A Study on Various Expert Systems in Agriculture

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Abstract
An Expert System also called a Knowledge Based System is a computer program designed to simulate the problem-solving behavior of an expert in a narrow domain or discipline. In agriculture, expert systems unite the accumulated expertise of individual disciplines, e.g., plant pathology, entomology, horticulture and agricultural meteorology, into a framework that best addresses the specific, on-site needs of farmers. Expert systems combine the experimental and experiential knowledge with the intuitive reasoning skills of a multitude of specialists to aid farmers in making the best decisions for their crops. The various expert systems were developed since evolution of Artificial Intelligence. This paper compares the availability of various expert systems in agriculture for last 30 years.

INTRODUCTION

Agricultural production has evolved into a complex business requiring the accumulation and integration of knowledge and information from many diverse sources. In order to remain competitive, the modern farmer often relies on agricultural specialists and advisors to provide information for decision making. Unfortunately, agricultural specialist assistance is not always available when the farmer needs it. In order to alleviate this problem, expert systems were identified as a powerful tool with extensive potential in agriculture.

Characteristics of Agricultural Expert System

- It simulates human reasoning about a problem domain, rather than simulating the domain itself.
- It performs reasoning over representations of human knowledge
- It solves problems by heuristic or approximate methods.

The expert system applied to the problems of diagnosing Soybean diseases is one of the earliest expert systems developed in agriculture. A unique feature of the system is that it uses two types of decision rules:
1) The rules representing experts diagnostic knowledge, and
2) The rules obtained through inductive learning from several hundred cases of disease.

POMME is an expert system for apple orchid management. POMME advises growers about when and what to spray on their apples to avoid infestations. The system also provides advice regarding treatment of winter injuries, drought control and multiple insect problems. In 1987 expert system technology was identified as an appropriate technology to speed up agricultural desert development in Egypt. CALEX system has been developed for agriculture management. It is domain independent and can be used with any commodity. CALEX consists of three separate modules: an executive, a scheduler, and an expert system shell.

In the nineties, several expert systems have also been developed. An agro forestry expert system (UNU-AES) was designed to support land-use officials, research scientists, farmers, and other individuals interested in maximizing benefits gained from applying agro-forestry management techniques in developing countries. UNU-AES is a first attempt to apply expert systems technology to agro-forestry.

In 1991, serious efforts have been started in Egypt to develop crop management expert systems for different crops. A prototype for an expert system for cucumber seedlings productions has been developed. This prototype has six functions: seeds cultivation, media preparation, control environmental growth factors, diagnosis, treatment, and protection. In Italy, an expert system for integrated pest management of apple orchards , POMI, has been developed.

Expert Systems Implemented at CLAES:
The Central Laboratory for Agricultural expert Systems (CLAES) is helping farmers through out Egypt optimize the use of resources and maximize food production
Some of the Expert Systems developed at CLAES are :

- Cuptex: An Expert System for Cucumber Crop Production
- Citex: An Expert System for Orange Production
- Neper Wheat: An Expert System for Irrigated Wheat Managment
- Tomatex: An Expert System for Tomatoes
- Limex: A Multimedia Expert System for Lime Production

CUPTEX currently provides the following services:

- Disorder Diagnosis
- Disorder Treatment
- Irrigation Scheduling
- Fertilization Scheduling
- Plant care

Disorder diagnosis : This subsystem provides the user with a diagnostic disorder which causes problems on plantation or verifies a user's assumption

Disorder treatment: This subsystem provides the user with the remediation of disorders after being verified or identified by the diagnosis subsystem.

Irrigation Scheduling: The main goal of this function is to obtain an irrigation schedule for a particular plastic tunnel. An irrigation schedule demonstrates the water quantity related to each time instance. The calculated water quantity is adapted according to some plastic tunnel characteristics such as intensity of plants, the efficiency of drainage system, use of mulch ,etc.

Fertilization Scheduling: The main goal of the fertilization subsystem is to determine the fertilization requirements for cucumbers. Fertilization requirements include several aspects such as the fertilizer's type, quantity, and the intervals between applications.

Plant Care Subsystem: The purpose of the plant care subsystem is mainly to predict from the last crop and plastic tunnel characteristics, the possibility of having a pest problem. Based on this information it produces a schedule of operations to be done to protect the plant from any expected disorder.

