UNIVERSITI PUTRA MALAYSIA

AN APPROACH TO THE DEVELOPMENT OF HYBRID ARCHITECTURE OF EXPERT SYSTEMS

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DOCTOR OF PHILOSOPHY
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1999
AN APPROACH TO THE DEVELOPMENT
OF HYBRID ARCHITECTURE OF
EXPERT SYSTEMS

By

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Dissertation Submitted in Fulfilment of the Requirements for
the Degree of Doctor of Philosophy in the Faculty of
Computer Science and Information Technology
Universiti Putra Malaysia

August 1999
Dedicated to my wife; Maha,

my kids; Moneeb, and Duha,

my mother and the family
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August 1999
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<td>AI</td>
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<td>BPNN</td>
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<td>DBMS</td>
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<td>DSE</td>
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<td>DSP</td>
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<td>DSS</td>
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<td>ES</td>
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<td>FN</td>
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<td>FP</td>
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<td>FTP</td>
<td>File Transfer Protocol</td>
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<td>GA</td>
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<td>IHS</td>
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<td>KAM</td>
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<td>NASA</td>
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<td>NES</td>
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<td>NKB</td>
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<td>UIM</td>
<td>User Interface Module</td>
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<td>VLSI</td>
<td>Very Large-Scale Integration</td>
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Abstract of dissertation presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Doctor of Philosophy.

AN APPROACH TO THE DEVELOPMENT OF HYBRID ARCHITECTURE OF EXPERT SYSTEMS

By

MOAWIA ELFAKI YAHIA

August 1999

Chairman:  Ramlan Mahmod, Ph.D.
Faculty:  Computer Science and Information Technology

The knowledge acquisition process is a crucial stage in the technology of expert systems. However, this process is not well defined. One of the promising structured source of learning can be found in the recent work on neural network technology. Neural network can serve as a knowledge base of expert system that does classification tasks. The combination of these two technologies emerges new systems called neural expert systems. Neural expert systems allow us to generate a knowledge base automatically from training examples. Also, they have an ability to handle partial and noisy data. Despite the advances of these systems, debugging their knowledge bases is still a big problem. Neural networks still have some problems such as providing explanation facilities, managing the architecture of network and accelerating the training time.
The concept of a rough set has been proposed as a new mathematical tool to deal with uncertain and imprecise data. Using this tool to approach the problem of data reduction and data dependency has emerged as a powerful technique in applications of expert systems, decision support systems, machine learning, and pattern recognition. Two methods based on rough set analysis were developed and merged with the development of neural expert systems forming a new hybrid architecture of expert systems called a rough neural expert system. The first method works as a preprocessor for neural network within the architecture, and it is called a pre-processing rough engine, while the second one was added to the architecture for building a new structure of inference engine called a rough neural inference engine. Consequently, a new architecture of knowledge base was designed. This new architecture was based on the connectionist of neural network and the reduction of rough set analysis.

The proposed design was implemented using an environment of object-oriented programming. Four objects and three modules were developed using C++ programming language. The performance of the proposed system was evaluated by an application to the field of medical diagnosis using a real example of hepatitis diseases. Data for this application was obtained from researchers working on a related study. Also, the proposed work was compared with some related works. The comparing results indicate that the new methods have improved the inference procedures of the expert systems. The findings from this study have showed that this new architecture has some properties over the conventional architectures of expert systems.
Abstrak disertasi yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Doktor Falsafah.

SATU PENDEKATAN KEPADA PEMBANGUNAN
SENI BINA HIBRID SISTEM PAKAR

Oleh

MOAWIA ELFAKI YAHIA

Ogos 1999

Pengerusi :  Ramlan Mahmod, Ph.D.

