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KNOWLEDGE REPRESENTATION TECHNIQUES USED FOR EXPERT SYSTEM DESIGNED FOR CROP IRRIGATION

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Abstract:
Knowledge Representation is the technique to represent real world information in such a way that a machine can learn from it and behave like a human expert. Such computer systems are known as Knowledge Based Expert System that can be used toper forms a task that would otherwise be performed by a human expert.
Agricultural production has evolved into a complex business which requires the accumulation and integration of knowledge and information from many diverse sources. And hence Expert systems have been applied increasingly for agricultural fields in recent years.
Crop water requirement depends on various parameters such as soil characteristics, wind velocity, humidity, temperature and other factors which often change. To analyze exact water requirement some kind of expertise is required.
The research was conducted for analyzing crop irrigation problems and studying various factors affecting irrigation. Researcher has tried to develop an Expert System solution for solving those problems. This particular paper talks about the knowledge representation methods that has been used by the researcher to represent a heuristic and factual knowledge while developing an Expert System designed for crop irrigation.

Keywords: Knowledge Representation, Knowledge Based Expert System, Agricultural Expert System, Crop water requirement, Expert System for Crop Irrigation.

INTRODUCTION

Expert system, also referred to as knowledge-based systems, is one of the important application branches of Artificial Intelligence. 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 modern time agriculture requires information and application of knowledge from different interacting fields of science and engineering to do appropriate decision-making. Expert systems have been applied increasingly for agricultural fields in recent years.
New agricultural irrigation methods such as sprinkle and drip irrigation are found to be very effective compared to conventional methods. Currently farmers deal with these methods manually which sometimes consumes more water or sometimes the water reaches late due to which the crops get dried. The quantity of water must be determined for irrigation scheduling

for a specific field and seasonal water needs for planning, management, and development of irrigation projects. And hence it is necessary to determine the period, amount and frequency of applied water for crop based on atmospheric and edaphic conditions of crop. Researcher has thus designed, developed and implemented an expert system based on knowledge base viz. Expert Irrigator for effective crop irrigation management.

Three main components of an Expert system are Knowledge-base (language for encoding knowledge) Inference engine (algorithms for reasoning) and User Interface. Knowledge in the Knowledge base can be represented any various methods. This paper talks about the techniques used for Knowledge representation.

1. SIGNIFICANCE OF THE STUDY

Information technology has changed the way products are designed, produced and delivered today. A stream of new software products and services are enabling continuous improvement in product quality and cost, while compressing the lead time for development. Today, a number of computer applications are available for the agriculture. But still there are some of areas where farmers are facing some of the challenges.

This problem can be perfectly rectified with recent developments in information technology, specifically the new capabilities of software development efforts associated with Artificial Intelligence, known as Expert system. With the use of knowledge base expert system any farmer can also make a big decision for irrigation scheduling of any crop. We would get exact water requirement of a crop.

Expert systems are intended to combine the experimental and experiential knowledge with the intuitive reasoning skills of a multitude of specialists to aid ordinary workers in automating various foundry activities.

This study was important particularly from the perspective of irrigation experts and farmers. Apart from this, the irrigation managers who runs common irrigation schemes which is the most widely used source of irrigation.

This research work was the part of an attempt made in this direction to analyse irrigation issues, solve the related problems and design an Expert System.

2. REVIEW OF LITERATURE

Several researchers have proposed information technology applications in agriculture.

Essam Mohamed Hokam in his "**Inaugural-Dissertation Computer-based expert system to optimize the water supply for modern irrigation systems in selected regions in Egypt"** [1] focused on water resources in Egypt and associated problems. The report also talks about measures to increase water use efficiency, factors to decide irrigation water requirement such as Reference Evapotranspiration, Crop Coefficient and their calculation methods, Irrigation Scheduling Using Remote Sensing Tool, Crop Water Stress Index, Irrigation Scheduling Options.

Anjum Awasthi and S.R.N Reddy, in their paper entitled '**Monitoring for Precision Agriculture using Wireless Sensor Network-A Review**' [2] explore the potential of WSN in the area of agriculture in India.

Mr. S. K. Jadhav et al, Jan 2012 in their paper **"Fuzzy Prolog Rules in Knowledge Based Diagnosis of Nutrient Deficiency in Sugarcane Crop"** [3] presents the knowledge-based diagnosis of nutrient deficiency observed in sugarcane crop using fuzzy prolog rules.

