Chapter 1

Introduction

An expert system is a computer system, which is developed with the help of human expertise and the data pertaining to domain of application. Expert System (ES) aims to achieve better solution of specialized problem with an involvement of computer program, which behaves like an expert person. The role of an expert system is to provide decisions or suggestions for specific process or task. Agriculture is a very complex and semi-structured system. Development and application areas of an expert system for agriculture encompass wide-ranging activities of agriculture such as irrigation scheduling, farm management, disease identification, disease forecasting, and nutrition advisory.

Increased demand of farm productivity and depleted water resources made the irrigation scheduling one of the impending subject areas for expert or decision support system. The presented research work provides a web based expert system for irrigation scheduling. It provides generalized, scalable and user friendly web solution. It has been developed primarily in accordance with the Indian farming conditions; however the proposed work can easily extended in global context.

The thesis comprises six chapters. After the introduction section, the next chapter starts with the basic understanding of precision agriculture and role of expert system in agriculture. It also covers the comprehensive review on the research work carried out in the field of expert systems for agriculture applications like irrigation scheduling, pest management, nutrition management, etc. A success of agriculture support system is quite influenced by local environmental,
infrastructural constrains and practices adopted by the users. Therefore, the development of such system needs close look of Indian farming practices. Technological endeavors made in the field of agriculture expert systems both in global perspective and for Indian conditions are critically reviewed and presented in the chapter of literature review. Entire discussion on past and present work on the expert systems for agriculture provides strength and limitations of available systems. In turn it helps to identify research issues required to be addressed and subsequently used to formulate the problem statement for the proposed research work. At the end of the chapter the problem formation is presented.

It is found that the development approach considered in the majority of the Agricultural ES is either rule based or knowledge transfer process based. The modeling approach to construct Knowledge Base Systems (KBS) or Expert Systems becomes well accepted among the Knowledge Engineering (KE) communities due to its modular structure and ability to break down the knowledge engineering problem into smaller tasks. In the initial two sections of the third chapter, overview and classifications of expert system as well comparison between knowledge transfer process and knowledge modeling approaches are discussed. At the end of the chapter, the web based expert system for irrigation scheduling and weather based disease forecasting in context of CommonKADS modeling framework is presented. The CommonKADS proposes six models in the construction process of KBS. The proposed models are organization, agent, task, communication, knowledge, and design.

Among all available methods for irrigation scheduling, weather based water balance approach is more practical and suitable to the Indian farming conditions. But, the accuracy of this method is largely depends on accurate estimation of evapotranspiration rate (ET$_0$), which indicates the evaporation and transpiration of water from the plant. Compare to other analytical equations, the
Chapter 1

Hargreaves equation is much simpler as it needs minimum weather data, i.e. temperature and solar radiation. But, it cannot offer consistent accuracy for different climate conditions. Manual calibration process of the equation constant $C_H$ and $E_H$ for different climate conditions is to be carried out for different geographic locations for effective use of the equation. The fuzzy logic based calibration method for the Hargreaves equation is developed and presented in the forth chapter. Validation of the proposed method is also given in this chapter. Fuzzy logic based calibration concept presented in the first half of the chapter successfully replace the experimental method of the Hargreaves equation constant $C_H$ and $E_H$ value calibration. However, there is a need for user friendly, universal software program which is capable to perform the calibration process and to estimate $ET_0$ accurately with minimum weather data.

The fuzzy based software tool to provide universal calibration of $C_H$ and $E_H$ to estimate evapotranspiration is developed. It is called as Evapotranspiration CALibration TOOL (ECALTOOL). Preferred features like - ease of use and universal applicability of the proposed tool make the ECALTOOL unique and distinctive from other such endeavors. The second half of the forth chapter presents development of tool using the LabVIEW platform. The tool is capable to provide calibration of $C_H$ and $E_H$ for accurate estimation of $ET_0$ for 1100 locations of 190 countries. The calibration of $C_H$ and $E_H$ is also possible for the places which are not included in the standard library (other than these 1100 locations). For the calibration of such locations the user needed only few additional weather data.

Early detection of pest and its control is one of the aspects of Integrated Pest Management (IPM). Weather based forecasting is well accepted method for this. Various meteorological data like- temperature, humidity, Leaf Wetness Duration (LWD) plays the vital roles in the growth of microorganism responsible for disease. Effective forecasting of such diseases on the basis of
climate data can help the farmers to take timely actions to restrain the diseases. Fuzzy logic based structure for the plant disease forecasting system is described in the fifth chapter of the thesis. Issues related to LWD estimation along with some simulation results on probability of diseases occurrence in a plant are presented at the end of this chapter. However the work presented in this chapter is quite introductory in nature. The idea is to explore the possibility to develop integrated web based expert system for irrigation scheduling along with weather based disease forecasting system.

The sixth chapter presents an actual development of web-based expert system called KrishiSENSE. It is deployed at www.krishisense.org. It provides current weather data and decision on irrigation scheduling to the farmers. It uses the water balance approach for irrigation scheduling. It uses the public web services for collecting required weather data, which eliminates the need of any kind of sensors or electronics hardware. KrishiSENSE also provides important information on current and forecasted weather conditions like temperature, air humidity, solar radiation, wind velocity etc. It helps the farmers to take important decisions for crisis management. To increase the accessibility among the farmers, the service is also provided through Android based mobile application. This application can run on any Android based mobile device. The chapter also describes functionality of the web based expert system and mobile application.

A summary of presented research work and concise report on future research direction are provided at the end of the thesis.