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Design and Development of Sensor Networks Interface- Semantic Web Based Wheat Expert System

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Abstract: In recent years sensors have been increasingly deployed in the Agricultural fields to monitor the extremely sensitive environmental and climatic changes. Since temperature and humidity are the key factors that affect the growth of crops, temperature sensor, humidity sensor, light sensor and growth sensor are generally plays key role in Agriculture. Expert systems may be used in agricultural field to offer information about the disease management and cure for the crop, soil management, irrigation level to be maintained for the crop, to suggest suitable seed varieties, quantity of fertilizers to be used and finally to find out the expected yield of the crop. Expert systems interact with the farmers and provide solution for the different problems they face in the field from time to time. Semantic web adds structured meaning to the available information and facilitates the machine readability of information. The power of semantic web over traditional web is data re-usability and more relevant accurate search. Agricultural knowledge is so vast and is in unstructured format. Hence it is necessary to incorporate the semantic web for building and processing the knowledge in a structured and disciplined way.

The present paper is aimed at designing and developing a semantic web based wheat expert system with an automatic sensor interface. The system consists of two components namely Information system and Advisory Systems with separate interfaces to both experts and ordinary farmers. The sensor interface is designed using the LM-35 temperature sensor, ADC, 8051 micro controller and MAX 232. Knowledge base is built using ontological structures for the information about the wheat crop with appropriate classes and properties and inference is achieved through SWRL rules. The information system provides the information about wheat varieties, nutrients, diseases, symptoms etc. The user interface takes the average values of temperature and humidity from the observations recorded and calculates the expected yield of the crop using artificial bee colony algorithm.

Keywords: Sensor Networks, Agricultural Sensors, Semantic Web, Expert System, ABC Algorithm.

I. INTRODUCTION

A sensor network comprises of sensing, communication and computation over a set of compute nodes. Nodes sense and monitor the environment, communicate over a network and process the information using computational techniques [1]. Sensor Networks play a major role in Precision Agriculture. Different types of agricultural sensors monitor environmental conditions such as temperature, humidity, sound, pressure etc. Fruit growth sensors calculate the growth of the fruit over a period of time. Humidity sensor [2] senses the percentage of humidity in the atmosphere. The temperature sensor senses the atmospheric temperature as well as soil temperatures. Temperature data loggers [3] are used to record the temperature values over a period of time.

Expert Systems provide solutions to variety problems and are normally used in situations where experts are unavailable. In agricultural domain, expert systems are used to advice the farmer about the yield and diagnosis of diseases and pests of the crop [4]. The main components of the expert system are knowledge base and inference engine. Knowledge is extracted by conducting programmed interviews with field experts. Inference engine uses the knowledge base to derive the conclusions from the existing rules. Most of the knowledge related to agriculture is unstructured and the search process for such knowledge is inaccurate and hence it is necessary to incorporate the semantic web concept, which adds structured meaning [13] to the unstructured information. The advantage of semantic web based expert system over traditional web based expert system is that it provides the access to data dynamically. The present system is developed in such a way, so that farmers, students and researchers can dynamically interact with it for their day-to- day activities.