Time series of optical satellite images acquired at high spatial resolution constitute an important source of information for crop monitoring, in particular for keeping track of crop harvest. However, the quantity of information extracted from this source is often restricted by acquisition gap sandun certainty of radiometric values. **Mahmoud El Hajjet al**, [4] in his paper entitled **"combining multi-source information for crop monitoring"** presents a novel approach that addresses this issue by combining time series of satellite images with other information from crop modeling and expert knowledge.

The main objective of research paper "**Evolution of Decision Support System Architectures: applications for land planning and management in Cuba**" of **S. Segrera et al** [5] is reviewing the evolution of Decision Support System's (DSS) architectures, particularly as they apply to natural resources.

3. OBJECTIVES OF THE STUDY

The primary objective of the research work is to study the knowledge representation techniques used for knowledge based expert system to predict the water requirement of crop with reasonable accuracy.

4. RESEARCH METHODOLOGY

The present study is an exploratory study to identify irrigation problems of sugarcane growers and develop an expert system in order to provide solution to these problems. It is largely based on the primary data and there after, there is development of the expert system on the basis of the problems identified with the help of primary data collected. For the purpose of the present study, following research methodology has been adopted. The present study is carried out at 5 stages. The outcome of previous stages is taken as input for next stage. These stages are,

1. Review of Literature
2. Pilot Study
3. Main Study(Pre-Implementation Study)
4. Expert System Development
5. Post Implementation Study

The paper focuses on the methods, sources used for generation of Knowledge base and the techniques used for representation of Knowledge base used to develop an Expert System.

5. ACONCEPTOFEXPERT SYSTEM

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. 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

Building an Expert System

Expert system is known as knowledge engineering. Knowledge engineering (KE) refers to all technical, scientific and social aspects involved in building, maintaining and using knowledge-based systems. Design of the domain knows ledge is the task of formalizing expert's years of experience in a tool which will then be used to solve real world problems.

Components of Expert Systems

ES has been structured in many ways. The various ES architecture includes different components. Basic components are discussed in following section.

A. User Interface*:* User interface acts as an intermediary between user and system which allows the user to enter irrigation parameters and get the result in the frm of irrigation scheduling. As per the objectives of this expert system which were set at the time of analysis, the interface was designed by taking farmers into consideration. Hence it is very simple and needs to enter very few inputs. Knowledge acquisition interface intermediates between knowledge engineer and acquisition module.

B. Knowledge Base: Experts take decisions based on their knowledge which is both experimental and experiential. In the same way this expert system consists of knowledge base as its main component. This knowledge base is made up of both factual knowledge and heuristic knowledge. Figure 5.3 depicts the components and sources.

Factual knowledge: The factual knowledge has been gathered from various authorized agricultural reports, help manuals and published journals. The required weekly evapotranspiration data has been taken from official website of Irrigation Water Requirement Advisory Service, Rashtriya Krishi Vikas Yojana Project of Mahatma Phule Krishi Vidyapeeth, Rahuri. The phase wise Kc values for sugarcane have been taken from Chapter 3 entitled 'Crop Water Needs Irrigation' published by Water Management of Natural Resources Management and Environment Department of FAO and All Taluka wise monthly normal rainfall values are selected from official website of Department of Agriculture, Maharashtra State to calculate effective rainfall.

The heuristic knowledge has been generated from experimental knowledge of sugarcane growers and experiential knowledge of sugarcane experts through interview at the time of problem finding itself. The major and minor factors which affect sugarcane irrigation have been identified from them. It was largely individualistic. Hence it was first analysed by SPSS tool which is widely used for software analysis and interpreted by the researcher being a knowledge engineer

C. Inference Engine: Inference engine is the main processing unit that interprets the submitted problem against the rules and logic of information stored in the knowledge base; In a Rule Based System the System takes Input and makes results with all the facts and rules that match with in the Knowledge base.

Hence a typicalrule-based expert system integrates a problem domain specific knowledge base, an inference engine and the user interface. The system is capable in using its internal knowledge and rules to formulate its own solution procedure based on problem definition.

6. Knowledge Base Generation

Knowledge representation is one of the fundamental concepts in expert systems and artificial intelligence (AI) [6] [7]. There are various techniques use for knowledge representation in Expert System.

The scope of the study is limited to Kolhapur agriculture division that consists of three districts viz. Kolhapur, Sangali, Satara. Sugarcane is water intensive crop and hence it is selected for study. And hence the knowledge base of Expert Irrigator, contains, information about Talukas

in 3 districts of Kolhapur, weekly ETo values of all talukas for all 12 months, possible Kc values, effective rainfall values, water holding capacity of different kinds of soil, irrigation efficiencies of irrigation methods and other reference factors necessary for irrigation scheduling. All this knowledge is represented in the form of knowledge base rules, decision table, attribute list and decision tree.