Fakulti: Sains Komputer dan Teknologi Maklumat

Proses perolehan pengetahuan merupakan satu peringkat yang genting dalam
technologi sistem pakar. Walau bagaimanapun, proses ini masih tidak jelas. Satu
sumber pembelajaran yang lebih berstruktur boleh ditemui dalam penyelidikan
terbaru ke atas teknologi rangkaian neural. Rangkaian neural menyediakan asas
pengetahuan bagi sistem pakar yang melakukan tugas-tugas klasifikasi. Kombinasi
daripada dua teknologi ini menghasilkan sistem baru yang dipanggil sistem pakar
neural. Sistem pakar neural membolehkan kita menghasilkan asas pengetahuan
secara automatik daripada contoh-contoh latihan. Selain itu, ia juga berkebolehan
untuk mengendalikan data spara dan data hingar. Meskipun terdapat pelbagai
kelebihan sistem ini, namun menyahpepijat asas-asas pengetahuannya masih menjadi
satu masalah yang besar. Rangkaian neural masih mempunyai beberapa masalah
seperti kemudahan menyediakan penerangan, mengurus reka bentuk rangkaian dan
meningkatkan kelajuan masa latihan.

CHAPTER I

INTRODUCTION

Background

In recent years, models for developing appropriate hybrid systems using Artificial Intelligence (AI) technologies have appeared. One reason of this approach is to build more powerful systems that can reduce drawbacks of implementing a single AI technology alone (Goon, 1995; Kandel, 1992; Medsker, 1992; Soucek, 1991).

The development of integrated technologies of Neural Network (NN) and Expert Systems (ES) has shown some advancement. The complementary features of neural networks and expert systems allow the combination of these two technologies to make more powerful systems than can be built with either of the two alone (Medsker, 1994). This integration comes to emerge new systems called Neural Expert Systems or Connectionist Expert Systems, firstly introduced by Gallant in 1988 (Gallant, 1988).

Neural expert systems are expert systems that have neural network for their knowledge bases. Most important features of these systems are the learning algorithm that allows us to generate a knowledge base automatically from training
examples, and the ability to handle partial and noisy data. Despite the advances of this system, debugging its knowledge base is still a big problem. Also the architecture of neural network and accelerating the training time are important issues.

Rough Set Theory, introduced by Pawlak in 1982 (Pawlak, 1991; 1995), is a new mathematical tool to deal with vagueness and uncertainty. It has proved its soundness and usefulness in many real life applications. Rough set theory offers effective methods that are applicable in many branches of AI. The idea of rough set consists in approximation of a set by a pair of sets called lower and upper approximations of the set. The definition of the approximations follows from an indiscrenibility relation between elements of the sets, called objects. Objects are described by attributes of a qualitative or quantitative nature.

Rough set approach to expert system appears in rule induction of expert system by providing two sets of rules; certain rules and possible rules (Slowinski, 1992). This approach is weak and not practical when the number of attributes is very large. Therefore, the useful approach is one considering the reduction of attributes. Also the rough set can be a useful tool for pre-processing data for neural networks by applying its concept of attribute reduction to reduce the network’s input vector, and hence to scale down the size of the whole architecture of the network.

Objectives of the Research

The main goal of the research is to show the emergence of rough set theory by providing new methods of it, and to merge these methods with the integration of
expert systems and neural networks. So the main objectives of the research can be derived from the goal as:

1) To develop a new method for pre-processing input to neural network based on rough set analysis. The method involves a new algorithm for reduction of neural network's input size. The method can be used as a pre-processing rough engine for knowledge acquisition of expert system that has neural network for its knowledge base.

2) To design a hybrid architecture of expert systems based on neural networks and rough sets. This architecture is composed from a pre-processing engine, a knowledge base and an inference engine. The structure of knowledge base is a product of combination of neural network and pre-processing rough description, instead of rules in the conventional expert systems.

Importance of the Research

The most difficult stage of building an expert system is the knowledge acquisition process. However, this process is not well defined. One of the promising structured sources of learning can be found in the recent work on neural networks. Neural network can serve as a knowledge base of expert system that does classification tasks (Gallant, 1988). The big issue here is how we can manage the architecture of the neural network. So this raises a question of how to develop an efficient tool that can help with the task.
The concept of a rough set has been proposed as a new mathematical tool to deal with uncertain and imprecise data, and it seems to be of significant importance to AI and cognitive sciences (Slowiniski, 1992). Using this tool to approach the problem of data reduction and data dependency has emerged as a powerful technique in applications of expert systems, decision support systems, machine learning, and pattern recognition.

This tool can be useful in managing the architecture of knowledge base of neural expert system. At first, a decision table has been developed from training example cases. Then by applying the rough set approximation concept to decision table, reduction in attributes can be discovered. So the reduction in network’s input vector assists to manage the whole architecture of the network (Yahia, 1997a).

