Chapter 2

Current Issues in Agriculture Information Systems

2.1 Introduction

Previous chapter presented information related to agricultural domain. It included facts that show the worth of addressing the limitation of existing approaches. Agricultural related researches on technology advancement could be viewed as one of the main area among the various types of researches in academic world. In the previous chapter we discussed the reason for this high demand.

In this chapter we are focusing our study about the existing systems and approaches that people have developed in the area of Agricultural Information Systems. In addition to that, it critically evaluates the existing approaches based on the usability and covered area of the domain, advantage of the approach, limitations and finally present a comparison between each approach.

2.2 Traditional Agriculture Information Systems (AIS)

Application of Information and Communication Technology (ICT) to Agriculture domain is one of the hot research topic emerged at the dawn of the twenty first century. So far studies has been conducted on various aspects of the Agriculture field, this includes automation of farming environments such as green houses, using robotic controlled equipments to farm on huge lands and precision farming which integrate Geographical Information Systems (GIS). Initially more concentration was made on the researches which use traditional software development techniques to address the issues in AIS development. However researchers have been realised that the complexity of related domains cannot be addressed by using these traditional software engineering approaches [8]. With this understanding, a trend has emerged towards the use of Artificial Intelligence (AI) techniques to model real world problems.

The use of AI techniques to develop management and planning tools for governments, organizations, farmers, foresters, and the general public has become an increasing trend worldwide. When it comes to natural sciences like agriculture temporal reasoning and spatial reasoning are critical for modelling the natural processes as well as individual or social behaviours (including adaptability) [24]. This is where AI techniques of modelling the real world became more accurate when compared with other system development methodologies such as structured programming, object oriented programming. In other words AI systems can provide a more natural, simple, interactive, participatory and effective approach to solve real world problems.

Various AI techniques being studied worldwide related to the field of agriculture and most agriculture dominant economies already making the use of such systems for effective decision making [12]. Critical reviews of researches which have been conducted in the area of agricultural information systems are given bellow.

Knowledge representation of an agricultural system could be considered in two ways as theoretical knowledge and tacit knowledge. As a result of extensive studies in agro informatics, AI based approaches were identified as ideal solutions to represent this knowledge. Traditionally expert systems were the most common approach used in agriculture information systems as the suitability of this technology has been recognized and realized in the field of agriculture [30]. An Expert System also called a Knowledge Based System is a computer program designed to simulate the problem-solving behaviour 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 [1]. However most of these expert systems are focusing on a single domain like plant diseases diagnosis, pest management decision support and agricultural information systems.

Some characteristics of Agricultural Expert Systems are, the ability to simulate human reasoning about a problem domain rather than simulating the domain itself, the ability to perform reasoning over representations of human knowledge, and ability to solve problems by heuristic or approximate methods. Worldwide expert systems were used in various dimensions of the agriculture domain and some of them could be summarized as bellow.

UNU-AES is an expert system in the field of agro-forestry and it supports research scientists, farmers, and other individuals to obtain benefits of agro-forestry management techniques. The Central Laboratory for Agricultural Expert Systems (CLAES)[1] provides a set of expert systems to help Egyptian farmers in maximizing food production. Each of these systems serve specific aspects of a given crop, for an example orange production expert system is concerned on facts such as assessment of a farm, irrigation scheduling, fertilization scheduling, disorder diagnosis, disorder treatment. At the same time National Institute of Agricultural Extension Management (MANAGE) in India has developed the expert system Rice-Crop doctor specifically targeting on few major pests and diseases and some deficiency problems limiting rice yield[1].

Likewise expert systems being used in the area of crop management which relies on crop state analysis which includes fertilizing, irrigating, and spraying insecticides. Crop state analysis consists of lot of fuzzy phenomena which requires the application of fuzzy set theory for crop management expert systems. As a result CMES, an expert system developed in China is able to handle fuzzy scenarios and advise farmers about optimal population and structure of crop in planting stage and when and what kind of practices to adopt on their crops to reach the optimal state. This will avoid Infestation in various stages of growth of crop, and as a result the farmer will be able to obtain the highest crop productivity in harvest stage [1].

Above two systems are important for obtaining timely information regarding both vegetable and fruit crops, but when it comes to seasonal fruit growers more specific information on frost protection is essential during the spring frost season. Such decision support system operates by Washington State University with the collaboration of the U.S. National Weather Service for real-time acquisition of weather data. Weather data processed by the system and actual forecasts are broadcast

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[1] http://www.claes.sci.eg/Home.aspx?TabId=0&lang=en

through a whether band in a local broadcasting station during the frost season to assist fruit growers to make effective decisions in frost protection [1].

Beside the generic expert systems discussed above, there are expert systems highly specialized in one dimension of crops. For an example Plant Diseases Diagnosis System (PDDS) [4] is one of the successfully developed and managed specialized expert system. In general plant diseases share lot of common symptoms hence identification of a single disease could be challenging therefore PDDS address these complexities by using step by step description method or graphical representational method. Step by step description method uses the gradual description of the observations about the diseases. Due to such improved usability, end users will find the system as easy to use. However this approach has some disadvantages as well; because it is totally dependent on the user's input and subjective to the user interaction. On the other hand the graphical representation system strictly based on the stored pictures of diagnosed cases, even though it is more accurate than the step by step method. At the same time this method is costly as it requires many resources to facilitate image identification and mapping.