1. List of Attributes

It provides all considered attributes and necessary values considered for those attributes. Following Table represents attribute tables of Expert Irrigator.

Attribute Table

Sr. No.	Attributes	Values
1	District	3 Districts of Kolhapur Division
2	Taluka	33Talukas in3 districts of Kolhapur Division
3	Month	12 Months
4	Sugarcane Type	Virgin, Ratoon
5	Wind Speed	Little, Strong
6	Climate	Dry, Humid
7	Duration	12 Months
8	Sugarcane Phase	0-1,2-4,4-6,7-12,13-16,17-18
9	Soi lType	Sandy, Sandy Loam ,Loam, Clayloam, Clay,
10	Irrigation	Furrow, Drip

2. Knowledge Base Rules

Knowledge in the expert system is coded as knowledge base rules. A rule consists of two parts: condition part and conclusion part, i.e: IF (conditions) THEN (actions). Antecedent part of the rule describes the facts or conditions that must exist for the rule to fire.

• Reference Evapotranspiration (ETo)Values

The required weekly Evapotranspiration data has been taken from official website of Irrigation Water Requirement Advisory Service, Rashtriya Krishi Vikas Yojana Project of Mahatma Phule Krishi Vidyapeeth, Rahuri. These values depend on taluka and month.

396 Rules have been framed for all 33 Talukas in 3 districts of Kolhapur division. Knowledge base rules of ETo are framed as follows:

IF Taluka Ajara AND Month January THEN ETo is 3.03

IF Taluka Ajara
AND Month February THEN ETo is 3.71

IF Taluka Bhudargad AND Month March THEN ETo is 5.8

• Crop Coefficient (Kc)

Kc values vary with sugarcane type, wind speed, climate and sugarcane growth phase. All these values have been taken from chapter 3 entitled ‘Crop Water Needs Irrigation’ produced by Water

Management of Natural Resources Management and Environment Department of FAO. 121 Knowledge Base rules are framed for Kc.

IF Sugarcane Type Virgin
AND Wind Speed Little

AND Climate Dry ANDGrowthStage0-2 THEN Kc is 0.4

IF Sugarcane Type Virgin
AND Wind Speed Little
AND Climate Dry AND Growth Stage3-4 THEN Kc is 0.8

IF Sugarcane Type Ratoon
AND Wind Speed Little

AND Climate Humid AND Growth Stage3-4 THEN Kc is 1.0

• Effective Rainfall (ER)
It is calculated based on taluka wise monthly normal rainfall which has been taken from Rainfall Recording and Analysis website of Department of Agriculture, Maharashtra State. 155 knowledge rules were framed for ER

IF Taluka Ajara AND Month January
AND Normal Rainfal l0.1
THENE R is 0

IF Taluka Chandgad AND Month April AND Normal Rainfall 44.1
THENE R is 16.46

IF Taluka Atpadi AND Month June AND Normal Rainfall 63
THENE R is 27.9

• Soil Moisture Holding Capacity (MHC)
These values are taken from soil experts and validated with epdf entitled “Irrigation Engineering Principles” published by CE IIT Kharagpur and a book of Majumdar, D K (2000) entitled “Irrigation Water Management” published by Prentice HallofIndia.6 rules are framed as below:

IF Soil Type Sandy THEN
MHC
Is
0.08m/m

IF Soil Type Sandy loam THEN

MHC
Is
0.12m/m
IF Soil Type Clay THEN
MHC
Is
0.2m/m

- **Irrigation Efficiency (IE)**

Irrigation efficiency varies with irrigation methods. These values were taken from irrigation experts. 2 rules are framed.

IF Irrigation Method Furrow THEN IE is
60%

2. Decision Table

Decision table is a structured approach used to formulate complex rule sets and corresponding actions. In Expert Irrigator decision to select particular value of various factors such as effective rainfall, ETo, Kc for calculation of irrigation requirements is based on combination of inputs as each such combination produces different results.