II. LITERATURE SURVEY

Expert systems are applied in agricultural domain from 1970's. Fahad Shahbaz Khan, Saad Razzaq and other (2008) [4] discussed the expert system for the diagnosis of diseases and pests using rule based system. Prof. M. Surendra Prasad Babu et al. [13] presented an expert advisory system using Artificial Bee Colony algorithm for disease management in the Garlic Expert advisory System. They developed the system using JSP as front end and MYSQL as backend. Prof. M. Surendra Prasad Babu et al[14] developed knowledge base for Soya Bean and expert system using Bagging algorithm to find the disease for the crop. M. S. Prasad Babu et al (2012) [15] designed an expert system for maize crop using Ada-Boost Algorithm and Naive Bayesian Classifier. The system receives the symptoms from the user and processes the information using trained data and determines the diseases of the crop. Vinay Divakar (2013)[3] presented the temperature logging system that displays on the PC continuously with the help of LM-35temperature sensor and LPC2148 microcontroller. He discussed the characteristics of LM-35 temperature sensor and the hardware required to interface the output of LM-35 to LPC 2148. Sujan Chowdhury et al (2013) designed Semantic web ontology for agricultural domain. They used AGROVOC as the base vocabulary which is developed by Food and Agricultural Organization for designing Ontology for fruit. Mostafa Nofel et al (2014) [12] proposed a tool to update the knowledge and induce rules based on semantic concepts and relations. They expressed that the Semantic web technologies permits the knowledge engineer and field expert to define the knowledge without having to know about AI. Asaju La' Aro Bolaji (2013) [17] discussed an overview of artificial bee colony algorithm and its applications.

III.DESIGN AND DEVELOPMENT OF SEMANTIC WEB BASED EXPERT SYSTEM WITH SENSOR INTERFACE

An expert system is a system that follows the decision-making ability of a human expert, designed to solve complex problems [5] by reasoning about the knowledge. The diagram represents the architecture of the present system.

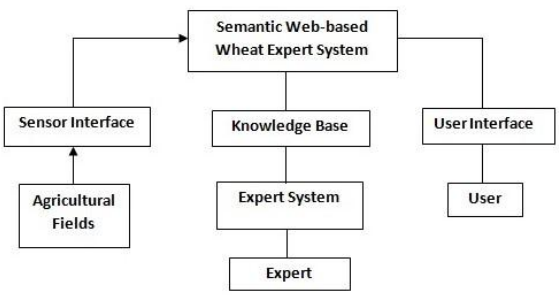

Fig1 System Architecture

The architecture comprises of different modules namely knowledge base and inference engine, sensor interface, information system and expert system. The information and expert system forms semantic web based expert system.

A. Knowledge Base
The Knowledge base is a repository which stores structured information used by a computer system. In the Semantic Web, knowledge is represented in the form of Ontology [6] [7] [11] so that unstructured knowledge may also be included. Ontology [11] [13] is the key component of the Semantic Web architecture. It consists of different classes, instances and relationships. Knowledge base for wheat crop is built using Ontology in the Semantic Web. Web ontology language is designed to be used by the applications that need to process the information instead of presenting information to humans.

B. Inference Engine
Title Inference in semantic web derives new relationships. It is a process to infer new relationship from existing resources and some additional information in the form of "set of rules" for the semantic web. Vocabularies give additional resources. Inference requires to process given knowledge in the semantic web. Pellet reasoner is an OWL DL reasoner for semantic web. It supports full expressivity using SWRL rules.

C. Sensor Interface
The interface designed using real time sensors is the sensor interface which uses the LM-35 temperature sensor to senses the temperature. The proportional voltage of temperature sensed is input to the ADC. The output of ADC is 8-bit value which is input to the microcontroller. The microcontroller converts 8-bit binary value to the equivalent value which is passed through the serial port using MAX232.

D. Information System
The information system displays the information of wheat by retrieving the data from the knowledge base. The knowledge contains the information gathered from experts is built as an ontology, which acts as knowledge base. The knowledge base combines the knowledge of multiple experts. This is responsible for retrieving data from the knowledge base and presenting it to the user or farmer.

E. Expert System
The systems that can be developed in the wheat expert system are diseases-symptom management, yield of the crop, irrigation level to be maintained and suitability of the soil. In this module, yield of the crop is assessed. Yield assessment system provides the yield of the wheat crop in tonnes per acre. The system takes different input parameters water supplied, nitrogen, phosphorous along with the sensor inputs temperature, humidity and computes the optimal yield using Artificial Bee Colony algorithm.

