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Developing Knowledge Based Recommender System for Crop Selection

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Abstract:
The most important role that agriculture plays in a country's political, economic and social stability makes degree of agricultural productions seriously sensitive. Agricultural production patterns vary markedly over Ethiopia according to agro-climatic conditions, in specific, broadly varying rainfall and elevation. To increase the cultivation process and improve agricultural productivity it is also require knowledge-based recommender system for crop selection, in order to advice how the farmers and experts select the crop type by considering soil texture, soil PH value, temperature, average rainfall, and other factors.
Knowledge-based systems are a branch of artificial intelligence which is a computer program that attempts to replicate the reasoning processes of a human expert. It can make decisions and recommendations and perform tasks based on user input. The expert`s knowledge is accessible when the human expert might not be and so that the knowledge can be accessible at all times and in numerous places, as necessary. Cultivators (farmers) need advance or specialist knowledge to take decision during soil preparation, seed selection, fertilizer management, pesticide management, water planning, weed management etc., so that to get high yield. In Ethiopia Current cereal yields are low, by international standards, indicating growth potential, since of lack of advanced agriculture experts and shortage of agriculture facilities. In the efforts to address such problems, it is important to develop Knowledge-based system recommender system that can provide advice for farmers and agriculture professionals to facilitate crop selection process to become more productive.
In this study, a prototype knowledge-based system (KBS) recommender system for crop selection is proposed. So, in order to develop the proposed recommender system an implicit and explicit knowledge used and acquired through interview, document analysis respectively. The data were collected from Gondar Agricultural Research Center which is found in Ethiopia. Knowledge Engineering research design was employed to develop the system. The prototype system reaches a good performance and meets the goals of the study.

Keywords: *Knowledge based system, recommender system, and crop selection*

1. Introduction

Ethiopia has wide ranges of agro-ecological diversity and therefore produces wide ranges of crops. The areas in the north and north central parts of the country are dominated by cereal based farming systems whereas root crops-based agriculture is most dominating in the south. Major crops include cereals (such as tef, maize, sorghum, barley, wheat, finger millet), roots and tubers (enset, sweet potatoes, potatoes), pulses (dry beans, faba bean, dry peas, grass pea, chickpeas, lentils), oilseeds (rapeseed, groundnuts, safflower, sesame, seed cotton, castor beans, linseed), vegetables (tomatoes, onions and shallots, pepper), fruits (bananas, citrus, pineapple, mangoes) and cash crops (coffee, tea, sugarcane, cotton, tobacco). As FAO agricultural database 2002 indicated, while cash crops such as coffee and tobacco have shown sustained yield increases over the years, it has not been possible to attain sustainable increased yield of food crops (Seyoum, 2013; Mellor and Dorosh, 2010). Ethiopian Economy is mainly based on agriculture. Major crops produced in the country include cereals, roots and tubers, pulses, oilseeds, vegetables like tomatoes, onions, shallots and pepper, fruits and cash crops.

Agriculture requires information and application of knowledge from different interacting fields of science and engineering to make a suitable decision making that in turn depends on interplay of these data and knowledge. This needs agricultural specializations and technical awareness in farmer or a human expert to help the farmers in decision making (Bethlehem, 2010; Abu-Naser et al. 2008).

In agriculture, applications of expert system are mainly found in the area of diseases diagnosis and pest controls (Sarma and Singh, 2009). Knowledge-based systems are a branch of artificial intelligence which is a computer program that attempts to replicate the reasoning processes of a human expert. It can make decisions and recommendations and perform tasks based on user input. The expert`s knowledge is available when the human expert might not be and so that the knowledge can be available at all times and in many places, as necessary. Experiences showed that knowledge base system can be used as a tool to disseminate the available best ways to combat plant diseases. Growers (farmers) require advance or expert's knowledge to take decision during soil preparation, seed selection, fertilizer management, pesticide management, water scheduling, weed management etc., so that to get high yield (Fahad et al., 2008; Ranjan, 2015).

