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APPLICATION OF EXPERT SYSTEMS IN AGRICULTURE

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Abstract: Information can be found in various forms and/or generated from knowledge. Text, images, audio and video are different forms of media on which information can be collected. The role of information technology is to invent and devise tools to store and retrieve this information. Expert systems can be defined as tools for information generation from knowledge that is capable of acting in accordance to a human reasoning process, giving similar advices and making similar decisions parallel to what a human expertise might achieve. Expert systems can become beneficial assistants to human decision makers, capable in the gathering of vast numbers of information and experience from multiple human experts of numerous disciplines and providing valuable recommendations to users. Ultimately, an expert system has the advantage of speeding up the decision making process. An Expert system use Artificial Intelligence and is being used for a wide range of fields including agriculture. In this paper the need of expert systems in agriculture is discussed and their importance as tools for information transfer through information generation from knowledge and expertise explored. Currently available expert systems in the agricultural domain are examined along with an assessment of their features and limitations. The paper has shown the possible benefits of an expert system over traditional method of decision making. This study reveals existence of some examples of expert systems for agriculture; more research is required to examine the effectiveness of these systems.

Keywords: Expert System, agricultural expert system, agricultural knowledge

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INTRODUCTION

Expert systems are widely employed to solve the complex and critical problems in many domains like medicine, manufacturing and agriculture being one of them. Expert system can be defined as a tool for information generation from knowledge [1]. They depend on inference and specific expertise of a human expert. They are widely used in situations where human experts are not readily available. In such situations they help to take timely and precise decisions. Expert systems are computer programs that are capable of acting in accordance to a human reasoning process, giving similar advices and making similar decisions parallel to what a human expertise might achieve [2]. Expert systems can become beneficial assistants to human decision makers, capable in the gathering of vast amount of information and experience from multiple human experts of numerous disciplines and providing valuable recommendations to users.

For developing an expert system it is important to extract knowledge from the domain expert, this is achieved by “Knowledge Engineer” [3]. This knowledge is then converted into a computer program. Knowledge and experience helps in generating information [4]. When a less experienced person in a domain seeks advice from an expert of the domain, the expert uses his/her knowledge and experience to generate the piece of information. This could be the most precious information as it is generated out of years of work and experience and interaction with other experts and practitioners of the domain. This piece of information may not be included in any form like text, audio, video or other. Incase it is included, it may not be linked with its scientific origin, especially if is a combination of different domains and methods. This information could be the result for solving a problem hence it becomes all the more precious [1]. Hence it is important to record this information for the benefit of the community. In the beginning the focus was only on textual information. Images were very difficult to be included in an information system. Recently with the advancement in technology, it has been made possible to include images as well in the systems [1]. Advancement in data processing has led to generating efficient and useful information from data. Expert systems technology can play a very important role in generating information from knowledge [4].

EXPERT SYSTEMS

An Expert system is a branch of Artificial Intelligence and is currently proliferating to a wide range of fields like automation systems, science and technology, medicine and agriculture [4, 5]. It focuses on specific domains such as forecasting, planning and diagnosis. Expert system acts like computer application which solves complicated problems that would have required large human experts [6]. The expert system has specific components as shown in figure 1 [4].

The three main components of an expert system are Inference engine, Knowledge Base and User Interface. The knowledge base is a collection of rules and facts describing knowledge about the specific problem domain. It consists of declarative and procedural knowledge. Declarative knowledge is fact about objects or events and procedural knowledge is sequence of actions [7]. The inference engine processes the knowledge by applying appropriate rules and facts according to the query given by the user. The user interface is the mode of conversation between user and the expert system. The interface takes the query in readable form and submits it to the system, also providing back the output to the user [4].

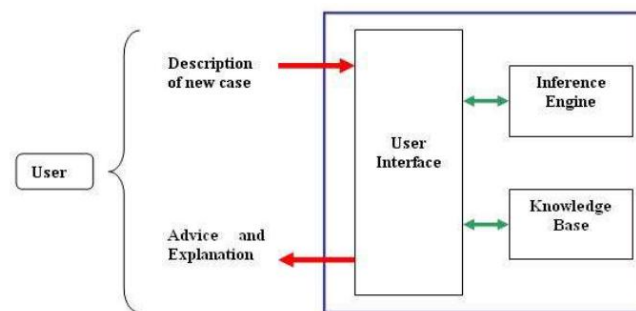


Fig. 1. Components of an Expert System [adapted from [4]]

The type of an expert system is specified according to its use like diagnosis, repair, instruction, interpretation, prediction, design, planning, monitoring and controlling [7].

NEED FOR EXPERT SYSTEMS IN AGRICULTURE

Now-a-days, technologies are emerging for applications in agricultural area in order to help scientists for research as well as help farmers for good agricultural practices. Advice of agricultural experts is well accepted by the farmers for making proper decisions in field for improvement in agricultural production. Assistance of the expertise is not always available at the time of emergency [8]. Also, farmers face multidisciplinary and complex problems in the field. Such problems can be handled by expert systems which enables farmers to take timely decisions in efficient way [3]. Successful crop production process requires proper and timely planning of farm land preparation, water, soil and fertilizers requirements and pest/disease control. Availability of agricultural experts at all stages may not be sufficient for farmers to make an informed decision. Additionally, the farmer cannot totally rely on such dependencies for each and every decision [5]. A solution to such problems could be the use of an agricultural based expert system. The motivation behind adopting such expert systems is it provides reasoning for each advice. Expert systems reduce the information that needs to be processed by farmer, also helps in reducing costs and increasing the agricultural output. Expert systems

can perform task in more consistent manner than the agricultural expert [4]. Thus, in agricultural systems, an integration of expert system may play an important role for better outcomes for the farmer.