IV. DESIGN AND DEVELOPMENT OF SENSOR NETWORKS INTERFACE

The temperature sensor senses the temperature every second and outputs the analogue voltage corresponding to the sensed temperature. In this module, LM-35 temperature sensor [2] is interfaced to 8051 microcontroller using MAX 232 for serial transmission of data.

F. Components Used for Data Collection using Sensor
Temperature Sensor: LM35 (1 no.)
ADC : ADC 0804(1 no.)
Micro Controller : 8051-AT89S52 (1 no.)
MAX232 : 1 no.
Resistors : 10KΩ (3 no.), 10KΩ pot (1 no.)
Capacitors : 33pf (2 no.), 150pf (1 no.), 10mfd (5 no.)

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Crystal : 11.0592 MHz (1 no.)
Dot Board : 1 no.

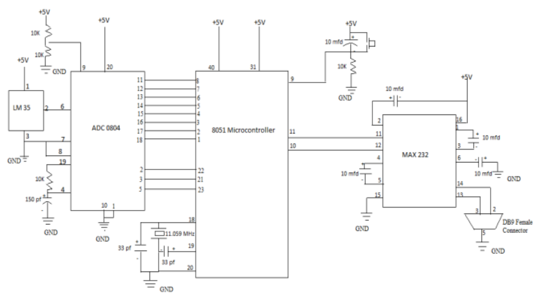

Fig. 2 Circuit Diagram for Sensor Interface

G. Description of Sensor Interface

ADC 0804 is an 8-bit pin which has one input channel connected from sensor to give analogue output. The output data pins of ADC (D0-D7) are connected to the port1input pins (p1.7-p1.0) of 8051 microcontroller. The data from port1 is stored in the serial buffer register of micro controller unit. Connect the TxD pin (pin11) of 8051 microcontroller to Tin pin (pin 11) of MAX-232 for serial communication between 8051 micro controller and PC. Connect T1out (pin 14) and R1in (pin 13) pins of MAX-232 to Tx (pin 2) and Rx (pin 3) of RS-232 (DB9 Female connector). MAX-232 IC is used to ensure the compatibility between serial port and microcontroller.

H. Working of Sensor System

The following are the steps involved in the working of sensor interface.

- It converts analogue data to digital data using ADC convertor.
- Digital data is in binary format and micro controller is programmed in assembly language to convert the binary data to hexadecimal format.
- Keil uVision software generates a hex file for the assembly language code.
- Dump the hex file into microcontroller using Super Pro programmer. Make proper connections and switch on the power.
- Open hyper terminal program in the computer and set the baud rate to 9600 bps, data bits to 8, parity bits to none, stop bits to none and Flow Control to none.
- Now, record the data from hyper terminal obtained from LM-35 temperature sensor. The hex file is viewed as ASCII format in hyper terminal.

I. Temperature Sensor

The temperature sensor LM-35 [2] measures the environmental temperature. The V_{out} pin of LM-35 is connected V_{in} pin of ADC. The sensor LM35 is precision integrated circuit temperature whose output voltage is linearly proportional to Celsius temperature. V_{out} is measured by voltmeter which is converted to temperature by a simple conversion factor. LM-35 temperature sensor has the sensitivity of 10mV/ºC.

J. Temperature Conversion

ASCII data obtained through hyper terminal is converted to its equivalent decimal values and thus obtain the temperature of the decimal equivalent using the following conversion. The analog to digital convertor (ADC) is 8-pin ADC. Hence the step size is $2^8 - 1$.

Step Size= 255 (Since 8-pin ADC is used, 2^n-1)
Step Value= V_{ref}/Step Size=3.13mV

$$\text{Temperature (ºC)} = \frac{\text{decimal value} * \text{Step Value}}{10} \quad (1)$$

Obtain the decimal value by converting the ASCII output from the hyper terminal. Fix the V_{ref} value to 0.80V in the ADC.