Farmers in both developed and developing nations must respond to challenges including climate change, market liberalization and the emergence of new environmental and economic constraints. Crop management systems (CMS) must be rapidly adapted to the new constraints (Muriel and Meynard, 2012). This has led to a growing interest in research on the development of methodologies to design and evaluate multi-objective, innovative crop management systems (Mellor and Dorosh, 2010); Ambisa, 2012). In this study, the researcher developed knowledge-based farmers recommender expert system on crop selection, an expert system that will use for recommending farmers about for which temperature, land type, types of soil, and average rain fall are suitable for some crops and not for the others. It enables domain experts to build effective expert system in their crops with minimal intervention of knowledge engineers and programmers. A knowledge based expert system on agriculture can have a powerful mechanism with extensive potential to solve the problems related to agriculture (Ambisa, 2012). Knowledge based expert systems are designed to emulate the logic and reasoning processes that an expert would use to solve a problem.

1.1. Statement of the Problem

Agriculture is the predominant activity for most rural households in Ethiopia. The sector is mainly based on small holder farms and contributes about half to the total Gross Domestic Product (GDP) of Ethiopia and the livelihoods of more than 80% of the citizens (Diao et al., 2007). The small-scale farming accounts for 95% of the total area under crop and more than 90% of crop output. Ethiopia is a Centre of origin and diversity for several crops, such as Teff, wheat, maize, sorghum and barely accounted for 86% of the cereal production and covered 80% of the total farm land under small-householder. Cereals are the staple of the Ethiopian diet and Teff is the most favorable staple crop for all different income levels of rural and urban consumers. It has been seen increasing output for several years (Central Statistical Agency of Ethiopia (CSA), 2010). However, the sector is characterized by poor and backward technology, acute shortage of purchased inputs, particularly fertilizer, poor infrastructure and inefficient marketing systems (Abrar et al., 2002).

The adverse effects of abnormal weather are also very common in Ethiopia. Ethiopian farm households use diverse farm systems as an insurance against uncontrollable factors such as weather, production and market fluctuations. 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 (Bethlehem, 2010; Ambisa, 2012). Therefore, the notion of knowledge-based recommender system has an adequate prospective to improve the agricultural production.

It is therefore, this study explored knowledge-based farmers recommender expert system on crop selection. Finally, this study discovers and answers the following research questions:

- What type of knowledge is required to design a knowledge base system which can assist experts and farmers in crop selection?
- How to acquire, model, represent, and implement KBS prototype for crop selection?
- How to evaluate the performance of developed prototype system?

1.2. Objective of the Study

1.2.1. General Objective

The main objective of this study is to develop knowledge-based recommender system for crop selection.

1.2.2. Specific Objectives

- To acquire the necessary tacit and explicit knowledge required for developing knowledge base.
- To model and represent knowledge acquired from domain experts and codified sources.
- To build prototype knowledge-based recommender system for crop selection
- To evaluate the performance of the developed recommender system.

1.3. Scope of the Study

The scope of this study was developing prototype knowledge-based recommender system for crop selection and evaluating its application. There are different kinds of crops in Ethiopia. But the study makes reference to major cereal crops in Ethiopia. This work mainly dealt with the most important and major cereal crops in the country. The task involved in conducting this work includes literature review, problem identification, knowledge acquisition, modeling, representation and implementation or encoding. The prototype consists of knowledge base, inference engine, user interface, explanation facility and rule-based reasoning mechanism. The learning component of the knowledge base is not developed in this study and is not employed local language like Amharic, Afan Oromo, Tigregna etc.

1.3. Significance of the Study

The result of this work is expected to contribute a lot to the development of knowledge based advisory expert system for crop selection and motivate further researches to be conducted in the area of agricultural expert system. Furthermore, it can also help to initiate recommender expert system researches in Ethiopian. The proposed system can help farmers in critical times where access to an agricultural expert is not forthcoming due to the unavailability of agriculture extension worker in the area.

2. Methodology of the Study

2.1. Research Design

By acquiring tacit and explicit knowledge from domain expert the domain knowledge was modeled and then represented. The acquired and represented knowledge was inserted into the knowledge base. In addition, during prototype development stages the sequence of the facts and rules were changes again and again until it fitted the best sequence. So, the researcher employed experimental research design methodology for study.

