PEST ACTIVITY PROGNOSIS IN RICE FIELDS USING FUZZY EXPERT SYSTEM APPROACH

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ABSTRAK

Logik kabur merupakan satu bentuk perwakilan pengetahuan bagi konsep yang tak dapat ditakrifkan secara tepat tetapi bergantung kepada konteks penggunaannya. Sistem Pakar adalah program komputer yang menggunakan pengetahuan manusia untuk menyelesaikan masalah khusus yang memerlukan kepintaran manusia. Oleh kerana pengetahuan yang terlibat dalam pengurusan serangga adalah tidak lengkap dan kabur, maka logik kabur diintegrasikan ke dalam sistem pakar untuk mengendalikan penaksiran anggaran. Sistem Pakar dan Logik Kabur mempunyai kelebihannya tersendiri dan gabungan kedua-dua teknologi yang membentuk sistem pakar-kabur dapat meningkatkan keupayaan sistem (Herrmann, 1996). Berdasarkan keupayaan logik kabur dan sistem pakar, peramalan aktiviti serangga di sawah padi menggunakan pendekatan pakar-kabur telah dibangunkan untuk menyediakan maklumat kepada petani dan penyelidik melalui Internet. Oleh kerana beras merupakan makanan ruji rakyat Malaysia dan Kedah merupakan kawasan utama penanaman padi di Malaysia, kajian ini memfokuskan kepada aktiviti serangga di sawah padi. Dalam MyPEST, jenis serangga yang mengakibatkan kerosakan pada tanaman padi ditentukan oleh sistem pakar, manakala Logik Kabur digunakan untuk meramalkan tahap aktiviti serangga. Ini penting supaya rawatan awal dapat dilakukan sebelum kerosakan bertambah buruk. Sistem MyPEST membantu pengguna dengan mengendalikan rundingan pakar yang dikawalselia oleh sistem pakar dan logik kabur untuk peramalan dan menguruskan ketidakpastian data menggunakan pembolehubah lingistik. Sistem berasaskan web ini juga membantu petani dan institusi pertanian untuk menguruskan ladang dengan cekap dan dapat meningkatkan kualiti serta kuantiti beras yang dihasilkan. Dalam kajian ini, proses peramalan menggunakan lebih daripada satu attribut telah dikaji. Dapatan kajian menunjukkan sekiranya lebih daripada satu atribut terlibat, graf keputusan 3-dimensi yang kurang tegar dihasilkan. Penentuan jenis serangga adalah dalam fasa pertama MyPEST dan diikuti oleh peramalan aktiviti serangga yang dikenalpasti. Sistem ini telah disemak oleh pakar serangga di MARDi dan disahkan membawa manfaat kepada penyelidik di MARDI, MADA dan DOA khususnya dan petani secara keseluruhan.

ABSTRACT

Fuzzy Logic (FL) is a form of knowledge representation which is appropriate for notions that cannot be defined precisely, but depends upon its context. An Expert System (ES) is a computer program that uses human knowledge to solve problems in typical tasks, which normally requires human intelligence. As knowledge involved in pest management is imperfect, vague and not completely reliable, fuzzy logic is integrated in this expert system to deal with the approximate reasoning. Expert system and fuzzy logic have their own significant capabilities the combination of both technologies that forms a fuzzy-expert system or a hybrid system could increase the systems performance (Herrmann, 1996). Due to the capability of fuzzy logic and expert system, pest activity prognosis in rice field using fuzzy expert approach was developed to provide information to the farmers and researchers through the Internet. Since rice is the main staple food of the Malaysian and Kedah is known as 'rice bowl' Malaysia, therefore this study focuses on the pest's activity in the rice fields. In MyPEST, the type of pest that causes damage to the rice plant is determined by the expert system. On the other hand, Fuzzy Logic approach is used to forecast the pest activity level. This is important so that early treatment or action can be applied before damage to the plant becomes worst. The system helps the user by managing the consultation which is performed by the expert system and fuzzy logic to make prediction and dealing with the natural and uncertainty data using linguistic variables. This web based application system also helps the farmers as well as agriculture institution representatives to manage farm successfully and to improve the quality and quantity of rice production. In this study, the forecasting process using more than one attributes was explored. From the findings, if more than one attributes involved, the less rigid 3-dimensional decision graph was produced. The identification for the type of pest is also involved in the first phase of this system which followed by the activity forecasting based on the identified pest. The system has been verified by MARDI entomologist and the system is confirmed to benefit the researchers at MARDI, MADA and DOA particularly, and the farmers at large.

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CHAPTER 1

INTRODUCTION

This chapter briefly explains the background of the project that mainly involves the integration between fuzzy logic and expert system to form a fuzzy expert system in order to utilize the advantages from both approaches. The problem statement, objectives, significance of the project and scopes are also presented in this chapter.

1.1 Background Study

Fuzzy Logic (FL) is a form of knowledge representation which is appropriate for notions that cannot be defined precisely, but depend upon its context. It enables computerized devices to reason more like humans. Fuzzy logic is an excellent means to combine Artificial Intelligence methods (Zadeh, 1993). The advantage of fuzziness dealing with imprecision fits ideally into decision systems; the vagueness and uncertainty of human expressions is well modeled in the fuzzy sets, and a pseudo-verbal representation, similar to an expert's formulation can be achieved. In a sense, fuzzy logic resembles human decision making with its ability to work from approximate data and find precise solutions.

An Expert System (ES) is a computer program that uses human knowledge to solve problems in typical tasks, which normally requires human intelligence. Expert systems were designed to reason through knowledge to solve problems using methods that

humans use. One of the key characteristics of an expert system is the explanation facility. With this capability, an expert system can explain how it arrives at its conclusions. The user can ask questions dealing with what, how, and why aspects of a problem. The expert system will then provide the user with a trace of the consultation process. The explanation facility helps the expert system to clarify and justify why such a digression might be needed.

However the conventional expert systems are developed using two logic values based on crisp rules. As knowledge involved in pest management is imperfect, vague and not completely reliable, therefore fuzzy logic is integrated in this expert system to deal with the approximate reasoning. Its application becomes mandatory to manage the uncertainty in the expert system (Zadeh, 1983; Zadeh, 1996). Since expert system and fuzzy logic have their own significant capabilities, the combination of both technologies that forms a fuzzy-expert system or a hybrid system could increase the systems performance (Herrmann, 1996).

To date, Hybrid Intelligent System (HIS) is more preferable to any single intelligent system approach (Kuciauskas *et al.*, 1998; Manner and Joyce, 1997; Herrmann, 1996). HIS refers to any integration of at least two AI techniques such as neural network and fuzzy logic (neuro-fuzzy), neural network and expert system (neural-expert), fuzzy logic and expert system (fuzzy-expert), neural networks, genetic algorithm and expert system or neuro-fuzzy-expert. The type of hybrid system to be used depends on the problem to be solved.

Prognosis has been used in medical applications. Prognosis is defined as a forecast of course of disease (Coulson *et al.*, 1990). Since prognosis requires forecasting ability as well as the ability to explain why a phenomenon occurs, therefore artificial intelligent techniques that are required to perform prognosis must be able to forecast and provide reasoning. AI techniques that are suitable for prediction are neural network, fuzzy logic and case based reasoning. On the other hand, expert system and case based reasoning are good at providing explanation to intelligent system. In this study, techniques which

have the forecasting and explanation abilities are required. For this purpose, fuzzy logic and expert system have been chosen to be integrated in a web based environment to demonstrate the used of hybrid system, on pest activity in rice fields.

Within the proliferation of internet usability, there is much effort to bring the agricultural community online in Malaysia. Focus on the Malaysian Agricultural sector was renewed following the Malaysia economic crisis in 1998 (Shariffaden, 2000). Malaysian Ministry of Agriculture has introduced the Third National Agricultural Policy 1998-2010 (NAP3). NAP3 (1999) identified several issues and challenges to help tackle the problem of foreign food dependency. It is expected that information technology will play an important role in the acquisition and dissemination of new knowledge and technologies to motivate the involvement of youth in the agricultural sector (Deraman and Bahar, 2000). Consequently, a new technological solution is needed to work in parallel with the government efforts to help educate and inform the farmers and smallholders about pests and their activities for specific crops. Currently, it can be said that there are a number of agricultural resource sites available on the Internet (Di, 2000).

Pest management in crops is a highly challenging problem and may yield losses if it is not handled properly (Saini *et al.*, 2000). Potential losses of up to 55% before harvest have been estimated, but these estimates often represent the worst case or highest levels of loss. Hence, there is a need of different technologies as well as awareness programs for effective, economical, environment friendly control of pests (Singh, 1990). Besides, the appropriate and optimal combination of control measures are used for cost effective and environment friendly control of pests (Atwal and Dhaliwal, 1997). As knowledge involved in IPM is imperfect and fuzzy logic has been successfully used for approximate reasoning in such cases, its application becomes mandatory to manage the uncertainty in the expert system (Zadeh, 1983).

1.2 Problem Statement

The current practice of pest management in Agricultural Department is by observing the data from the selected plot in rice fields. The Agricultural Department in Teluk Chengai Kedah is responsible to rice fields located in Kedah and Perlis that involves 78 000 ha with 440 sampling point. The responsible employee at this department will observe the sampling plot in each selected location and state in the paper form of data observation. This data collected includes the name of the pest found, the stage of rice plant, the water status in rice fields and the number of pest present in the plot. This data is stored in the system and used to calculate the level of damages caused by particular pests. All these information will remains in this department and institute. The report from the observation is used to counsel farmer the action should be taken.

Due to the imperfect, vague and not completely reliable of knowledge involved in pest activity and damage level in rice fields, it is difficult to measure the symptom occurrences with simply yes or no, or absence and presence notation. However, the existing expert system allows the user to answer the set of questions using the rigid crisp values (Saini *et al.*, 2000). In crops management, it is important to estimate the damage that has been affected by pests since the degree of damage will determine the activity of pests (Atwal and Dhaliwal, 1997). Therefore, there is a need of a forecasting tool that can predict the level of pest activity so that early treatments can be applied to crops before the damage becomes worst.

1.3 Objectives

The main objective of this project is to develop the fuzzy expert system for determining and diagnosing pest and its activity in rice fields. Specifically, the objectives of this system are:

i. To forecast the pest activity level in the rice field.

ii. To provide explanation facilities using expert system approach.

1.4 Significance of the Study

The pest activity prognosis in rice fields offers computerized fuzzy expert system in dealing with uncertainty information in a way to identify the kind of pests attack on the rice plant derived from the symptoms given by the farmers. The system allows the users to input percentage of symptoms in uncertainty forms (high, very high, medium) rather than the common form of yes/no or absence/presence form. The proposed system enables the users particularly the farmers and the MARDI representative to identify the pest that damages the plant. The system also allows the users to forecast a pest activity level in the rice field. This allows the farmers and MARDI representative to provide the treatment before the pest activities become worst. In addition, all the information and knowledge about the pests, treatment control measure and prevention steps are managed in the specific knowledge base. Apart form identifying the pest and its activity level, the system can be used as part of portal development for MARDI and MADA in particular and the farmer community as a whole

1.5 Project Scope

The scope of this project is to develop prototype fuzzy expert system for pest management in rice fields. Fuzzy system is expected to be used in handling uncertainty type of rules while expert system copes with the explanation and reasoning tasks. The integration of expert system and fuzzy system is aimed to utilized advantages of both approaches. This fuzzy expert system is specifically developed for pest management in the rice fields. The main target users for this system are farmers in prior and MARDI officers as well as the Agricultural Institute.

1.6 Thesis Overview

This thesis report is constructed into six chapters. The first chapter is an introduction chapter that explains the background overview, problem statements, objectives, significance of the study and scope. The second chapter discusses a related literature review while the system design and implementation is discussed in chapter three Results and conclusion is revealed in chapter four and five respectively.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

MyPEST is a Pest Activity Prognosis in rice fields that has been developed using Fuzzy Expert approach. Expert system and fuzzy logic have their own significant capabilities. Therefore the combination of both technologies that forms a fuzzy-expert system or a hybrid system could increase the systems performance (Herrmann, 1996). MyPEST offers computerize fuzzy expert system in dealing with uncertainty information in a way to identify the kind of pests attack on the rice plant derived from the symptoms given by the farmers. The system helps the user by managing the consultation session in order to forecast the pest activity. A set of questions will be asked through graphical user interface and helps user diagnose their given symptom to infer such a conclusion. The consultation performed by the expert system also involved fuzzy logic when dealing with the natural and uncertainty data. This study focuses on the software development using hybrid AI technology and the employment of fuzzy expert system in agriculture domain typically in Malaysia.

Artificial Intelligence (AI) is a science and engineering of making intelligent machines, especially intelligent computer programs. The field of AI concerned with methods of developing systems that display aspects of intelligent behavior. These systems are designed to imitate the human capabilities of thinking and sensing. Turban (2001) explained that AI concerned with two basic ideas of human thoughts processes study and

representing these processes via machines. It is often described in terms of various technologies developed over the last three or four decades (Watson, 1998). The technologies involved are logic programming, rule-based reasoning, neural networks, genetic algorithms, fuzzy logic, constraint-based programming and others. These technologies are characterized by specific programming languages or environments (e.g., Prolog or rule-based shells) or by specific algorithms and techniques (e.g., A*, the Rete algorithm or back propagation).

2.2 Expert System

An expert system is an interactive computer-based decision tool that uses both facts and heuristics to solve difficult decision problems based on knowledge acquired from an expert. The development of an expert system involves the construction of a problem specific knowledge base by acquiring knowledge from experts or documented sources (Turban, 2001). An expert system operates as an interactive system that responds to questions, asks for clarification, makes recommendations, and generally aids the decision-making process.

Complex decisions involve complex combination of factual and heuristic knowledge. In order for the computer to be able to retrieve and effectively use heuristic knowledge, the knowledge must be organized in an easily accessible format that distinguishes among data, knowledge, and control structures. Therefore the expert system is constructed in modularity to enable the system to perform effectively. The basic components of an expert system are its internal knowledge base and its reasoning capabilities based on the contents of the knowledge base (Luo *et al.*, 2002). Expert system development usually proceeds through several phases including problem selection, knowledge acquisition, knowledge representation, programming, testing and evaluation. Moreover, they are also has a characteristic of reasoning with uncertainty, and explanation of the line of reasoning. The reasoning capability in expert system is provided by an inference engine (Turban, 2001).

Expert systems were designed to reason through knowledge to solve problems using methods that humans use. The expert system rules utilize the concept of linguistic variables which are associated to fuzzy term set where each term represents a specific fuzzy set (high, low, medium). They are easy to understand and modify (Loncaric *et al.*, 1998). In expert systems, knowledge is represented in the form of rules that are used to carry out tasks usually performed by human experts (Dean *et al.*, 1995). The basis of such rules is the theory of propositional logic which uses propositional variables (true/false) and truth-functional propositional connectives, including conjunction, disjunction, negation, implication and logical equivalence. If axioms and rules of inference are provided, a sequence of inferential rules results in a proof. However, abundance of uncertainty and/or fuzziness degrades the performance of expert systems (Lee *et al.*, 1998).

Most applications of expert systems will fall into one of the categories such as interpreting and identifying, predicting, diagnosing and instructing and training. Well design systems imitate the reasoning process experts use to solve specific problem (Turban, 2001). . Such system can be delegated by the experts as knowledgeable assistants. Successful expert systems will be those that combined facts and heuristics and thus merge human knowledge with computer power in solving problems. To be effective, an expert system must focus on a particular problem domain

Durkin (1996) explained that Expert Systems have been successfully used in almost all application areas such as Agriculture, Business, Chemistry, Law, Medicine, Manufacturing, and Space Technology i.e. the problems, which involve diagnosis, control, interpretation, monitoring, planning, prediction, prescription etc. The experts, who are consulted to create the Expert Systems, being humans, their expressions are moderated by the terms such as *may be, can be, very likely* etc. This often results in a knowledge base, which for the most part is neither certain nor consistent. The classical two valued logic cannot cope up with such uncertainty and inconsistency, therefore Fuzzy Logic (Zadeh, 1983) has been employed to manage this issue.

Expert system seems like to be a part of human life. From the decade it has been applied until nowadays, there are many improvement has been taken to ensure the expert system goal are achieved effectively. Expert systems offer an environment where the good capabilities of humans and the power of computers can be. Expert systems in general are able to increase the probability, frequency, and consistency of making good decisions. It helps very much in distributing human expertise and preservation of scarce expertise (Turban, 2001). The scarcity of expertise becomes evident in situations where there are not enough experts for a task. Further, an expert system for a particular decision problem can be used as a stand alone advisory system for the specific knowledge domain perhaps with monitoring by a human expert. In addition, an expert system can decrease decision time making and improved the decision quality.

In recent years, research and development of the expert system fields of agriculture domain have been paid much attention by many countries (Saini *et al.*, 2000). At the beginning of development of the agriculture expert systems, the areas selected are applications to diagnosis the diseases and pests of various crops. The difficulty of problems confronting farmers like yield loses, soil erosion, diminishing market prices from international competition, increasing chemical pesticides costs and pest resistance and economic barriers hindering adoption of farming strategies necessitates that they become expert managers of all aspects of their farming operations. On the other hand agricultural researchers need to address problems of farm management and discover new management strategies to promote farm success. Numerical methods have failed because understanding about crop systems are qualitative based on experience and cannot be mathematically represented (Mann, 1992).

