AgriDaksh-Tool for Expert System

The Internet was opened to general users in 1994 and this new era of information and communication technology has played an important role in the field of expert systems. The Web technologies allowed the knowledge engineers and domain experts to build the expert systems that were having dynamic knowledgebase capabilities [Marwaha et al. 2002]. The domain experts could update the knowledge at the central server and the users had an access to the recent knowledgebase through a Web interface. AgriDaksh, a tool for building online expert system for various crops, has been developed at Division of Computer Applications, Indian Agricultural Statistics Research Institute, New Delhi. AgriDaksh has modules on Knowledge Model Creation, Knowledge Acquisition, Problem Identification, Knowledge Retrieval, Ask Questions to Experts and Administration. AgriDaksh enables domain experts to build online expert system in their crops with minimal intervention of knowledge engineers and programmers. With its use, it is possible to build online expert system for each and every crop in significantly less time and resources. Online expert systems have the capability to transfer location specific technology and advice to the farmers efficiently and effectively. This in turn will reduce losses due to diseases and pests infestation, improve productivity with proper variety selection and increase in income of the farmer.

Maize AgriDaksh is the first system developed by IASRI in collaboration with Directorate of Maize Research, New Delhi using AgriDaksh. Maize AgriDaksh provides ICT based advisories on Maize Crop and allows interaction with experts using Internet. This system is a farmer oriented and user friendly software which provides spectrum of information with
images of maize crop such as Variety Selection, Cultural Practices, Disease Diagnosis, Insect Identification, and Post Harvest Technology etc. The Variety Selection module advises location specific varieties and Cultural Practices advises on the aspects of irrigating, application of fertilizers and insecticides. Disease Diagnosis and Insect Identification module helps the stake-holders to diagnoses the disease and to identify insects affecting the maize crop and suggest preventive and control measures. Post Harvest Technology subsystem deals with storage and processing of maize for developing value added products. In Introduction module, detail information about basic, Origin & History, Soils and suitable areas for cultivation are covered. Maize technology module has many links such as introduction, production technology, seed production technology, varieties, value addition in maize product. Production technology provides information about specialty corn which contains detail information on a quality protein maize (QPM), baby corn, sweet corn, pop corn, high oil corn.

The knowledge acquisition module has data entry forms for insertion, updating and deletion of new basic, specific and economic features for variety management, diseases, physiological disorder, nematodes, weeds, insects, soil & climate, agriculture chemicals.

The knowledge retrieval module gives detail information about varieties, cost benefit comparison of varieties, which has provision for search varieties of maize crop for state wise as well as district wise varieties and each variety having basic and specific features. Basic features gives detail information such as variety parentage, seed chain, release center, source of seed availabilities, release year, avg. yield, variety recommended location and specific features of the varieties gives detail information such as distinguishing feature, taxonomic name, crop group, accession number, release year, release level, release date etc.

Plant protection module has provision for insertion, updating and deletion of specific features of a new disease, insects, physiological disorder, nematodes, weeds. It also generates various general reports about detail information of insects, diseases, nematodes, weeds, physiological disorder, herbicide, insecticide, nutrients and many more.

The knowledge processing module has Rule based Problem Identification and Ontology based Problem Identification sub modules. In Rule based Problem Identification, the users enters into the question answering mode and he chooses one of the multiple options provided in the page. Here, all the options are given in the text format. The question answering session yields in reaching the solution of the problem such as of disease diagnosis or identification of pests. In Ontology based Problem Identification also the users enter into the question answering session, but here the text is supported along with the pictures. Presently, it can answer the disease and pest identification as well as variety selection.

Expert management module has provision for insertion of new decision tree for solving the problem, creation of new nodes in decision tree, updating/deletion of the nodes in decision tree and linking the nodes of the decision tree to solve the problem.

Quality Protein Maize (QPM ) provides information on QPM such as suitable areas for cultivation, soils, selection of cultivars, time of sowing, seed rate and plant population, seed treatment, method of sowing, nutrient management, water management, weed management, insect-pest management, disease management, harvesting and post harvest management etc.
Baby Corn link gives detailed information about selection of suitable varieties, sowing time, sowing method, seed rate, seed treatment, nutrient management, weed management, water management, intercropping, protection from serious insect pests, harvesting, yield, by-products etc.

Sweet Corn link gives detailed information about Land Selection, Land Preparation, Time of Sowing, Varieties, Popular sweet corn varieties in India, Seed Rate, Seed Treatment, Method of Sowing, Transplanting, Nutrient Management, Fertilizer requirements for sweet corn, Weed Management, Water Management, Inter-cultivation, Intercropping, Pest and Disease Management, Harvesting of Cobs, Harvesting of Green Fodder, Post-harvest Handling, Precautions with Modified Endosperm Sweet Corn to Avoid Xenia.