2.2. Study Area, Population and Sampling Technique

The researchers selected Gondar Agricultural research center and North Gondar Zone Agriculture office which are found in Amhara regional state, Ethiopia. The populations of this study were the professional staffs of Gondar Agricultural research center and North Gondar Agriculture office. In this study purposive sampling technique was used to select domain experts for knowledge acquisition from the above research centers. 12 experts were selected for interview. The criteria used in selecting the domain experts for the study considered their professions, educational qualification level and years of experience on their specialization.

2.3. Knowledge Acquisition

In this study, several methods were conducted, such as direct interviews with some domain expert of the crop, metro logiest; examine documentation about types of crop, soil, rainfall, temperature and etc. The knowledge collected and prepared from different data sources and via different data collection methods such as questioner, interview experts in crop or plant science, methodologist, land administrator, soil scientist and agricultural extension professionals.

24. Knowledge Modeling Method

Knowledge modeling is a cross disciplinary approach to capture and model knowledge. Knowledge models view the knowledge-based system using diagram and other structured representations such as trees, maps, and KBS construction methods typically provide tools for knowledge analysis in the form of conceptual models of knowledge [8]. In this study the acquired knowledge was modeled using decision tree that links the type of crops and their associative criteria to make appropriate decisions based on observed criteria of cereal crop selection.

2.5. Knowledge Representation Method

After the knowledge is acquired it is represented using rule-based knowledge representation method. For this research the knowledge representation method, rule based is chosen because it clearly demonstrates the domain knowledge. In a rule-based system much of the knowledge is represented as a rule that is as conditional sentences relating statements of facts with one another. Most factors that affect crop growth are predefined sets of rules. There are already defined sets of criteria that enable to select crop. As a result, rule-based representation method is more appropriate to represent and demonstrate the real domain knowledge in crop selection.

2.6. Knowledge Based System Development Tools

The tool to be employed for develop the recommender system was SWI-Prolog. SWI-Prolog is AI open source tool used for case based expert system, rule based expert system and the integration of them. SWI-Prolog has machine learning techniques and approaches like case based and rule based.

3. Implementation and Experimentations

3.1. Architecture of the Proposed Prototype

The architecture design of this recommender system incorporates the knowledge base (facts and rules), explanation facility, inference mechanism, the knowledge base editor and the user interface.

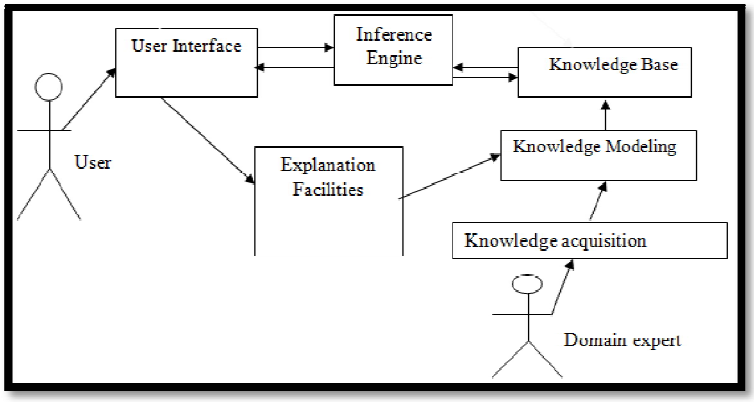

Figure 1: Architecture of the Developed Prototype System

The knowledge acquisition subsystem performs the eliciting and organizing of knowledge from the agronomy experts and vital documents. The main program that contains the inferencing, requests user to load the knowledge base and begins the selection process. An inference mechanism consists of search and reasoning methods that enable the system to find solutions and if necessary, provide justification for its answers. The researcher used backward chaining reasoning strategy.

In this study presented knowledge are encoded in to the knowledge base of the system utilizing prolog programming in SWI-prolog. The represented knowledge is in rules of the form "IF THEN" and the reasoning technique for this research was backward chaining because the goals are pre specified. The next figure below demonstrate sample of how the prototype system accepts user response and provide the ultimate recommendation about crop. To interact with this system to begin with the clients must star the framework by writing crop followed by full halt (Crop.)

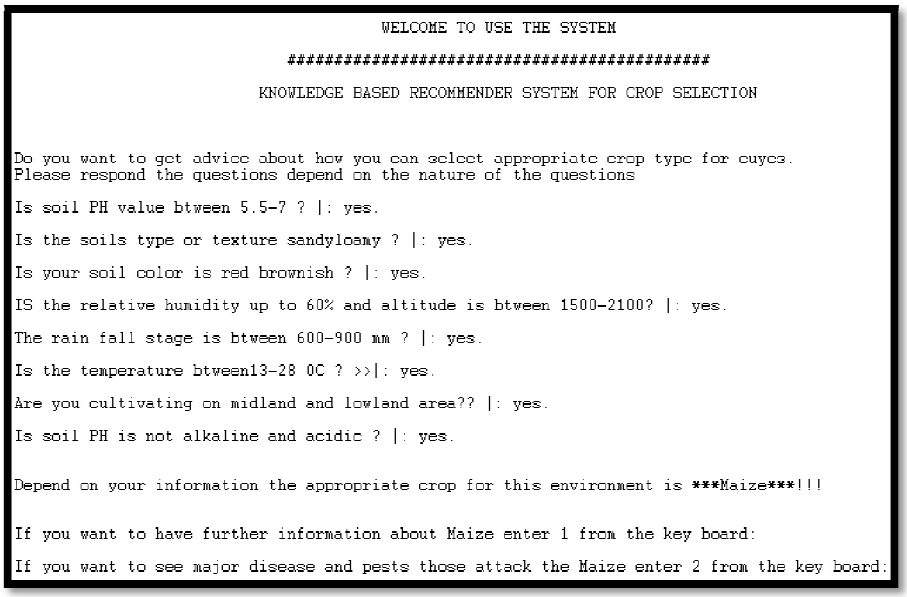

Figure 2: Sample Conversations That Shows How the Recommender System Receives the User Answer and Provide Recommendation

The user interacts with the knowledge base system via user interface. Knowledge base is a set of rules or encoded knowledge about crop suitable environment. The validated knowledge is represented in the form of rules by rule-based representation technique and the rules are codified to the knowledge base of the prototype system using Prolog programming language.

The next figure shows how the system gives additional information after the system decided the appropriate crop type.

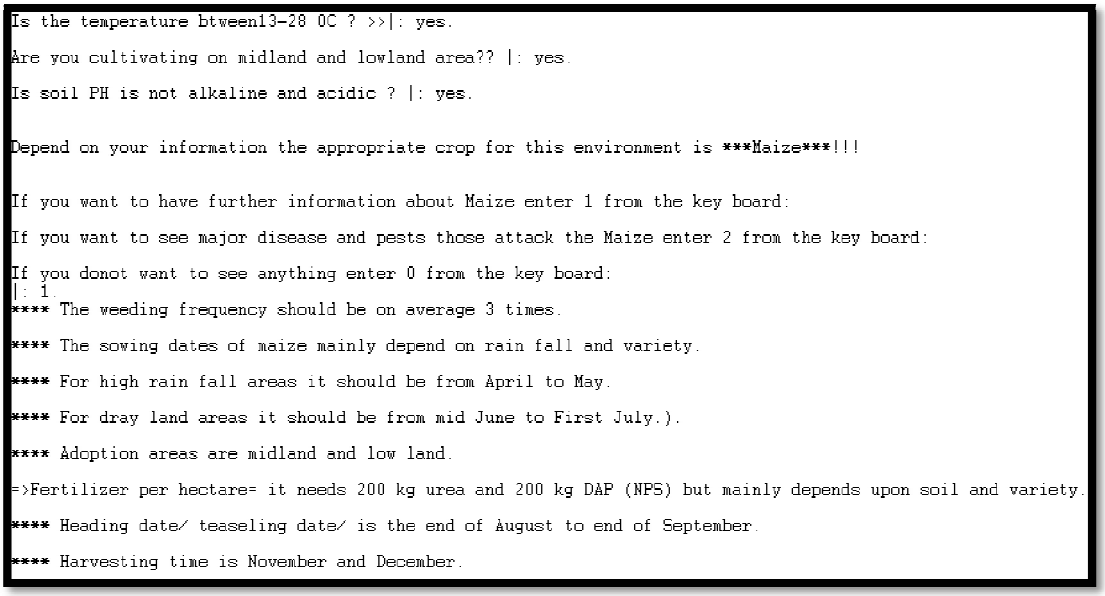

Figure 3: How the System Gives Further Information after Selection of the Appropriate Crop

The KBS presents questions to acquire the indications or characteristic of the factors those to be considered to select crops. The system is able to decide the appropriate crop type to cultivate around that environment based on the factors or criteria that displayed on the system and show the right conclusion for end users. But, the KBS does not learns and upgrade its fact base when unused facts were created during reasoning.

