



Expert Systems in Agriculture

Pratibha Tewari

Principal Scientist, Central Arid Zone Research Institute, Jodhpur

Email: pratibhatewari1@gmail.com

An expert system in agriculture is a kind of modern engine having forward and backward linkages in the knowledge domain. The agriculture expert systems are created after long fruitful discussions with all subject matter specialists. Expert systems help farmers to make logical decision at different levels in agriculture.

Introduction

An expert system also called a knowledge based system can be defined as a tool for information generation from existing knowledge. It is a computer programme designed to simulate the problem solving behaviour of an expert in a specific discipline. Expert system generates advises based on information generated from knowledge based data (Prasad and Babu, 2006). In simple terms use of expert systems offsets the requirement of having an expert in person to guide farmers in agriculture related operation. Advancements in agriculture has made to evolution of complex business strategy that requires competitive knowledge and information from diverse sources at one place to outperform in the agri-business. Agriculture is backbone of our country as it engages more than 65% of our population, but is staggering with age old methods of cultivation there by being able to contribute only 14% to GDP. Less contribution percentage to GDP from agriculture sector is an indication of engagement of poor people in agriculture. Poor people have limited assets, if economy is to improve, it must benefit and raise the returns accrued from their assets like land and environment. Present agriculture is a kind of locomotive that has an engine of pre-colonial times and bogies burgeoning with ample food produce that can't stop at any stoppages due to poor technical strength. An expert system in agriculture is a kind of modern engine having forward and backward linkages in the knowledge domain. Imagine for a country like India that ranks number one in the world production of milk, banana, guava, mango, buffalo meat and cashew-nuts, number two in the world production of rice, wheat, ground-nuts, onion, peas and sugarcane, to have a smart engine and smart locomotive to carry all 65% of agriculture population smartly.

History of Expert Systems

Edward Feigenbaun is considered as father of expert systems as he developed an insight of early expert systems that tried to identify domains where expertise was highly valued and complex during 1977-78. Edward shortliffe, Bruce Buchanan and Randall Davis were among the first truly successful contributors of artificial intelligence softwares. Around 1980 expert systems proliferated, universities offered courses and fourtune1000 companies applied the technology in

their daily business. Client server modules gained popularity that had tremendous impact on the expert systems. In the 1990 and beyond the term expert systems mostly dropped from information technology. The interpretation of this downfall was termed as expert systems failed because they did not deliver on their over hyped promise. The other interpretation was expert systems became victims of their success, (Wikipedia). The expert systems have application beyond doubt in agriculture advancement particularly in developing contraries.

Some Operational Terms

Expert Systems: Computer programme containing expert knowledge about particular problem domain

Knowledge Engineer: collects knowledge from domain expert and transfer it to create knowledge base.

Inference engine: Apply different knowledge acquisition techniques and deliver advice to solve problems

Operation Level Decision: The extension workers can use the system to support him in making advisory decisions

Planning Level Decision: Decision maker can use the systems to predicate need of water/ fertilizer/ pesticides

Knowledge Base: Use of knowledge of books, subject matter expert, research article, etc. to represent formalised subject knowledge in DBMS system.

Artificial intelligence Programme: Is made up of knowledge base and a procedure to infer an answer.

User Interface: Presents question and information to user and supply the user's responses to the inference engine

Inference Rule: Is a statement that has two parts and if clause and a then clause

Classes: These are questions asked to the users

Parameter: It is a place holder for a character string

Procedures: These are definition of calls to external procedures

Rule Nodes: The inference in the systems is done by a tree structure, which indicates the roles that mimics human reasoning

Information: Available through resources like literature maps, conventional digital form, aerial photography, survey on experimental data.

Knowledge: Acquired personal ability of individual based on information

Importance of Expert Systems in Agriculture

As the farmer to extension worker ratio is fast declining there is a great need for an expert system which may suggest precisely suitable solution to the farmers' problems. The complexity of problem faced by farmer are yield losses, soil erosion, selection of crop, increasing chemical pesticides cost, pest resistance, diminishing market crises from international competition and economic barriers hindering adoption of farming strategies. The farmers may not become expert manager of all these aspects of farming operations. Therefore, agricultural researchers need to address problems of farm management and discover new management strategies to promote farm success. When an expert in a specific area gives an advice to a less experienced person he actually uses his knowledge and experience to generate this piece of information in the form of advice. This is a very precious piece of information because it is generated after long time of work and experience. Sometimes this piece of information is not included in any textbook, audio or video. Even if it is included, it is not linked with its scientific origin, especially if it is a combination of different domain and methods. This piece of information becomes more valuable

because it is the result of arriving at a decision with participation of different specialists. This information is rarely found in any text. The agriculture expert systems are created after long fruitful discussions with all subject matter specialists. Expert systems help farmers to make logical decision at different levels in agriculture. (Ragea, 1991, 1994, 1995)

