May 26-28.

Petrie, C.J. (2001). Agent-based Software Engineering. In J. Bradshaw & Arnold, G. (eds). *Proceedings of the 5th International Conference On the Practical Applications of Intelligent Agents, & Multiagent Technology* (PAAM2000). Manchester, UK.

Poutakidis, D., Padgham, L., & Winikoff (2002). Debugging Multi-agent Systems Using Design Artifacts: the Case of Interaction Protocols. In *Proceedings of the International Conference on Autonomous Agent & Multiagent Systems (AAMAS'02)*, July. Bologna, Italy. pp960-967.

Povinnelli, R.J. (1999). *Time Series Data Mining: Identifying Temporal Patterns for Characterization, & Prediction of Time Series Events.* Phd Thesis, Marquette University , Winsconsin, USA.1999

Povinnelli, R.J., & Feng, X. (2002). A New Temporal Pattern Identification Method for Characterization & Prediction of Complex Time Series Events. *IEEE Transactions on Knowledge, & Data Engineering.* (in press)

Pratt, K.B. (2001). *Locating Pattern in Discrete Time-Series.* MSc (Comp. Sc) Dissertation. University of South Florida.

Puteh, M. (17 Jun, 2003). Flood-warning signs were too late. *New Straits Times.* (EBSCO HOST Accession No: 2W83880145898).

Rao, M., Yang, H., & Yang, H. (1998). Integrated Distributed Intelligent System Architecture for Incidents Monitoring & Diagnosis. *Computers in Industry.* 37, 143-151.

Rathmell, A., Overill, R., & Valeri, L. (1997). *Information Warfare Attack Assessment System (IWAAS).* Paper presented at Information Warfare Seminar, 21-23 Oct. London.

Roberts, V. (1994). Flood Management: Bradford paper. *Disaster Prevention, & Management.* 3(2), 44-60.

Robichaud, F. (2001). *Implementing a Naturalistic Command Agent Design.* Paper presented at the Workshop on Computerized Representation of RPD. Oct. Boulder, CO.

Robichaud, F. (2002). *A Computational Model for Naturalistic Decision-making in the Context of Military Simulations.* MSc (Comp. Sc) Dissertation. Royal Military College, Canada.

Rose, J. (1998). *Dynamic Decision Support for Command, Control, & Communications in the Context of Tactical Defense.* DAG Research Group,

Dept. of Comp. Sc., Uni. South Carolina. Online. Retrieved 12 April, 2001, from http://www.cse.sc.edu/research/dag/

Rothrock, L., Koubek, R., Fuch, F., Haas, M., & Salvendy, G. (2002). Review & Reappraisal of Adaptive Interfaces: Toward Biologically Inspired Paradigms. *Theoretical Issues in Ergonomic Science.* 3(1), 47-84.

Russel, S., & Norvig, P. (1995). *Artificial Intelligence: A Modern Approach.* USA: Prentice Hall.

Sargent, P. (1992). Back to School for a Brand New ABC. In *The Guardian.* 12 March. p28

Sauvola, J., & Pledkalnen, M. (1995). Page Segmentation & Classification Using Fast Feature Extraction & Connectivity Analysis. In *Proceedings on International Conference On Document Analysis, & Recognition.* pp1127-1131

Schmitt, J. (1996). Mastering Tactics. Tactical Decision Games Workbook. Marine Corps University, Quantico, Virginia, US.

Schumann, J., & Whittle, J. (2000). Automatic Synthesis of Agent Designs in UML. In *Proceedings Of Goddard Workshop on Agent-based Systems* (pp148-162). Springer.

Sendzimir, J., Light, S., & Szymanowska, K. (1999). *Adaptive Understanding, & Management for Floods. Environments.* 27(1), 115-136.

Shehory, O., & Sturn, A. (2001). *Evaluation of Modeling Techniques for Agent-based Systems.* Agents-01. Montreal, Canada. pp624-631

Shoham, Y. (1997). An Overview of Agent-oriented Programming. In *Software Agents.* J. Bradshaw (eds). Menlo Park: AAAI Press.

Slap, A.J., Hillman, D., & Moore, D.A. (1998). Expert Systems in Emergency Response. Paper presentation at the *1st Annual Symposium of the Mary Kay O'Connor Process Safety Second Nature.* George Bush Presidential Conference Center, College Station, Texas. Mac 30-31

Sloman, A. (1993). Prospects of AI as the General Science of Intelligence. IN A. Sloman, D. Hogg, G. Humphrey, D. Patridge and A. Ramsey (eds). *Prospects for Artificial Intelligence.* pp 1-10. Amsterdam: ISO Press

Sloman, A. (1997). What sort of architecture is required for a humna-like agent? In M. Wooldridge and A, Rao (eds). *Foundations of Rational Agence.* Kluwer Academic Publishers.

Solowski, J. (2001). Can a Composite Agent Be Used to Implement Recognition-primed Decision Model? In *Proceedings of the 11th Conference On*

Computer Generated Forces, & Behavioral Representation . Orlando, FL. pp431-436

Stewart, K.G. (1995). *Flood Warning Systems, & Early Notification Procedures in Denver, Colorado.* Paper presented in International Invitational Workshop, Flood Hazard Research Centre, Middlesex University, London, England, UK. 10-12 Sep.

