Integrating Agricultural Expert Systems with Data Bases and Multimedia

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This paper presents the needs for integrating agricultural expert systems with data bases and multimedia and gives examples of typical expert systems already developed and deployed , that include a data base and multimedia components. The needs for integration with data base are: the storage of large number of static data that should be entered when consulting an expert system, and the unavailability of some of these data to users. The main problem identified as a result of this integration is the maintenance of both the knowledge base and the data base assuming that the expert system tools supports calling a data base retrieval program. The needs for integration with multimedia are: enhancing the symptoms acquisition, disorder verification, and explaining agriculture operation. The main problem identified to accomplish this integration is proper identification of the media to be integrated assuming that large storage area , and input/output devices are available.

Introduction

This paper uses an expert system of crop management as an example of agricultural expert systems. Crop management can be defined as the set of agricultural operations done to produce a crop. Advice about these operations are given by specialists in: soil and water management, plant pathology, entomology, production, breeding, and horticulture. Analysis of these operations has revealed that an expert system for crop management is a family of expert systems that works together to generate a schedule for agricultural operations. It is a complex scheduling problem. In order to break down this complex problem into a less complex problem, the functionality of these operations was analyzed and consequently classified into these categories: irrigation, fertilization, plant caring, and disorder remediation. The analysis also revealed that knowledge behind advising about these operations is also dependent on a certain crop though the same categories stand for any crop. As these expert systems use some common data and knowledge about the domain, a common knowledge base was built to be shared by all these expert systems. Data base and multimedia are identified as essential components for the success of those expert systems.

The paper consists of three sections in addition to the introduction and conclusion. The first section reviews expert systems developed in Agriculture. The second and third sections discuss the needs for integrating data bases and multimedia with expert systems.

Expert Systems in Agriculture

Knowledge-based expert system technology has been applied to a variety of agricultural problems. EPINFORM (Caristi et al., 1987) is an expert system developed with the INFER inference engine and the EXPLAIN program for predicting the effects of stripe rust and Septoria nodorum blotch on wheat yields relatively early in the growing season. PMDS (Rauscher and Hacker, 1989) is an expert system to facilitate insect pest population control. An expert system for wheat using Generic Task methodology has been also developed in collaboration between Central Lab. for Agricultural Expert Systems, Egypt, and Michigan State University (Kamel et al., 1994).

COMAX (Lemon, 1986) the Crop Management Expert, developed by the USDA, Mississippi State University and Clemson University, is an expert system which can predict crop growth and yield in response to external weather variables, soil physical parameters, soil fertility, and pest damage. Another system has been developed for cotton (Plant et al., 1988). Palmer (1986) and other researchers at Purdue University have developed PLANTER, which suggest whether and when to plant or replant corn or soybeans, and the GRAIN MARKETING ADVISOR, which utilizes information and knowledge about prices, drying and storage facilities, and transportation to make marketing decisions. A set of expert systems for cucumber production management have been developed (Rafea et al., 1991; Rafea et al., 1992; El-Dessouki et al., 1993).

The United Nations University (UNU) Agroforestry Expert System (AES) was designed to support land-use officials, research scientists, farmers, and other individuals interested in maximizing benefits gained from applying agroforestry management techniques in developing countries (Warkentin et al. 1990). It provides recommendations for tree species and interspace parameters for tree-crop symbiotic plantings using alley cropping. DBL-CROP (Halterman et al., 1988) was developed for the double crop winter wheat and soybean domain. It provides recommendations for fertilization, herbicide selection, variety selection, seeding rate, and residue management.

CHAMBER (Jones and Haldeman, 1986) was designed for the diagnosis of failures in controlled environment plant research chambers. NERISK (Rauscher and Hacker, 1989) assists users in assessing the impact of pesticides on beneficial arthropod predators and parasitoids in agricultural systems.

Expert systems have also been applied to the problems of diagnosing Soybean diseases (Michalski et al., 1983), pest and drought control for apple orchard management (Buchanan, 1986), and pine seedling management (Rauscher and Hacker, 1989). Expert system technology can also be applied to tactical management of agricultural systems and for hybrid corn drying control (Peart et al., 1986)

Integration with Data Base

This section presents the need for integrating expert systems with data bases, and gives an example of this integration using an irrigation expert system.