**Contributions of the Research**

The most contribution of the research is proposing a hybrid system combines the two technologies of neural networks and rough sets as supplement to the expert system technology. Neural network can address the knowledge acquisition bottleneck by gleaning knowledge from training data and storing the information as connection weights. Rough set theory is a new approach to data analysis with advantages of providing efficient algorithms for finding hidden patterns in data, finding minimal sets of data and generating sets of decision rules from data. The three technologies can represent different characteristics of intelligent behaviour and thus the combination of them in the hybrid system can solve more complex and useful problems.
The main contributions of the research could be highlighted as:

1) Designing a new hybrid architecture of expert systems based on neural networks and rough sets.

2) Developing a new algorithm for pre-processing inputs to neural networks based on rough sets analysis.

3) Designing a new structure of knowledge base based on connectionist of neural networks and pre-processing description of rough sets analysis.


5) Introducing a new model for implementing the hybrid architecture based on the object-orientation.

6) Developing of expert system of hepatitis diseases as an application of proposed hybrid architecture.

**Application**

Over the past years a great deal of AI research has been directed towards the development of knowledge based systems (expert systems) for problem solving in medical diagnosis domain. Medical diagnosis is an attractive domain that helps us to illustrate the working of the research. We consider a real life example to apply research's operations. The example deals with a special medical problem (e.g. liver diseases and especially hepatitis diseases).

Our information table, in this case, describes a hospital. So each training example is a patient’s case history; the attributes are symptoms and tests; and
decisions are diseases. Each patient is characterised by the results of tests and symptoms and is classified by the doctor (expert) as being on some level of disease severity. So we bring a suitable number of cases from a consultant doctor who performs a study or survey in our case.

**Organisation of the Dissertation**

The dissertation is organised in accordance with the standard structure of theses and dissertations at Universiti Putra Malaysia. The dissertation has five chapters, including this introductory chapter. The remaining chapters are: literature review, design of hybrid expert system, implementation and evaluation, and conclusions and recommendations.

Chapter II – *Literature Review* covers all literatures related to the topics of the research describing intelligent hybrid systems as a new trend in the field of artificial intelligence. It shows the needs for the hybrid systems, presents their classifications and offers some guidelines in developing such a system. The chapter focuses on the technology of expert systems, its characteristics and limitations. The chapter discusses the integration of expert systems and neural networks as one of new trends in the field of artificial intelligence. Two models of neural network were clearly described. The chapter presents the back-propagation neural network as a classical model for neural networks, while it introduces the probabilistic neural network as a new model for classification systems. The benefits from using rough sets theory as a new tool for handling uncertainties was also discussed, focusing on its approach to improve the working in expert systems and neural networks.
Through the discussion of all these topics the related works, which were done or currently are going on, were mentioned with some critical views.

Chapter III – Design of Hybrid Expert System describes a proposed model for hybrid system. The chapter offers a hybrid architecture of expert systems that based on neural network and rough sets theory, as a new intelligent hybrid system to improve the working on classification expert systems. The chapter describes all components of the new architecture in details. The chapter also introduces the object-oriented programming as an excellent environment tool for developing the proposed hybrid system. As description of the development phase of the model, objects and modules which constitute the system components were clearly defined, designed, and then developed. Finally, one illustration example was offered to explain the described methods and algorithms.

Chapter IV – Implementation and Evaluation is devoted to presenting the application of the system model described in chapter III. The chapter contents mainly three parts. The first part is the system learning, which describes the implementation of this model using the developed objects and modules for rough set analysis and neural network learning. The system testing is coming on the second part as an evaluation of the performance of implemented parts of system model by applying them to the field of medical diagnosis. The third part contents the discussion of results of the study. It highlights the main findings with comparison with related study.
Chapter V - Conclusion and Recommendations contents concluding remarks of the study with some recommendations of further development. The conclusion part includes a description of features and capabilities of this proposed design of hybrid expert system. The recommendations were presented as guidelines for development a new design with new capabilities that can be added to the system. The chapter also introduces the automated technique of example-based knowledge engineering as a promising area of further development of the hybrid system. Finally, the chapter opens some ways for the proposed system in the coming future of artificial intelligence.