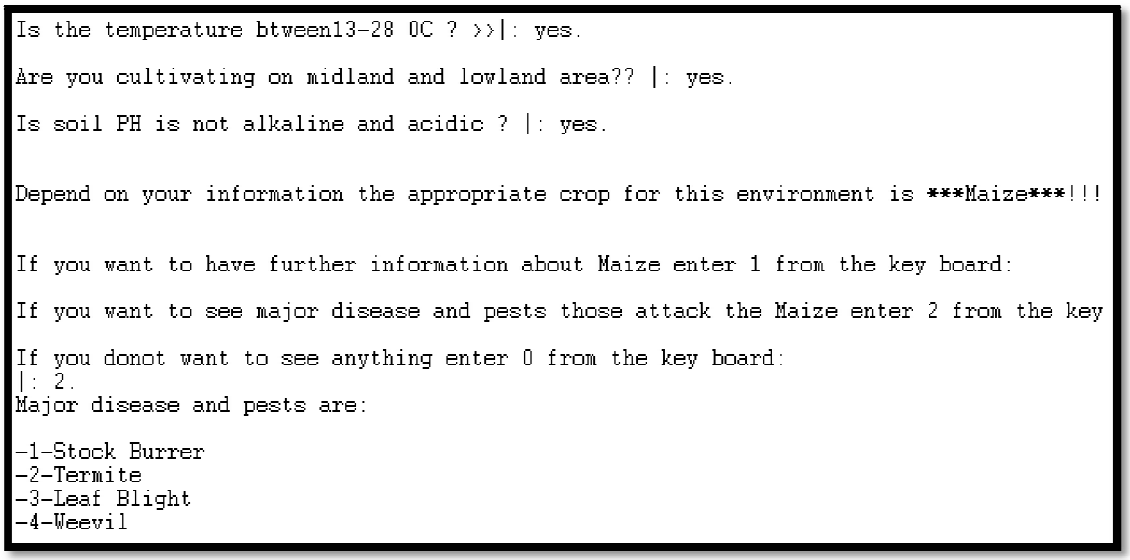

Figure 4: Sample Dialogues That Shows How the Recommender System Show Major Disease and Pests of the Selected Crop

Researchers used backward chaining reasoning strategy.

3.2. Testing and Evaluation of the Prototype System

To assess the performance of the system two set of testing was conducted. To test the performance of the prototype system we have utilized confusion matrix and the execution of the system was computed using recall, precision and F measure for measuring effectiveness. The accuracy of the prototype system is calculated as 87.2% based on the test cases and the average evaluation result filled by the domain experts in the domain area is 89.29%, respectively. The overall performance of the prototype system is 88.23%. The user acceptance of the prototype system is not registered 100% because of unawareness of domain experts about KBS importance in their domain area.

4. Conclusion and Recommendation

Ethiopia's crop agriculture is complex, including substantial variation in crops grown across the country's diverse regions and ecologies. Ethiopia's crop agriculture in general, and the cereals sub-sector in particular face serious challenges including selection of appropriate crop type for intended area. Hence, it's coherent to develop knowledge-based recommender system to imitate the knowledge of agriculture specialists who are exceptionally few in numbers in some field. The developed recommender system can be used for selection of crop type where there is shortage of agriculture professionals and/or agriculture extension workers. This recommender system can be utilized as an additional source of information when agricultural specialists are not accessible. Developing the system in local language, like in Amharic, Afan Oromo and Tigrigna is prescribed as future work. Finally, the recommender system would be more applicable if the system is deployed on mobile phones and it should be considered as a future research work.

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