Need for Data Bases

Data Base technology is one of the fields that extensively makes use of computers. It is the heart of any information system to be developed within any organization. In agriculture, information systems have been used, as in any other discipline, in management, research, finance, and other areas. At some sites where expert systems may be needed, information system may already be there. Therefore, it may be necessary to integrate the expert system with the working environment, especially if the data needed by the expert system is part of an existing data base. If there is no previous information system within any location, we found that expert systems need data bases to store static data of a specific plantation in order to be used by the inference engine of the expert system, otherwise the system has to ask the user each time they run the system to enter these data. For sure, this is inconvenient to the user who is, in our system, the extension worker giving advice to several growers who may have more than one plantation. Although one may claim that this problem can be solved by simply keeping these data on a file and retrieve them when needed, this claim is untrue because managing the set of files for all plantations, memorizing the name of each plantation file, maintaining the integrity of the knowledge base with the data base, and other reasons require the usage of a knowledge and data bases management system.

Data Base Integration Example

We consider irrigation expert system within a larger framework which is the crop management. Three expert systems were developed for irrigation of Orange, Cucumber, and Lime. The method used for the first two systems (Orange, and Cucumber) was based on model approach implemented using expert systems techniques. The method used for the third system (Lime) was based completely on heuristic approach. In this section, the expert system which was based on model approach will be described as it is the approach which needs more data than the heuristic approach..

Irrigation system can be defined in terms of inputs and outputs. The inputs are the properties of soil, water, and climate of a certain plantation in addition to other factors related to the plantation such as the irrigation method, number of trees, drainage status, and others. The outputs are essentially the water quantity, and the application frequency. The inputs can be classified into two broad categories: static data and dynamic data. The static data include data which do not change in short period while the dynamic data include the changeable data in the field. The static data consist of farm data , soil data , data of water used for irrigation, and climate data. Farm data include the area, number of trees, distance between trees and between rows, used irrigation system, source of irrigation water, and drainage system. The soil data include soil texture, field capacity, and permanent wilting point. The water data include electrical conductivity of irrigation water. The climate data include monthly average of daily temperature, daily relative humidity, daily duration of maximum sunshine hours, actual sunshine hours, and extra terrestrial radiation. On the other hand, dynamic data include status of weeds in the farm.

The irrigation schedule is produced using an irrigation model (Hargreaves,1983). This model is based on calculating the potential evapotranspiration (Etp) and then the model considers the soil and calculates soil moisture deficit for each crop, taking into account the individual crop requirement A typical case of using this model to the citrus expert system (Salah et al, 1993) is as follows:

Site:	Toukh	Grower:	Khaled
Plantation date :	01/01/1978	Area :	20 Feddan
Distance between rows :	5 Meters	Distance between trees :	5 Meters
Irrigation System :	flooding	Water Source :	River

It should be noticed that these data are not enough to compute the irrigation schedule as the data for soil ,water, and climate are not known by the grower. The system, in this case, assumes default values stored in the system data base to respond to this consultation. The generated schedule for the first six months of the year is shown in table-1.

The integration of this expert system with the database has necessitated the development of a knowledge and data management system in order to maintain both of them. For example, if we have

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when consultation begins, deleting this attribute from the data base should be prohibited in order to keep the integrity of the system.

Integration with Multimedia

This section presents the need for integrating expert systems with multimedia and gives an example of this integration using a disorder remediation expert system.

Need for Multimedia

The need for integrating expert systems with multimedia will be done through discussing where each multimedia type could be used to enhance the utilization and performance of the expert system. Providing explanations during consultation and/or after reaching a conclusion can also be enhanced using all types of multimedia.

Images

It was found that describing symptoms in words is very difficult and sometimes is very confusing. Therefore, images are identified to be used for two main purposes: describing a disorder symptom, and confirming the diagnosis of the cause of a certain disorder. Detailed images for all symptoms, and unique images that confirm the occurrence of disorders at different stages should be collected.

Although images are very useful in acquiring the user inputs, the uncertainty problem is still there. Therefore, giving the user the option to select an image with a degree of certainty should be provided. Providing more than one picture for the same symptom can reduce the user uncertainty, but this will lead to exerting more efforts in collecting and classifying the images.