Pop Corn link gives detailed information about Cultivation, Variety Selection, Popular popcorn varieties in India, Maturity, Cultural Practices, Soil Requirements, Fertility, Planting, Seed Rate, Irrigation, Intercultural operations, Weed Control, Intercropping, Insect and Disease Control, Harvesting, Marketing, Popping Quality, Value Addition and Uses of Popcorn.

High-Oil corn link gives information about Land Selection, Land Preparation, Date of Sowing, Seed Rate, Seed Treatment, Method of Sowing, Nutrient Management, Weed Management, Water Management, Inter-cultivation, Pest and Disease Management and Uses of High-Oil Corn.

Administration module allows the administrator to manage self account, handle user management, create new users and retrieve the information about the users.

Expert System for Maize Crop is available online through IASRI website http://www.iasri.res.in or at its direct link http://expert.iasri.res.in/agridaksh. The system was released by Honorable DDG Crop Science Dr. S.K. Dutta at 54th Annual Conference of Maize at Coimbatore during 2-4 April 2011. The system was also demonstrated in the meeting.

Architecture of Ontology based Expert System

The presented expert system is based on the n-tier model of the web applications. This model allows different components of the system to be built by different experts, specialized in their domain. Figure 2 shows how the components of the system interact with each other. Each of these components can exist on the different machines or anywhere on the web. Knowledge base and inference engine are the two most important components of an expert system. The basic principal of the separation of the knowledge from its treatment is of prime importance in the building of every expert system. The building and maintenance of an expert system is greatly facilitated by trying to adhere to this principal as closely as possible.

- **The Knowledge Base Layer (KBL):** The knowledgebase is built using OWL ontology. It contains knowledge about Maize varieties and diseases and insect-pests.
- **The Database Layer (DBL):** This layer is implemented using MS SQL Server 2008 database. This contains the authorisation information about users and crop specific information.
- **The Reasoning Engine:** The reasoning engine accepts user input queries and responses to questions through the I/O interface and uses this dynamic information together with the static knowledge stored in the knowledge base. The knowledge in the knowledge base is used to derive conclusions about the current case or situation as presented by the user’s input. JENA is used here for this purpose.

- **Server Side Application Layer (SSAL):** Application layer is built using Java Server Pages (JSP). The JSP provides the web developers with a framework to create dynamic content on the server using HTML, XML, Java classes, which is secure, fast and independent of server platform.

- **Client Side Interface Layer (CSIL):** It will be implemented using Hyper Text Markup language (HTML), CSS and JavaScript. The CSIL consists of forms for accepting information from the user and validation those forms using JavaScript. It also provides the explanatory interface to the users of expert system.

Fig. 2: The N-tier architecture of the software

**Class Hierarchy for Varietal Selection of Maize - A Case Study**

This section explains about the class hierarchy, properties and relation between classes and properties about Varietal Selection.

Variety: This is a class for maize variety that gives the name of the varieties grown around India throughout the year. Variety is a sub-class of owl: Thing and its individual has restrictions namely, has_yield exactly one, has_path exactly one, has_language exactly one (this restriction is applied to every class under owl: Thing), is_located_In only Location (means variety can grow more than one Locations) and has_maturity_type only Maturity_type. It also has object properties like has_grain_color, has_grain_type and variety_of. The following snapshot shows the class view for Variety and its individuals view for variety named HM 10 [Fig. 3].
Fig. 3: Class Variety and its individuals with different object and datatype properties

Fig. 4: Class Maturity_type and its individuals

Maturity_type: This is a class that shows different types of maturity for maize crop. It is a sub-class of owl: Thing and it has four individuals which has only one restrictions i.e. has_language exactly one. The above snapshot gives a view of class Maturity_type and its individuals [Fig. 4].
Grain_color: This is a class that shows different types of grain color for every maize variety. It is a sub-class of owl: Thing and it has four individuals which have only one restriction i.e. has_language exactly one. Following snapshot gives a view of class Grain_color and its individuals.

Grain_type: This is a class that shows different types of grain color for every maize variety. It is a sub-class of owl: Thing and it has four individuals which have only one restrictions i.e. has_language exactly one. The following snapshot gives a view of class Grain_type and its individuals.