Stewart, D.R. (2000). *Environmental decision-making: Combining Engineering, & Business aspects.* PhD Thesis. Colorado State University.

Sycara, K.P. (1998). Multiagent Systems. *AI Magazine.* Summer 1998. 19(2), 79-82.

Teh, S.K., & Ong, S.H. (2000). *Strategy for Flood Response.* Persidangan Tahunan Pengurus Kanan JPS Malaysia 2000, Langkawi, Kedah. 7-8 Sep.

Thearling, K. (1995). *An Overview of Data Mining at Dun & Bradstreet.* IDIG White Paper 95/01.

Tsien, C.L. (2000). Event Discovery in Medical Time Series Data. *Americans Medical Informatics Assoc. 2000 Symposium.* Nov 4-8.

Torsun, I.S. (1995). *Foundations of Intelligent Knowledge Based Systems.* London: Academic Press.

Tung, A.K.H., Lu, H., Han, J., & Feng, L. (2000). Efficient Mining of Intertransaction Association Rules. *IEEE Transactions on Knowledge, & Data Engineering.* 15(1), 43-56.

Tung, A.K.H, Lu, H., Han, J., & Feng, L. (1999). Breaking the Barrier of Transactions: Mining Inter-transaction Association Rules. In *Proceedings 5th International Conference On Knowledge Discovery, & Data Mining (KDD'99).* San Diego. pp297-300

Turoff, M. (2002). Past & Future of Emergency Response Information Systems. *Communications of the ACM.* 45(4), 29-32.

Tveit, A. (2001). A Survey of Agent-oriented Software Engineering. In *Proceedings of the 1st NTNU Computer Science Graduate Student Conference*, May. Tondheim, Norway.

Two Crows Corporation (1999). Introduction to Data Mining & Knowledge Discovery. 3rd ed.

Vale, A.A., Fernandes, M.F., Rosado, C., Marques, A., Ramos, C., & Faria, L. (1998). Better KBS for Real-time Applications in Power Systems Control Centers: The Experience of SPARSE Project. *Computers in Industry.* 37, 97-111.

Voss, M.S. (2000). Complex Adaptive Systems + Soft Computing= Emergency Design Systems (EDS). In *Proceedings Of the 3rd IASTED International Conference – Artificail Intelligence + Soft Computing.* July 24-26. Banff, Alberta, Canada.

Wright, I.P. (1997). *Emotional Agents.* PhD Thesis. School of Computing Science, The University of Birmingham, England.

Xia, B.B. (1997). *Similarity Search in Time Series Data Sets.* MS Dissertation. Simon Fraser University.

Xiao, Y., Milgram, P., & Doyle, D.J. (1992). Incident Evolution & Task Demands: An Analysis & A Filed Study of 'Going Sour' Incidents. *In Proceedings of the Human Factors Soc. 36th Annual Meeting,Ssanta Monica, CA.* Vol 2. pp 1279-1283

Warwick, W., McIlwaine, S., Hutton, R., & Dermott, P. (2001). Developing Computational Models of Recognition-primed Decision-making. In *Proceedings of the 10th Conf. On Computer Generated Forces*, Norfolk. VA. 15-17 May. pp232-231.

Weiner, A.J., Thurman, D.A., & Mitchell, C.M. (1996). FIXIT: An Architecture to Support Recognition-primed Decision-making in Complex System Fault Management Activities. In *Proceedings of the 1996 Annual Meeting of the Human Factors & Ergonomic Society*, Philadelphia, PA. pp209-213.

Weiss, G.M., & Hirsh, H. (1998). Learning to Predict Rare Events in Categorical Time-series Data. Technical report WS-98-07 from the AAAI Workshop, Predicting the Future: AI approaches to Time-Series problems. Pp83-90

West Yorkshire Fire Service ICS Manual. (2001). West Yorkshire Fire & Civil Defence Authority.

White, R. (1999). Water in Rivers: Flooding. A White Paper for World Water Vision on behalf of International Assoc. of Hydraulic Research (IAHR).

Wong, B.L.W. (2000). The Integrated Decision Model in Emergency Dispatch Management & its Implication for Design. *The Australian Journal of Information System(AJIS).* 7(2).

Wooldridge, M. J.(1999). *An Introduction to Multiagent Systems.* Sussex: John Wiley & Sons Ltd.

Wooldridge, M.J. & Ciancarini, P. (2001). Agent-oriented software engineering: The state of the art. In P. Ciancarini & M.J. Wooldridge (eds). *The Proceedings of the 1st International Workshop on Agent-oriented Software Engineering* (1957, pp1-28). Berlin: Springer-Verlag.

Wooldridge, M.J., & Jennings, N.R. (1994). Agent Theories, Architectures & Languages: A Survey. In *Proceedings of the 11th European Conference on Artificial Intelligence (ECAI94).* Springer.

Zhang, W., & Hill Jr., R.W. (2000). A Template Based & Pattern Driven Approach to Situation Awareness & Assessment in Virtual Humans. In *Proceedings of the 4th International Conference on Autonomous Agents,* June. pp116-123

Zsambok, C.E. (1993). Implications of a Recognitional Decision Model for Consumer Behavior. *Advances in Consumer Research.* 20, 239-244.