Need of Expert Systems in Agriculture

In this information age, the available information from various sources is growing at phenomenal rate and this information is primary requirement and considered as the heart of precision agriculture. Numerous researches are being carried out, new results are discovered at the research institutes and they continue to accumulate in the form of reports and dissertation. Most of these findings/ recommendations do not reach to the farmers at implementation levels it is because there is lack of proper channel between researchers and farmer. (Yelpure & Kulkarni, 2012). The need of the hour is to have a virtual expert who can give personalized expert advice to a large community specific to their need and aspiration considering various knowledge bases, since it is impossible for any human expert to consider every piece of available information before arriving at optimal decision.

Characteristics of Expert Systems

- It stimulates human reasoning about a problem domain, rather than simulating the domain itself.
- It performs reasoning over representation of human knowledge
- It solves problem by approximate methods (Prasad & Babu 2006)

Components of Expert Systems

Expert systems are composed of several basic components such as a

- User interface,
- A data base,
- A knowledge base and
- An inference mechanism.

The function of user interface is to present questions and information to the user and supply the user response to the interference engine. Then user interface checks all responses to ensure that they are of the correct data type, Whenever, the user enters an illegal response, the user interface informs the user that his input was invalid and prompt him to correct it. Knowledge base is collection of rules for other information structures derived from the human expert. The inference mechanism will be integrated as a software programme (inference engine) that contains reasoning capability. It interacts with knowledge base, (and if not, if then else statement) to solve problems within a problem domain. Sometimes inference mechanism is linked to online system where it draws information from global memory to a specific problem. The inference engine compare what it knows about the specific problem domain in general with what it knows about the specific problem, the inference engine tries to proceed logically towards a better solution. Inference engine follows inference rules that give expert systems the ability to find solutions to diagnostic and prescriptive problems. These rules are in a unit form, therefore, can be deleted or added without affecting other rules (Salunkhe and Rai, 2014). Thus an expert system does

- Problem selection
- Knowledge acquisition
- Knowledge representation
- Programming, testing and evaluation are different phases of expert system development

Available Expert Systems in Agriculture

The most successful application of artificial intelligence in the decision making so far is the development of decision support system particularly expert system, which is a computer programme that acts as a consultant or advisor to decision makers.

- The earliest expert system in agriculture was developed for diagnosing Soyabean disease. The unique feature of system is it uses two types of decision rules.
 - Rules representing expert diagnostic knowledge.
 - Rules obtained through inductive learning developed from several hundred cases of disease.
- 98% disease diagnosis was correct through this system.

POMME- Expert system for apple orchard management (Roach et al., 1985)

- When and what to spray to avoid infestation
- Treatment of winter injuries, drought control, multiple insect problems.

COMAX- Expert system for cotton crop management (Lemmon, 1986)

- Can predict crop growth and yield in response to external weather variable soil physical parameters, soil fertility and pest damage.
- Computer model is integrated with expert system with simulation methods.

CALEX- Domain independent expert system (Plant, 1989)

- I module: An executive- primary interface to user
- II Module: A scheduler- generates sequence of management activities by activating expert system.
- III module: Expert system shell- makes actual management decisions.

UNU –AES- Agroforestry expert system

- Supports stakeholders in maximizing benefits
- Options for alley cropping between woody species
- Advice on alley cropping in diverse geographical and ecological conditions.

ESMMDM- Expert System for Malformation Disease of Mango (Chakraborti et al., 2008)

- Plant variety, number of mal formed shoots , climatic facts
- Prescribe suitable treatment packages

Fuzzy Xpest: Expert system for rice crop (Siraj et al.,)

- Focused on pest activity on rice crop
- Forecast pest activity level that determine damage level and control

CUPTEX: Expert system of cucumber crop production:

This system contain five sub systems

- Disorder diagnosis: verifies user's assumption
- Disorder treatment: remediation of disorder
- Irrigation scheduling: through particular plastic tunnel for intensity of plants, efficiency of drainage systems
- Fertilization schedule: fertilization requirement for type, quantity, intervals between applications
- Plant cave subsystem: schedule of operations to be done to protect the plant from expected disorder

CITEX: expert systems for orange production

It contain four subsystems

- Assessment of farm: a new farm evaluation for possible citrus cultivation and evaluation of old farm to enhance yield.
- Irrigation subsystem: determines water quality to each time instance.
- Fertilization subsystem: determine fertilizer requirement including all aspects.