CITEX currently provides the following services:

- Assessment of a Farm
- Irrigation Scheduling
- Fertilization Scheduling
- Disorder Diagnosis
- Disorder Treatment

Assessment of a Farm: The Assessment Subsystem : This subsystem has two functions. The first one is to evaluate a new farm in a given location for determining the possibility of cultivating citrus

in it (a feasibility function). The second function is to evaluate a given farm that is already cultivating citrus in terms of its productivity and to give recommendations concerning how to improve its conditions to get more yield.

Irrigation Scheduling: The Irrigation Subsystem : The main goal of this subsystem is to produce a schedule for irrigation of a particular farm. An irrigation schedule should demonstrate the water quantity related to each time instance. The calculated water quantity should also be adapted according to some farm characteristics such as intensity of plants, efficiency of drainage system, etc.

Fertilization Scheduling: The Fertilization Subsystem : The main goal of the fertilization subsystem is to determine the fertilization requirements for the citrus crop. Fertilization requirements include several aspects such as the fertilizer's type, quantity, the fertilizer's application method, and the intervals between applications.

Disorder Diagnosis: The Diagnosis subsystem : This subsystem performs two primary functions. First, it concludes the causes of user complaint. Alternatively, it can verify/reject a user assumption if the user suspects a given disorder(s) and wants to obtain a treatment. This subsystem takes into account the possibility of a plant being infested with more than one disorder at a time, and so the user can select more than one value for an attribute of an observation. The system can conclude the causes of all user complaints in one session.

Disorder Treatment Subsystem : The purpose of this subsystem is to provide the user with appropriate treatment for the infected plants.

The current version of the system (TOMATEX ver. 3), provides recommendations concerning the following agricultural activities:-

- Disorder Diagnosis
- Disorder Treatment

Disorder Diagnosis subsystem : There are two purposes for this subsystem:-

- It concludes the causes of user complaint.
- It verifies the user assumption.

The output of this subsystem is as follows:-

- If there are user complaints, the output is the causes (disorders) of these complaints. Each disorder must have a certainty factor. The certainty factor of the confirmed disorders is either "likely" or "most likely".
- If the user knows the cause of the abnormal observations, and he wants treatment for the assumed disorders, this subsystem must verify the user's assumption.

Disorder Treatment subsystem: The purpose of this subsystem is to advice the user about the treatment operation of the infected plant.

The output of this subsystem is the treatment schedule. The output includes a complete specification about the treatment operation: disorder name, material name, material quantity, mode of entry, method of application, the tool used in the treatment operation, application time, and advice. The treatment subsystem takes into account the seriousness of the disorders, and so it orders the treatment operations according to their seriousness

LIMEX Expert System

The purpose of integrating the LIMEX expert system with multimedia was to develop functional modules capable of supplying end users with adequate information and advice to solve their

problems. LIMEX is divided into subsystems, each of which is concerned with a specific problem. The functional modules are:

- Assessment
- Irrigation
- Fertilization
- Pest Control

Assessment : The assessment expert system evaluates the climate, water, and soil properties and provides the user with the advice on the feasibility of cultivating Lime in this site. In the assessment subsystem there are two ways of integration with multimedia. The first one is through building the link to the media inside the knowledge base. The second one is dynamic and based on building the link to the media during the consultation time.

Irrigation : Irrigation schedules used by lime growers are acquired verbally from inherited expertise. Consequently, most of those schedulers are undocumented. In both drip and flood irrigation, a number of tables are used as a basic schedules to produce the appropriate schedule table according to some factors, including: plant age, soil type, water EC, soil calcium carbonate content, type of fasting , and required fasting month. According to user input, LIMEX provides the end user with time schedules in addition to the appropriate water quantities for irrigation.

Fertilization : The fertilization module was developed on top of the irrigation module. Fertilization was designed as being a complementary task to irrigation. According to the irrigation schedule output and the user inputs in the irrigation module and according to the fertilizer application method, LIMEX provides the user with the appropriate amounts and frequency of fertilizer by type (manure, nitrogen, potassium, phosphorus fertilizers and iron, zinc, and manganese elements). These schedules are in agreement with the recommended irrigation schedule.

Pest Control : In case of pest control, LIMEX assists the user to diagnose a particular disorder according to the user- defined symptoms and provides advice on the most appropriate treatment for the case in hand. The system also advises the user on routine agricultural operations as plowing and pruning.