Similar to above agriculture information systems there have been many studies carried out in the domain related to expert systems in agriculture. The need of expert systems for technical information transfer in agriculture can be identified by recognizing the problems also the advantages that an expert system can offer are better than traditional methods. Today, it is proven globally that expert systems in agriculture helps a lot in increasing the crop production [2]. Even though the values of such expert systems were highly appreciated by all parties in an agricultural eco system, it can be seen that almost all the expert system address only one particular domain of expertise in agricultural industry. However it is believed that the best solution could be obtained by concentrating the entire interconnected domains. On the other hand when it comes to complex systems, we cannot solve problems only considering one aspect of the domain, a successful and accurate solution should consider all the aspects stressing on a particular problem which lacks in all the expert systems described above [20].

2.3 Approaches based on Agent technology

Multi agent based approach is proposed to overcome the limitations in expert systems [7]. A multi agent prototype consists of several agents. Each agent is devoted to one part of the problem. The agents cooperate during the problem solving, and this cooperation is, as in a real agency, achieved through communication.

From the architectural point of view of an agent based Agriculture Information system (AIS), there are several agents to represent each entity of the prototype. They are Climate-agent, purpose-agent, Group-agent, Soil-agent, Mechanization-agent, Diseases and pests-agent, Interface-agent and evaluator-agent. Climate-agent is concerned with the weather conditions in the area where a plant will be cultivated. The Purpose-agent contains important propositions describing the purpose of a crop, such as animal feeding, industrial processing, and nutrition–of–people. The Group-agent does not communicate with the user. Its task is to determine the optimal group. The Soil-agent is devoted to soil type information. The Mechanization-agent is devoted to the available mechanization and agricultural technology. The Diseases–and–pests-agent is concerned with diseases and pests in the environment of the farm. The Interface-agent has actions that are used for user-friendly data exchange between user and the system. The Evaluator-agent is the agent that makes a decision about the optimal hybrid for given conditions.

This prototype basically uses agent mental state to make the decisions. Agent mental stat consists of a set of simple propositions. To every proposition a certain factor (CF) is attached. This is an integer between 0 and 10. At the beginning of the problem solving, every proposition considered has unknown CF and some information which can be used to calculate CF value. When some certain factor is required to make a decision, CF value calculates based on the information. Beside its beliefs, the agent contains capabilities to perform some actions such as exchange of messages with another agent. Every agent also possesses explanation facilities. It can explain why its proposition has a certain value.

When multi agent system based techniques introduced, there have been lots of researches carried out in the domain of agriculture. Initially these researches were based on a mixed approach with the combination of algorithmic based approaches and multi agent based approaches. Multi agent technology and constraint programming based agriculture information system for water management was one of the research based system build in Yemen [23]. This system can be considered as a practical example for this mixed approach. It addresses the issue of water points (wells, springs and other) sharing between several resource requesters. With traditional approaches some of the water points are heavily used and some of them are barely used. Above system has been used as the decision support system to manage these complex requirements easily and effectively.

The above system uses the concept of a controller agent to verify the constraint satisfaction. In addition to that there are two other agents use to represent resources (supplier agent) and requesters (Farmer agent). Farmer agent calculates the water requirement according to the crops, and irrigation method. It also negotiates with other farmer agents and demand for supply from supplier agent. Supplier agent mange the water resources and decides water quantity and quality to be provided to each consumer agent. Controller agent is the main agent who controls the validation of constraints of the system. In this model each agent does not communicate with each other. Instead, they send the values to control agent who verify these values according to the constraint which they hold. Although the approach performs better compared with the traditional approach, this centralized control approach can be considered as a deviation from the fundamentals of the multi agent approach because it will add extra limitations to the system compared with pure multi agent approach. However these centralized controllers may be arranged with a fail over mechanism in the real time deployment.

As a conclusion, by studying many of approaches which are used to facilitate AIS systems, it can be seen that all the approaches has tried to implement the systems using traditional AI based technologies like expert systems and Rule based systems. However we have found that, some researchers developed prototypes using mixed approaches as a combination of multi agent system and logic based systems. It is also possible to find researches purely based on multi agent technology as well. Finally by considering real world examples, it is possible to conclude that multi agent systems can be developed in a way that how real world experts solve problems through interactive communication and negotiation with different related entities.

2.4 Summary

This chapter mainly considered about the researched that have been carried out in the domain of agriculture. Furthermore this chapter critically reviewed the technological and domain specific limitations of the system. Table 2.1 summarised the approaches and tools currently using in the domain of agriculture.

System Type	System/ Tool Name	Technology	Limitations
Traditional software	GIS,	Traditional software Engineering Techniques	Cannot cater the complexity and dynamic nature of the problem.
Traditional mechanical	Automated machines	Mechanical and Engineering techniques	Limited functionality. Cannot adopt into a dynamic environment
Traditional AI based	UNU-AES	Expert system	Limited domain. Agro-forestry only.
Traditional AI based	CLAES	Expert system	Limited domain
Traditional AI based	MANAGE	Expert system	Limited domain. Rice cope information only
Traditional AI based	CMES,	Expert system and Fuzzy	Limited domain
Traditional AI based	U.S.National Weather Service	Expert and with real time data processing	Weather
Modern AI with constant programming	Yemen water management system	Multi Agent system with traditional programming techniques.	Cannot get maximum capabilities with multi agent based

			approaches
modern AI based	AIS	Multi Agent system	Limited domain

Table 2.1: AI approaches in agriculture domain

As a conclusion it could be seen that all the approaches were targeting only single or limited amount of domain when dealing with problem solving. However when it comes to working with complex environment, it is necessary to consider about all the aspect of inter related to domains especially with information system [5].

The next chapter will describe the technologies behind the existing approaches and there negative and positive properties related to AIS.