- Disorders diagnosis and treatment subsystem: It concludes user complaints, and suggests appropriate treatments for infected plants.

TOMATEX- Expert system for tomato disorder identification and treatment

LIMEX- Expert system for lime cultivation

MANAGE RICE CROP- Expert system for rice crop

SEMAGI-Micro computer programme for sunflower

SOY BUG, PLANT, HERB- Soyabean crop based

Evapotranspiration Based Expert Systems

Since evapotranspiration (ET) is an important parameter needed by water managers for the design, operations and management of irrigation system it is integrated with the methods that calculate ET factor. ET can be calculated using climatic data, hydrological data by many methods. To overcome selection of methods to calculate ET an intelligent front end expert system (ETES) was developed to calculate ET in south India. Ten meteorological stations located in different climatic regions and 13 ET estimated methods have been considered in this expert system. CAZRI is having one such meteorological station at its campus. ETES suggests suitable correction factors for converting the resulting ET values to those of method that results in an accurate estimate

How to Develop an Expert System: Agridaksh Example

Maize AGRIdaksh is a farmer friendly expert system on maize (Yadav *et al.*, 2012). It has six essential components.

Knowledge model creation: Domain expert select attributes list for which knowledge has to be entered corresponding to the character. Once the attribute list is prepared AGRIdaksh allows entering desired attributes from attribute list and moves them to selected list.

Knowledge acquisition: It is used for entering knowledge about various entities such as crop variety, disease, insect, pests, weeds, nematodes, physiological disorders and post harvest technology. Domain expert first fills basic features of variety and then specific features of that particular variety.

Problem identification: Two sub models are provided in this module one to define the problem and other to develop decision tree.

Knowledge retrieval: This is most important module for farmers, because they get information about each and every thing they want. Images of disease are provided to identify it and decide treatment.

Ask questions to experts: Farmer can directly ask questions to human expert through mail, it helped to build network of scientists of a crop.

Administration: Administrator controls expert system through this module. He can assign different roles to users or experts advantages and disadvantages of expert system.

Advantages

- Provides consistent answers repeatedly
- Encourages human experts to bring knowledge in public domain
- Never forgets to ask questions

Disadvantages

- Requires infrastructures of networking and desktop
- Expert system does not use common sense
- Reliability of tool is not guaranteed.

Conclusion

Expert systems are knowledge based information tool that can be very effective in fast dissemination of agriculture technology. Simultaneously it has advantages as well as some disadvantages. Expert systems are tools available in public domain for better crop production and enhancement of yield. It helps farmers and extension workers to obtain information on recent knowledge without having physical presence of human expert.

References

Chakraborti et al., 2008

Lemmon, 1986

Plant, 1989

Prasad and Babu, 2006

Rafea A, Edress S, El-Azharia S and Mohmud M. 1994. A development methodologies for expert systems based on KADS. In: proc. Second World Congress on Expert Systems

Rafea A, El- Azhari S and Hassan. 1995. Integrating multimedia with expert systems for crop production management. In: Proc. Second International IFAC Workshop on Artificial Intelligence in Agriculture, Wageningen, the Netherland.

Rafea A, Warkentien M and Ruth S. 1991. Knowledge engineering: creating expert systems for crop production management in Egypt. In: Expert systems in Developing Countries: Practices and Promise (eds.) Stephen R. Ruth and Chip Mann, Boulder, CO: Westview press. Pp. 89-104

Ragea, 1991, 1994, 1995

Roach et al., 1985

Salunkhe SR and Rai SK. 2014. Expert System in Agriculture Development. <http://www.krishisewa.com>

Siraj et al.,

Yadav VK, Marwaha S, Kumar S, Kumar P, Jyoti K, Parihar CM and Supriya P. 2012. Maize agridaksh: A farmer family device. Indian Res. Jr. Ext. Edu. 12(3):13-17

Yelapure SJ and Kulkarni. 2012. Literature review in expert system in agriculture. International Journal of Computer Science and Information Technologies 3(5): 5086-5089

Yelpure & Kulkarni, 2012