Location: This is a class to show where maize varieties are grown in India. It is a sub-class of owl: Thing and it has five sub-classes. Among them, three are our concerns which are State, Union_Territories and Other_locations. Each sub-class has its own individuals and has two restrictions like has_language exactly one and has_maize_type only Maturity_type. The following two snapshots show the sub-class State and Other_locations of class Location with their own individuals.
Fig. 5: Class Location, its sub-classes and class State with its individuals

Fig. 6: Class Location, its sub-classes and class Other_locations with its individuals
When the project is run the home page of Maize Agri Daksh appears. As the software is integrated with this project, the option Problem Identification appears on the left frame. When it is clicked the following SPARQL query is fired with the following page.

```
SELECT ?tree
WHERE { ?tree :has_sequence ?sequence.
  ?tree :has_language "english"}
```

![Fig. 7: Problem Identification Module](image)

After selecting Varietal Selection the following SPARQL query is executed with the following page. This query is used to show the variety_sequence has the properties no_of_ques and has_ques sequence.

```
SELECT ?select_part ?query_clause ?ques
WHERE { :variety_sequence :has_ques1 ?qid.
  ?ques :has_id ?qid.
  ?ques :has_select_clause ?select_part.
  ?ques :has_query_clause ?query_clause.
  ?ques :has_language "english" }
```

The following query is used for selecting the varietal selection of a crop.
SELECT distinct ?Crop?path
?Crop :has_language "english".
?pic :has_path ?path}

Fig. 15: First Question asked by the Expert System to select the crop under Varietal Selection

Here, the above snapshot shows the question asked by the expert system. As the user answers a question his response is stored in a java bean. After the crop Maize is selected the following next SPARQL query is fired.

SELECT distinct ?Area
WHERE { :Maize :is_Located_In ?Area }
ORDER BY(?Area)

This query is used for selecting the area of adoption means where the users want to grow a particular maize variety.
Fig. 8: Second Question asked by the Expert System to select the stage the area of adoption with Question-Answer History

The system has Question-Answer session which gives a table that shows the answer selected by the user when a question is asked by the expert system previously.

When a particular area of adoption is selected the following SPARQL query is executed with the following page.

SELECT ?Maize_type
WHERE { :Andhra_Pradesh :has_maize_type ?Maize_type }
ORDER BY(?Maize_type)

This query is used to select the maturity type of maize variety grown in Andhra Pradesh.

As the system proceeds the previous question asked and the answer selected by the current user is added to the Question-Answer History.
Fig. 9: Third Question asked by the System to select the type of maturity of the variety

As an option is selected from the list the following SPARQL query is executed and the snapshot of respective page is given below.

```
SELECT distinct ?grain_type
WHERE { ?variety :variety_of:Maize.
  ?variety :is_Located_In:Andhra_Pradesh.
  ?variety :has_maturity_type:Extra_early.
  ?variety :has_grain_type?grain_type.}
ORDER BY(?grain_type)
```

This query is used to select the grain type under the maturity type Extra-early which is grown in State Andhra Pradesh.
When an option Flint is selected and proceeds further the following SPARQL query is executed.

```
SELECT distinct ?grain_color
WHERE {  ?variety :variety_of:Maize.
        ?variety :is_Located_In:Andhra_Pradesh.
        ?variety :has_maturity_type:Extra_early.
        ?variety :has_grain_type:Flint.
        ?variety :has_grain_color ?grain_color.
ORDER BY(?grain_color)
```

It is used to select the grain color of a grain type Flint whose maturity type is Extra-early grown in Andhra Pradesh.

This query uses all previous input given by user, i.e. crop, area of adoption, maturity type and grain type to extract the most likely grain color, hence, again leaving the irrelevant options.

Fig. 10: Fourth Question asked by the Expert System to select the grain type
After last question, expert system dynamically creates a SPARQL query given below to display the final result, i.e. user can choose the variety or varieties along with an average yield of respective variety is given according to given parameters selected.

```
SELECT distinct ?path ?grain_type ?grain_color ?yield 
WHERE { ?variety :variety_of:Maize. 
?variety :is_Located_In:Andhra_Pradesh. 
?variety :has_maturity_type:Extra_early. 
?variety :has_grain_type:Flint. 
?variety :has_grain_color :Yellow. 
?variety :has_path ?path. 
?variety :has_grain_type ?grain_type. 
?variety :has_grain_color ?grain_color. 
?variety :has_yield ?yield}
```
Fig. 12: The complete Question-Answer History showing Questions asked by the Expert System and Answers selected by the user under Varietal Selection.

Fig. 13: Final page showing the user can adopt the following Variety/Varieties along with Grain Type, Grain Color and Avg. Yield.
This system at present provides facilities to select a variety for a particular area. In the presented expert system, the user or farmer will provide input by selecting through radio button. The program will ask questions until it reaches a conclusion. The conclusion may be a single solution or a list of possible solutions. Multimedia support like image for varieties is also added.

References:


