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INTEGRATION OF EXPERT SYSTEM AND FUZZY THEORY FOR DIAGNOSIS WHEAT PLANT DISEASES

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Abstracto: Los sistemas expertos son programas de computadora que se derivan de una rama de investigación de la informática llamada Inteligencia Artificial. Los programas de AI que alcanzan la competencia de nivel experto para resolver problemas en áreas de tareas al llevar a cabo un conjunto de conocimientos sobre tareas específicas se llaman sistemas basados en el conocimiento o expertos. Este artículo presenta un sistema experto basado en la web para la cosecha de trigo. El trigo es uno de los principales cultivos de cereales. Se cultiva en vastas áreas de Punjab seguido por Sindh y se clasificó primero como cultivo de cereales en el país. Nuestro sistema experto basado en reglas cubre dos clases principales de problemas a saber enfermedades y plagas, encontradas normalmente en la cosecha del trigo. El sistema de expertos está destinado a ayudar a los agricultores, investigadores y estudiantes y proporciona un enfoque eficiente y orientado a objetivos para resolver problemas comunes de trigo. El sistema da resultados que son correctos y consistentes.

Palabras clave: Sistema Experto, Fuzzy, Trigo.

Abstract: Expert Systems are computer programs that are derived from a branch of computer science research called Artificial Intelligence. AI programs that achieve expert-level competence in solving problems in task areas by bringing to bear a body of knowledge about specific tasks are called knowledge-based or expert systems. This paper presents a web-based expert system for wheat crop. Wheat is one of the major grain crops. It is cultivated in vast areas of Punjab followed by Sindh and ranked first as a cereal crop in the country. Our rule-based expert system covers two main classes of problems namely diseases and pests, normally encountered in wheat crop. The expert system is intended to help the farmers, researchers and students and provides an efficient and goal-oriented approach for solving common problems of wheat. The system gives results that are correct and consistent.

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1. INTRODUCTION

The agriculture sector plays an important role in the overall development of world's economy. Expert system is a computer program that contains expert knowledge about a particular problem domain, often in the form of if -then rules that is able to solve the problems at a level equivalent to or greater than human expert. Knowledge Engineer collects knowledge from domain expert and transfers it into production rules and creates Knowledge Base. Inference engine then apply different knowledge acquisition techniques and catch the knowledge and deliver it in the form of advice to solve problem. Because of it's explanation facility, it can be used as training tool to agricultural persons.

High yield is aim of Grower. To achieve this, it should acquire expert knowledge, so that depending on that knowledge, Grower can take decision related to different factors like soil preparation, seed selection etc.

Expert system can be used to make decision at different levels in agriculture. Operational Level and Planning Level. On Operation Level, the extension workers in the villages, districts and /or Governorate can use the system to support him in making his decision in giving appropriate advice to Growers. On the Planning level, the decision makers can use expert system who predicates need of water, fertilizers and pesticides.

The rapid development of World Wide Web has provided another way of using expert systems. Now developers can build expert systems and distribute them over web. In this way multiple users can use such systems where they may not exists enough experts to provide the required assistance. Such systems are successfully employed in the field of agriculture as the information doesn't need to be protected and it is a lower cost alternative.

The conventional decision support have predefined set of input data, after that they begin analysis. They precede the data, step by step as directed by algorithm, to reach conclusion. Here the algorithm plays important role since knowledge is represented in the form of Algorithm. If knowledge of problem got changed then Algorithms need to be changed or rebuilt. Also solving new problem in same domain needs to develop new system. Against this, human expert tend to follow cognitive approach rather than algorithm. They rely on extensive knowledge base (in their mind) which may contain facts, assertions, past mistakes, trial – by – error method. The machine equivalent human experts are expert systems. The expert system works with cognitive approach and stress the knowledge in knowledge base which is separate component. So that changes in knowledge do not change whole structure of expert system. Another advantage is reasoning capability. They can explain reasons for arriving at particular decision.

The development of web-based expert systems is a difficult task. Duan et al. mentioned that the development of such systems requires a general methodology and research. Dokas described the development of web-based expert systems as a web engineering project that can be developed by combining an expert system and a website with application sub projects. Grove mentioned several factors that make the Internet an ideal base for expert system delivery by contrast to standalone platforms. Some of the factors are:

• The instant availability of internet.

• A common multimedia interface provided by web browsers.

Web based applications are inherently portable. Several web based KBS development tools are available. This paper discusses our experiences in developing a web-based expert system for wheat. The expert system is constructed using e2gLite™ expert system shell available freely on the internet. This web-based expert system shell allows a JAVA interface to process its input and output sets. The system can act as a powerful tool with extensive potential in agriculture especially in situations where agricultural specialist assistance is not readily available when the farmer needs it.

The remainder of this paper is organized as follows. In section 2, we give an introduction of expert systems in agriculture. In section 3, we present a brief review of this work. Section 4 is about design and development of our expert system. As for conclusions, they are provided in section 5.

2. RELATED WORK

At the end of 1970's, the expert system starts to be applied in agricultural domain. After nearly 30 years development, its application domain has spread into the crops cultivation management, installation horticulture management, poultry raising, aquaculture activity, plant protection breeding as well as economical decision making. Yang and Okrent (Yang et al, 2005) had said that the most successful application of Artificial Intelligence (AI) in decision making so far is the development of Decision Support System (DSS), particularly expert system, which is a computer program that act as a 'consultant' or 'advisor' to decision makers.

The NEPER wheat expert system is used for handling the production management aspects of wheat crops. Yialouris and Sideridis (1996) developed an expert system for

tomato. It handles the tomato disease identification problem. The US Department of Agriculture has developed an expert system for cotton crop management to provide appropriate management recommendations to cotton growers.

Fadzilah Siraj & Nureize Arbaiy, proposed expert system FuzzyXPest, related to Rice crop since Rice is a staple food of Malaysia. FuzzyXPest is proposed to provide information to farmers and researchers through the internet using fuzzy expert system. It deals with uncertain information derived from the symptoms given by the farmer to forecast the pest activity level that will determine the damages caused by pests in rice crop.

Nureize Arbaiyet al has developed a fuzzy expert system to forecast the pest activity in rice fields. The system is able to educate and inform the farmers and smallholders about pests and their activities in the rice field. Questionnaires are asked to help users diagnose their given symptom in order to get to a conclusion.. The consultation performed by the expert system also involves fuzzy logic to deal with the natural and uncertainty data. The information and knowledge about the pests, treatment control measures and prevention steps are stored in specific knowledge base created in the system.

Pinaki Chakraborti, Dr. Dilip Kumar Chakraborti, discussed the success of expert system for management of Malformation disease of Mango i.e. ESMMDM. This system considers variety of plant, the number of malformed shoots, climatic facts etc and prescribes suitable treatment package. It is interactive software tool with graphical user interface.

El- Helly, Rafea and El- Gammal developed an integrated image processing expert system capable of diagnosing three disorders, Downy mildew with percentage 84%, Leafminer with percentage 74%, and Powdery mildew with percentage 94%. Also, the system is capable of deciding the normal leaves with a percentage 98%. Moreover, the system is capable to recognizing the unknown disorder with a percentage 92%. A set of features was selected to be extracted using feature extraction phase, and those features were stored in the feature database, which is designed for this purpose.

Kumar, Lehri, Sharma, Meena and Kumar developed "Image based Rapeseed-Mustard Disease expert system" which is an integration of image and textual data. The system can be used by extension personnel, researchers and farmers to identify rapeseed-mustard diseases and enable their management. User can easily identify the disease on the bases of photos of symptoms and text description of disease. The user friendly software developed using windowing environment, thus provides enough facilities to identify the disease and to suggest the remedy conveniently.

Savita Kolhe, Raj Kamal, Harvinder S. Saini and G.K. Gupta described the development of a web-based intelligent disease diagnosis system (WIDDS) using the fuzzy logic approach. It is a disease diagnostic system for particularly oilseeds like soyabean, groundnut rapeseeds etc. It helps to increase the ability of the cultivators/extension workers researchers in decision making.

Yushu Yang, Fullin Wang, Yongsheng Ma (2005) , introduces Intelligent Soyabean Decision- Making System, to help pleasant to solve practice problem which they encounter in the production of soyabean about picked seeds, balance fertilization, prevention and cure the pests, analysis of economic benefits and it provide the technician of soyabean production with decision making service (Yang et al, 2005).

Lai, Ming, Li, Wang, Xie and Gao studied an image based expert system for corn diseases. Accurate identification and treatment depends on the method which is used in disease and insect pest diagnosis. The old adage a picture is worth a thousand words" is crucially relevant. Considering the user's capability to deal and interact with the expert system easily and clearly, a web-based diagnostic expert-system and frames with a color image database was developed and applied to corn disease diagnosis as a case study. Visual color image displays with the phrases of questions and answers from the expert system, enables users to identify any disease, makes the right decision and chooses the right treatment. This may increase their level of understanding of corn disease diagnosis. The expert system can be applied to diagnosis of other plant pests or diseases by easy changes to the knowledge base

3. EXPERT SYSTEM IN AGRICULTURE

Expert systems have applications in many domains. They are mostly suited in situations where the expert is not readily available. In order to develop an expert system the knowledge has to be extracted from domain expert. This knowledge is then converted into a computer program. Knowledge Engineer performs the task of extracting the knowledge from the domain expert. Rule based expert systems are the most commonly known type of knowledge based systems. The knowledge is represented in the form of IF-THEN rules.

Expert systems have been developed and applied to many fields. In agriculture, expert systems are developed to diagnose the diseases and pests of various crops. Farmers across the world face problems like soil erosion, increasing cost of chemical pesticides, weather damage recovery, the need to spray, mixing and application, yield loses and pest resistance. On the other hand researchers in the field of

agriculture are constantly working on new management strategies to promote farm success. In many countries today, farming has become technologically advanced and expert systems are widely used in the field of agriculture. In this way farmers can get expert opinion on their specific problems like selection of most suitable crop variety, diagnosis or identification of livestock disorder, suggestion tactical decisions throughout production cycle etc. from the expert system. Symptoms of diseases, disorders and pests have due geographical variations. So there is always a need to develop a new expert system for a different geographical region. Using expert system technology in agriculture is not new.

POMI an expert system for integrated pest management of apple orchards has been developed in Italy. CUPTEX is an expert system for handling management of cucumber disorders. The NEPER wheat expert system is used for handling the production management aspects of wheat crops. Yialouris and Sideridis (1996) developed an expert system for tomato. It handles the tomato disease identification problem. The US Department of Agriculture has developed an expert system for cotton crop management to provide appropriate management recommendations to cotton growers. Center for Informatics Research and Advancement Kerala has prepared an Expert System called AGREX. It helps the Agricultural field personnel give timely and correct advice to the farmers.

4. PROPOSED METHOD

Fuzzy logic is one of the methods of Soft Computing. Soft Computing is a computational method that is tolerant to sub-optimality, impreciseness, vagueness and thus giving quick, simple and sufficient good solutions. Lotfi A. Zadeh, a professor at University of California at Berkeley was the first to propose a theory of fuzzy sets and an associated logic, namely fuzzy logic. Essentially, a fuzzy set is a set whose members may have degrees of membership between 0 and 1, as opposed to classical sets where each element must have either 0 or 1 as the membership degree-if 0, the element is completely outside the set; if 1, the element is completely in the set.

Fuzzy expert systems use fuzzy logic instead of classical Boolean logic and collection of membership functions and rules that are used for reasoning about data. They are oriented towards numerical processing and handles uncertain or imprecise information. A fuzzy expert system is an expert system.

Which consists of fuzzification, inference, knowledge base and defuzzification subsystems (as shown in figure 1), and uses fuzzy logic to reason about data in the inference mechanism. While inference module consists of a set of cooperating programs that execute procedural component of expert system, knowledge base and base of facts represents passive data structures. Knowledge engineer collects knowledge from domain expert and transfers it into production rules and creates knowledge base.

During fuzzification the input real values are transformed into linguistic values each with a membership function with a range of [0,1]. Fuzzy if-then rules and fuzzy reasoning are the backbone of fuzzy expert systems, which are the most important modeling tools based on fuzzy set theory. IF-THEN rules are applied to the terms of the linguistic variables where combinations of conditions lead to conclusions. The collection of these fuzzy rules forms the rule base for the fuzzy logic system. Using suitable inference procedure, the conclusion is drawn. This results in one fuzzy subset to be assigned to each output variable for each rule. Again, by using suitable composition procedure, all the fuzzy subsets assigned to each output variable are combined together to form a single fuzzy subset for each output variable. Defuzzification is applied to convert the fuzzy output set to a crisp output that best represents the fuzzy set. The basic fuzzy inference system can take either fuzzy inputs or crisp inputs, but the outputs it produces are always fuzzy sets.

A precise domain is required by an expert system. The domain must be compact and well organized. The quality of knowledge highly influences the quality of expert system. The first step in the development of any expert system is problem identification. The problem here is a diagnostic problem aimed to identify ailments in the wheat using symptoms of diseases and pests. The problems occur frequently and the consequences on farmer's financial status are enormous. The demand for help is increasing rapidly. Experts are there to help but sometimes they are not readily available, especially in rural areas. Therefore expert systems are needed in those rural areas where the help to the farmers is not readily available.

Diagnosis or diagnostic problem solving is the process of understanding what is wrong in a particular situation. Thus gathering of information and then interpreting the gathered information for determining what is wrong are of central importance in diagnostic problem solving. In a typical abductive problem, the task of a diagnostic problem solving is to find a hypothesis that best explains a set of observations Whereas, the empirical classification rules collected from the domain expert are used in deductive or heuristics diagnosis. By using formal causal theory abductive diagnosis can be expressed and implemented in the form of deductive diagnosis.

In the present work, we have used causal knowledge about ailments and symptoms to develop logical model of the diagnosis. Hence deductive diagnosis is used to diagnose ailments independently.

The knowledge base is the core component of any expert system. It contains knowledge acquired from the domain

expert. Building the knowledge base with the help of domain expert is the responsibility of knowledge engineer. The first task in the development of knowledge base is knowledge acquisition. Knowledge acquisition is considered as one of the most important phases in the expert system development life cycle.

Knowledge acquisition is to obtain facts and rules from the domain expert so that the system can draw expert level conclusions. The process of knowledge acquisition is difficult especially in case if the knowledge engineer is unfamiliar with the domain. Some commonly used approaches of knowledge acquisition are interviews, observations, taking experts through case studies and rule induction by machines.

After the knowledge acquisition begins the process of representing that knowledge. There are many approaches used for knowledge representation, for example rules, logic expressions and semantic networks. The rule-based expert systems have been successfully used previously. Rules are made on the basis of the hierarchy and these rules lead to diagnoses of desire disease. Figure 1 shows the system structure of expert system.

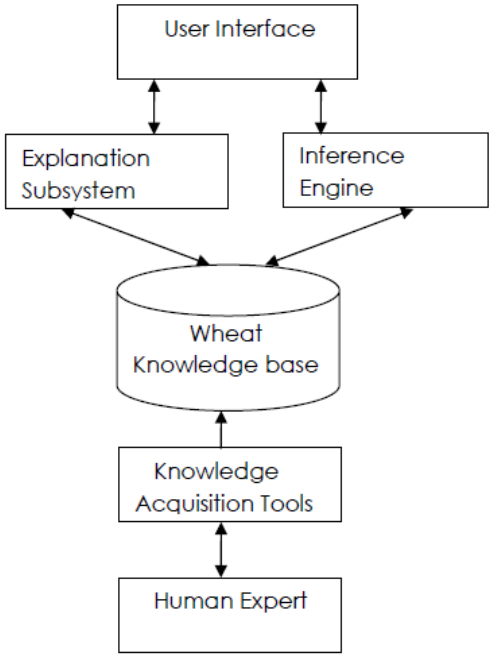

Figure 1. System structure of Wheat Expert System

The knowledge base for e2glite expert system shell consists of simple if-then rules. The rules are usually fired on the basis of internal logic of inference engine. Forward chaining and backward chaining techniques represent the fundamental reasoning approaches implemented in rule-based expert systems. Forward chaining is data driven whereas backward chaining is goal driven.

5. EXPERIMENTAL RESULT

Validation was performed to test the hypothesis that the expert system's recommendations came from the same underlying knowledge base as that of the experts. In other words, the results of the expert system should be indistinguishable from the opinions of the experts it was meant to mimic, when applied to independent test scenarios.

An example test case showing all the input data is included. Each of the three human experts also gave values of Low, Medium, or High for each case and for each pest in their domain area. In addition, the entomology expert gave probability values for each of the qualitative values for each pest in each case. Also, the plant pathology expert gave eight equally probable qualitative values for each pest in each case corresponding to eight possible weather scenarios that would affect the outcome of the pest risk values.

The fuzzy system is an in-built system that takes in multiple inputs into its membership function, these inputs are gotten from the data. The data, which in turn, has numeric values and assigned numbers and variables were used to classify and arrange these data. Equals to this, some of these data were classified as categorical or numerical, in which there is adequate implementation.

The results of the comparison of the human expert predictions with the expert system predictions are reported in Table 1.

Table 1. Statistical data summary

Pest Type			Percent Agreement	
	p-value	z-statistic	Corrected	Distance
Insect	0.92	0.34	92	95
Disease	0.21	0.01	75	78
Weeds	0.18	0.15	82	85
Overall	0.51	0.23	81	84

The Graph in Figure 2 depicts inferences using $\lambda = 3$, $\lambda = 2$ and our expert system.

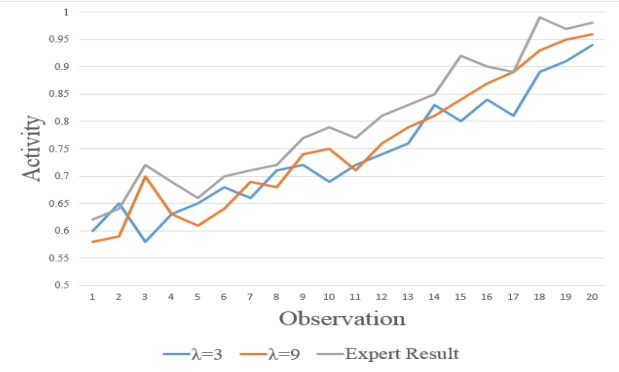

Figure 2. Plot cmparing different inference values

Moreover, in Figure 3 prediction accuracy for different method is shown.

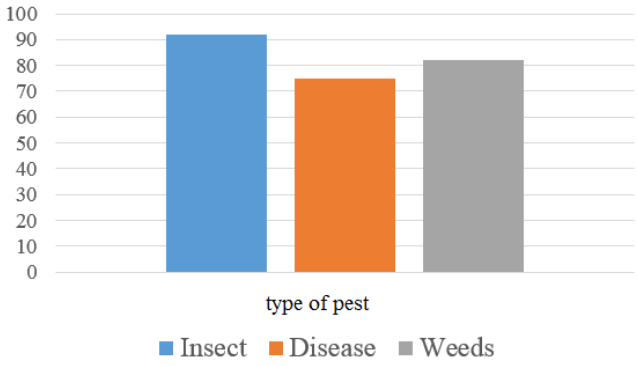

Figure 3. Prediction accuracy for proposed method

Moreover, the default system has one input and one output and uses the Mamdani inference and aggregation method. This editor also illustrates the three aspects of a fuzzy contoller; fuzzification, inference, and defuzzification. In Figure 4 membership function of

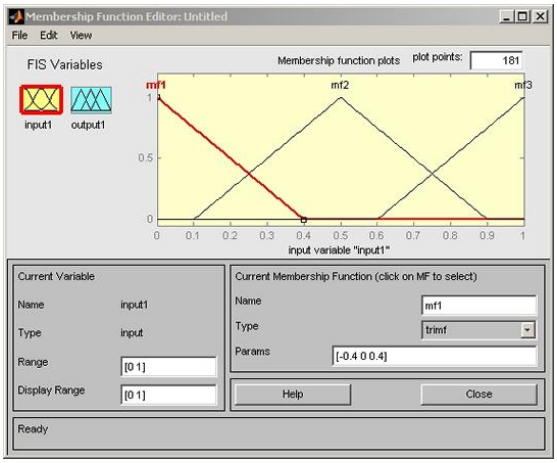

Figure 4. Membership Function

5. CONCLUSION

One of the main challenges in agriculture industry is to transfer latest updated information to farmers. Expert systems are a better option over traditional systems. We propose a new automatic ES for greenness image identification in agricultural. Including fuzzy logic in expert system to handle imprecise information agriculture field is been useful and have shown good results.

This paper presents the use of expert systems in the agriculture domain. The rapid development of internet technology has changed the way of expert system development. In summary, general objective of an expert system is to provide expert knowledge to non experts. The use of internet technology has greatly enhanced the benefits of such systems. However the development of web-based expert systems poses new challenges and emphasis on more research to be carried out.

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