Expert Systems From MANAGE

The National Institute of Agricultural Extension Management, popularly known as MANAGE, is an apex national institute set up in 1987 as an autonomous society under the Ministry of Agriculture, Government of India. MANAGE is the Indian response to the challenges of management in a rapidly growing agricultural sector. As a management institute, MANAGE has a mandate to assist the State Governments, the Government of India and other public sector organizations in effective management of their agricultural extension and other agricultural management systems. MANAGE is a nodal institute for conducting International Programmes and organizing study visits for foreign delegates in the above areas.

Rice-Crop

The MANAGE has developed an expert system to diagnose pests and diseases for rice crop and suggest preventive/curative measures. 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 MANAGE while the subject matter expert knowledge on rice pathology and entomology, has been obtained from Scientists of AndhraPradesh Agricultural University (APAU), Directorate of Rice Research (DRR).

WEIPING JIN EXPERT SYSTEM

There are fertilizing, irrigating, spraying insecticide process and adopting other measures in crop management, which rely on crop state analysis. However, there is a lot of fuzzy phenomenanin crop state analyse. Then it is necessary to analysis or to measure these fuzzy phenomena by means of fuzzy set theory for crop management. An expert system that can deal with fuzziness has been developed for crop management in PR.China. This paper shows the principal construction of the expert system, CMES, for growers to manage their crop. CMES provides support for crop growth control system (CGCS), i.e., advises growers about optimal population and structure of crop in planting stage and when and what to adopt measures on their crop to keep at optimal state, to avoid Infestation in various stage of growth and development of crop, and finally to obtain the highest crop productivity in harvest stage

LEY Expert Systems:
A RF-telemetry based computer-controlled, automated, remote, real-time weather data acquisition and reporting system in Washington State is described. Cooperation among Washington State University the National Weather Service and the U.S. Bureau of Reclamation and several private grower organizations has made this system possible. Data is collected, processed and transmitted to the NWS hourly. These hourly updates of actual conditions are broadcast on the NOAA weather band during the spring frost season to assist fruit growers with frost protection. Real-time weather data are also being used in applications such as irrigation scheduling, crop protection and pest management.

A decision support system by P.H.Heinemann exists as a prototype and is being refined to assist managers with the development, implementation, and management of frost protection systems. The program is divided into four main modules: frost protection strategies, operational management, forecasting, and instrumentation.. It is being designed to be an addition to other commodity management expert systems that are commercially available or are under development.

Using a unique satellite downlink facility at by R.R. Getz Auburn University, real time meteorological data are being processed on a network of advanced computer workstations. This data feeds a series of computer models that generate site specific predictions of temperature, dew point, wet bulb temperature, and other parameters used to alert Alabama fruit, vegetable, and nursery growers of freezes. Model outputs are distributed to Extension specialists and others over a campus-wide fiber optic communications system and to all county Extension offices over the ACENET computer network. During critical freeze situations, information can be disseminated live via satellite to media and rural satellite dish owners using the Auburn University uplink facility. A pilot network of automated weather stations incorporating a 10-m tower for monitoring inversions has been installed to enhance the program.

The capabilities that knowledge engineering offers for solving ill-structured agricultural problems where data, information and knowledge are incomplete has excited many agricultural scientists. Limited acceptance has resulted, primarily because of lack of understanding of the decision- making process, inadequate user involvements, and improper problem definitions. User behavior during decision making is beginning to be realistically considered in program development. From another perspective, most programs represent interests and knowledge from a scientific viewpoint. These do not satisfactorily address the needs of the decision-making users, expressed in familiar words, terms, symbols and logic. Efforts to include client-users in the development of software to improve the management of production with emphasis on corn and soybeans are here in introduced. A procedure and results of observing expert producers to identify missing or incomplete information, to determine critical success factors and to define logic leading to decisions made by expert producers over managerial time are presented.

CALEX

This is a blackboard based integrated expert decision support system for agricultural management, developed at University of California. CALEX can be used by growers, pest control advisors, consultants and other managers.

CONCLUSION

This paper has discussed the need of expert systems in agriculture and availability of various expert systems in various countries. The need of expert systems for technical information transfer in agriculture can be identified by recognizing the problems. The advantages that an expert system can offer better than traditional methods. It is proven that expert systems in agriculture helps a lot in increasing the crop production. But most of the expert systems are in English language. By developing an expert system in agriculture in a mother tongue of a farmer, helps him/her to know the facts and truths in increasing the production.

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Article received: 2006-11-28