EXISTING EXPERT SYSTEMS IN AGRICULTURE

Expert systems have been shown to have a wide range of applications in agriculture. Depending on the agricultural activities and usage the expert systems can be categorized as follows [3]:

1. Crop Management: These expert systems give decision to farmers about growing any particular crop for example; various expert systems are available for crops like wheat, rice, cucumber, tomatoes, lime, apples, oranges [2, 9, 10].
2. Production Planning: These expert systems deal with planning of cropping activities which will help in building profitable cropping plans [3].
3. Pest Management: These expert systems look after managing pests/weeds which are harmful for crops. There is a weed seedling identification expert system available which identifies the weeds at very initial stage so that they can be managed [9]. In case of pests, expert systems are available for managing pests for crops like cucumber, lime, rice and many more [2, 11].
4. Diagnostic Systems: These expert systems are available to manage diseases and infections to various crops and plants. Expert system identifies the diseases and provides the decision to manage and treat them [9, 11, 12].
5. Conservation Systems: These expert systems deal with soil or water conservation and management in agriculture. An expert system is available for control over soil erosion and another for selection of water pumps for agricultural irrigation [13].
6. Process control Systems: These expert systems use sensors for monitoring various agricultural activities [3].
7. Marketing Advisory Systems: These expert systems give advices to farmers in order to obtain profits on the agricultural production in the markets [3].

There are several existing agricultural expert systems available for different crops. Each of them has a specific purpose according to the need of the crop. Following are some focused expert systems in agriculture:

Expert System for Wheat Yield Protection (ESWYP)

This expert system is being designed and used in Egypt in order to diagnose insect pests that harm wheat crops. It acts like an agricultural expert and help farmers to identify the pests that affect the wheat crop and suggest best treatment for the same. It also provides the reasoning facilities that enable farmers to know the diagnosis and treatment details for wheat crop [10].

POMME

This expert system is for apple orchid management. It provides information to the famers about the time and type of sprays they should use on apples in order to prevent them from infection. It also deals with drought control and various insects problem [1, 2].

CUPTEX

CUPTEX is an expert system for cucumber crop production. This expert system provides facilities like disorder diagnosis and treatment, irrigation and fertilization scheduling and plant care. It deals with finding out the infection and then treating on it. Along with that, it plans the proper schedule for irrigation which includes proper quantity of water to be used for crops and proper time of watering the crops. Fertilization schedule includes type and quantity of fertilizers along with time of intervals for their applications on the cucumber plants [1,2].

DR. WHEAT

It is a web-based expert system which is meant for diagnosis and treatment of pests on wheat crop. All the suggestions regarding diseases and pests are obtained online [9, 10].

CITEX

This is an expert system for orange production. It provides facilities for assessment of farms, irrigation and fertilization scheduling and disorder diagnosis and treatment. Assessment deals with evaluation of farm area and checking if it is ready for cropping. Also this system provides proper irrigation and fertilization requirement schedule for oranges. Along with that, it looks after the diagnosis and treatment of diseases on the crop [2].

COMAX

COMAX is an expert system for managing cotton crop. It predicts the crop growth and crop yield with respect to variables like weather, soil parameters, soil fertility and pests. This expert system is integrated with computer model which simulates the growth of cotton plant [1].

TOMATEX

This is an expert system designed for tomato crop. It takes the user complaints and generates the cause for that complaint related to the crop. If the user of the system knows the cause of certain disorder, his assumption is verified by the system [2].

LIMEX

LIMEX is an expert system for lime production. It deals with assessment, irrigation, fertilization and pest control. Assessment looks after evaluation of climate, water and soil properties and advises the feasibility of lime cultivation. Irrigation and fertilization deals with proper scheduling of lime crop. Pest control mechanism diagnoses proper disorders for limes and suggests treatment for the same [2].

CALEX

It is an independent expert system which is able to work on any commodity. The system makes actual management decision for a particular crop. It has been used for crops like cotton and peaches [1].

Expert System for Identification of Weed Seedlings

This expert system is designed for identification of weeds at initial stage and managing them. It uses name based classification along with text and images description of the weeds. It deals with accurate identification and then management of weeds at seedling stage which causes less harm to actual crops at the growth stage [9].

Expert System for Selection of Pumps in Agricultural Irrigation

This expert system is designed for selection of appropriate water pumps for plant efficiency. It is designed considering all aspects like irrigation area, irrigation methods, water resource, climate, soil properties and crop pattern. The system advises the correct water pumps to be used in the farms [13].

Integrated Disease Management Expert System

It is an expert system designed for selection and application of different disease control strategies which will be helpful for minimizing the production losses. The system first identifies the symptoms and then the disease. It then checks the severity of the attack and finally gives remedial measures [12].

CONCLUSION

This study has pointed out the need of expert systems in agriculture and discussed some of the existing expert systems in the agricultural domain. There are many expert systems existing for various agricultural activities which are beneficial to the farmers. Some of the most useful expert systems are for pest management and diagnosis of various diseases and prescribing treatments [14]. Expert systems provide a means to be able to transfer technical information to the farmers to achieve greater productivity. This can be achieved by identifying the problems they face and get the solutions using the expert systems of the domain.

The use of expert systems will continue to increase with the adoption of ICT by agricultural community especially farmers and thus lead improvements in the timely and proper advice when dealing with various issues at farm level [15, 16, 17, 18]. There are many advantages in using expert systems over traditional methods. It is also important to construct the expert system using the right methodology and with a hybrid expert system recommended to overcome the weakness of using one methodology alone. Many other researchers have shown that use of technology can significantly improve the crop productivity [19, 20]. Further, it will be more beneficial to the farmers if the expert systems are created in the regional language and are trained to make optimal use of the expert system for best and precise results.

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