The expert system has been developed with an objective to provide the pest management decision support to the farmers through the Internet (Saini *et al.*, 2000). This has been used for the crops grown in the different Indian regions and has been tested for the real world situations using feedbacks from the IPM users as well as IPM experts. Pasqual and Mansfield (1988) developed a prototype ES for identification and control of insect-pests.

SOYBUG ES was developed by Beck *et al.* (1989) for insect pest management, which is meant for soybean crops grown in the US. Later, Batchelor *et al.* (1989) developed an expert simulation system SMARTSOY for insect pest management. SMARTSOY incorporated soybean crop growth model SOYGRO in its knowledge base. A PC based SOYPEST ES was developed for application to the Indian conditions and standard ES design (Saini *et al.*, 1997; Saini *et al.*, 1998). National Institute of Agricultural Extension Management (MANAGE) has developed an expert system to diagnose pests and diseases for rice crop and suggest preventive/curative measures (Rice Crop, 1991). The rice crop doctor illustrates the use of expert-systems broadly in the area of agriculture and more specifically in the area of rice production through development of a prototype, taking into consideration a few major pests and diseases and some deficiency problems limiting rice yield. This prototype is a result of joint effort by the experts from NIIT and computer professionals of MANAGES while the subject matter expert knowledge on rice pathology and entomology, has been obtained from Scientists of Andhra Pradesh Agricultural University (APAU), Directorate of Rice Research (DRR). An Internet-based Pest Alert and Management System for Oregon (ORPAS) have been developed to deliver real time pest alerts with expert advice (Bajwa *et al.*, 2003). This system provides framework to be readily extended to other crops. Virginia Integrated Pest Management Expert for Wheat was developed to combine wheat pest management into decision support (Warren, 1999). The inference engine designed analyzes specific crop information to determine potential risks of pest outbreaks.

Expert Systems will play a major role in the dissemination and application of useful knowledge leading to economic growth and higher standards of living. They are not only providing expert's knowledge to particular problems but are potentially powerful learning resources to help Expert System users to develop their own expertise. More productivity and employment in Agriculture is obvious through wider and more diverse applications of new scientific results.

2.3 Fuzzy Logic

Zadeh (1998) introduces the concepts of Fuzzy Logic to present vagueness in linguistics, and further implement and express human knowledge and inference capability in a natural way. The accuracy of the approximation in real system is highly influenced by the fuzzy inference engine. The design of fuzzy system mainly involved two operations of the derivation of the knowledge base and the selection of the fuzzy inference with Defuzzification process that the system will use to perform the fuzzy reasoning (Cordon *et al.*, 1994). Fuzzy set theory and fuzzy logic are mathematical theories widely used in artificial intelligence (Klir, 1995). Fuzzy rule-based systems and fuzzy expert systems are AI systems with the ability of mapping sub symbolic to symbolic knowledge with the aid of fuzzy mathematics (Yager, 1992). The real-world decision-making is too much complex, uncertain and imprecise to lend itself to precise, prescriptive analysis. It is this realization that underlies the rapidly growing shift from conventional techniques of decision analysis to technologies based on fuzzy logic. It was originally proposed as a means for representing uncertainty and formalizing qualitative concepts that have no precise boundaries (Hasiloglu *et al.*, 2003).

In order to develop such intelligent system embedded with some prediction and forecasting ability, there is a lot of effort needed. The successful development of a fuzzy model for a particular application domain is a complex multi-step process, in which the designer is faced with a large number of alternative implementation strategies (Garibaldi *et al.*, 1999). Fuzzy logic representations are more intuitively satisfying than classical Boolean (bivalent) logic, as well as more precise and compact compared to classical rule-based representations (Reynolds, 2001). The difference between probability and Fuzzy Logic is that probability measures the likelihood that a future event will occur, whereas Fuzzy Logic measures the ambiguity of events that have already occurred.

Fuzzy logics are a way of formalizing the symbolic processing of fuzzy linguistic terms, such as *excellent*, *good*, *fair*, and *poor*, which are associated with differences in an attribute describing a feature (Mendel, 1995). Much of the decision making in the real

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