Decision Table for Kc Values

Sr. No.	Decision	Sugarcane	Wind Speed	Climate	Growth
1	0.4	Virgin	Little	Dry	0-2
2	0.8	Virgin	Little	Dry	3-4
3	1.1	Virgin	Little	Dry	5-6
4	1.25	Virgin	Little	Dry	7-12
5	0.95	Virgin	Little	Dry	13-16
6	0.7	Virgin	Little	Dry	17-18
7	0.5	Virgin	Little	Humid	0-2
. .	. .	. .	. .	. .	. .
48	0.65	Ratoon	Strong	Humid	12

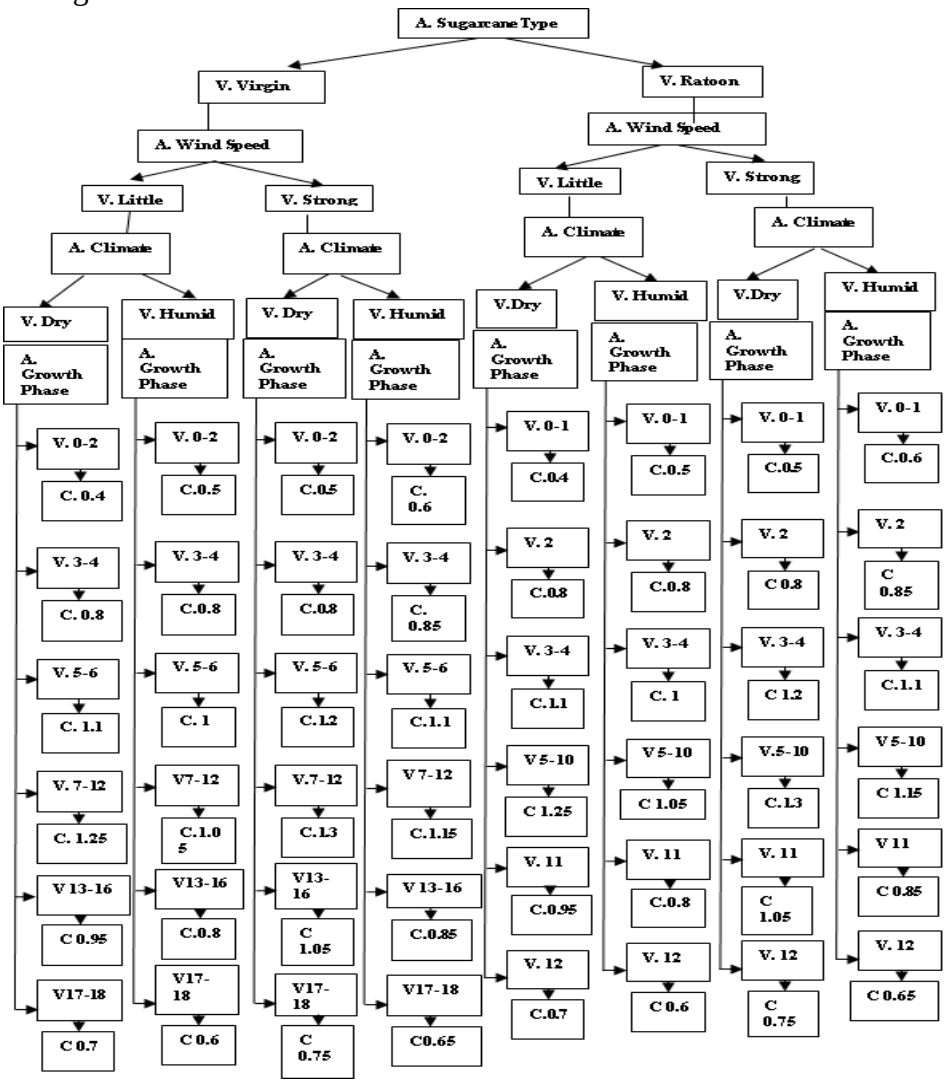
Source: Compiled by researcher

4. Decision Tree

It is also decision support tool and used for generating a knowledge base in Expert Irrigator. Decision trees for all irrigation affecting values (intermediate results needed for irrigation requirements) have been formulated to calculate final results and possible consequences or event outcomes.

Various irrigation parameters are represented as Attributes which are denoted with alphabet A in front of each attribute, values to those parameters are denoted with V and conclusions are denoted with C. Decision tree for selecting Kc values is depicted in figure

Knowledge in the knowledge base is acquired through knowledge acquisition module, structured and formatted using knowledge formulating module and managed by knowledge base management module.



Decision Tree for Kc

Conclusion:

Knowledge base is the brain of expert system and contains all knowledge necessary to provide expert advice. The irrigation requirement of a crop is based on various factors. The experimental knowledge of farmers and experiential knowledge of experts combined with factual l knowledge and a knowledge base is designed. The Knowledge is represented in an expert system efficiently to produce correct output thereby effective irrigation management of a crop.

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