Video

As already explained, the output of an expert system for crop production management, is a set of agricultural operations. Describing how to perform an agricultural operation in words, is very hard and one can never guarantee that the user can understand what has been written. Displaying a video for a professional doing the recommended operation would be very informative.

Sound

The sound is essential because sometimes, it is not easy to write terminologies used by growers in daily life. In addition, combining the video with sound is also recommended to comment on how the operation is done.

Multimedia Integration Example

The main function of the disorder remediation expert system is to generate a prescription to remediate a certain disorder or a set of disorders. In case that the user suspects the cause of disorder(s), they can provide the system with their suspicion, and the system confirms or rejects this suspicion. If the user has no suspicion, they can provide the system with the symptoms of the disorders, and the system identifies the cause(s) of the disorder(s). Figure 1 depicts a typical output screen of disorder remediation expert system for cucumber production under plastic tunnel (El-Dessouki et al.,1993).

So far, we have only integrated images with the expert system. The integration process has passed into several steps: the identification of images to be included, collection and scanning of images, and modifying the knowledge base to integrate the images.

Images Identification

The identification of images was done by studying the relation between the knowledge representation and its presentation. For example, the value of the attribute "leaf spot color" of the object "leaf spot" has a set of images for different colors. For each color, there may be more than one image pending on other attributes of the spot such as its shape, its position,... . Another example is the images of a diagnosed disorder which may differ according to the severity of this disorder. Therefore thorough examination of typical observation has been conducted to identify proper images.

Collection and Scanning of Images

Four sources are recognized to get the identified images: the slides used by domain experts in their presentation, the extension documents, books, and pictures taken from the field, when no available images were available.

A combined slide, and flat bed color scanner with a resolution up to 1200 dpi was used for scanning pictures and slides. However, scanning with this high resolution needs a lot of disk storage. We have found, practically, 300 dpi is sufficient to produce a good image. A typical size of the images used in the system ranges from 60 to 369 KB. This difference is due to the size of the image to be displayed. In order to solve the problem of the disk storage space, we decided to distribute the Expert Systems with images on CD's in the future.

Knowledge Base Modification

The observation class was modified to include links to images, and additional rules were added in order to enable the image display method to select the appropriate image out of a set of related images and then present it to the user.

For example, when the system is to ask about the leaf spot color, and the user wants to retrieve the image related to a white spot, there should be a method to select the appropriate image among the set of images linked to this attribute value. If the shape of the spot is irregular , and we have four images of white spot, then the system should select the irregular white spot image.

Conclusion

This paper has revealed that integration of expert system with data bases is needed to store static data of a certain plantation, and to have default values of different locations where the system is to be installed. A more general solution of accessing default values is to integrate the expert system with a geographic information system (GIS). The main technical problem that can be raised due to integration with data bases is the maintenance of both the knowledge base and the data base assuming that the expert system tools supports calling a data base retrieval program. The unavailability of a such retrieval program is a major problem which should be taken care of from the very beginning of an expert system project. The maintenance problem could be solved, either manually in case that the developer uses ready made package, by taking care of the data base, when making any modification to the knowledge base, or by building a knowledge and a data base management system in case that the developer uses a tool built in house.

The needs for integration with multimedia are: the enhancement of the symptoms acquisition, disorder verification, and the explanation of agriculture operations. The main problem identified to accomplish this integration is the proper identification of the images, video tapes to be integrated, and the knowledge modification to link the different attributes, and values with proper media, assuming that large storage area , and input/output devices are available.

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Table-1 Example of an Irrigation Schedule

Month	Quantity m3/Feddan/Irr	Frequency
January	0	0
February	360	1
March	290	1
April	280	2
May	310	2
June	350	2

Treatment Operation
Detailed Operation Information

Date :	28/6/94
Disorder :	white_fly
Material Name :	actellic 50%
Mode of entry :	contact
Quantity :	300 ml/100 L
Method :	foliar application
Tool :	sprayer
Application : Time	avoid high temperature during spraying
Advice :	install nets before transplanting spray only when number of insects reaches 2-3 per leaf, make deep harvest before spraying

Fig. 1 Typical Output Screen of the Disorder Remediation Expert System