V. DEVELOPMENT OF SEMANTIC WEB BASED WHEAT EXPERT SYSTEM

Semantic Web-based wheat expert system provides yield of the wheat crop using Artificial Bee Colony (ABC) algorithm. The system develops two modules- information system and yield assessment system. The information system displays the ontological information of wheat dynamically and inference through SWRL rules. The yield assessment system takes the different input parameters water in litres, nitrogen in kgs, phosphorous in kgs, temperature in centigrade and humidity in percentage. It also computes the sensor values by performing the average of temperature values obtained through sensor interface. 'Click for Sensor Value' button provides sensor interface which gives the average of the temperature values from the above module.

K. Design of Ontology

The ontology is the knowledge base with different classes, subclasses and individuals. Thing is the main class in the ontology representation and Wheat is the subclass of the main class Thing.

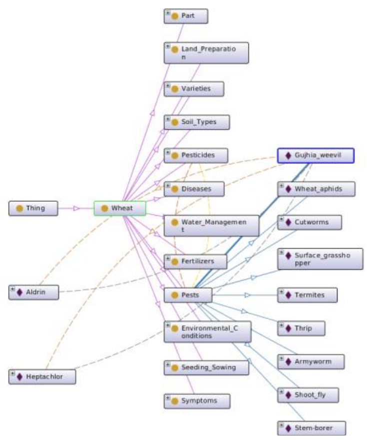

Fig. 3 Ontology Design

Description: Web ontology Language (OWL) is the family of knowledge representation languages for authoring ontologies [6]. The OWL file structure represents the ontology of wheat crop. In the figure, part, varieties, diseases, pests, symptoms, pesticides, environmental conditions, soil types represent the sub classes of the class wheat. Each class has one or more individuals. Gujhia weevil, wheat aphids, cut worms, termites, thrip, army worm, shoot fly are the individuals of the class pests. Each individual inturn is associated with the properties such as hasValue, hasDescription, hasName.

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L. SWRL Rules/Inference Engine

SWRL is Semantic Web Rule Language. It is a language proposed for Semantic Web which expresses rules as well as logic [10]. SWRL follows the forward chaining. First various conditions are evaluated, if all the conditions returns true then the goal is executed.

Rule List Symptoms: Part(?p) ∧ hasSymptom(?p, ?sym) → sqwrl:select(?p, ?sym)
Rule Leaf_Symptom_Cause: Part(?p) ∧ hasName(?p, "Leaf") ∧ hasSymptom(?p, ?symp) ∧ causes(?symp, ?cause) → sqwrl:select(?p, ?symp, ?cause)
RuleWater_Deficient: Symptoms(?p) ∧ hasDeficiency(?p, water) ∧ is SymptomOf(?p, ?Symp) → sqwrl:select(?p, ?Symp)

M. Artificial Bee Colony Algorithm

The ABC algorithm [9] is a swarm optimization algorithm. There are three groups of bees: employed, onlookers and scout bees. Initialize the food sources by inputting data from the OWL file. Associate each employed bee with a particular food source and calculate new solutions. Onlooker bees wait the fittest food source. Scout bees search for the improved food source. The steps involved in the algorithm are:

- Calculate the objective function by assigning the food source values in solution array.
- In employed bees phase, calculate the new solution by the following equation and fitness for each solution.
- $v_{ij} = x_{ij} + \emptyset_{ij}(x_{ij} - x_{kj})$ (2)
- In onlooker bee's phase, select the fittest food source by the onlooker. The selection process works by calculating probabilities.
- $p_j = \frac{f(x_j)}{\sum_{k=1}^{SN} f(x_k)}$ (3)
- In the scout bee phase, search the improvement in the food sources by replacing the abandoned food source.
- Memorize the best food source using GlobalMin variable which holds the best value for every iteration.
- Repeat the steps 2 to 5 till the maximum cycle number.
- End Process

VI. RESULTS AND DISCUSSIONS

In this section, we discuss the results of the information system and yield assessment system of the wheat crop, which are two main modules of the paper and sensor interface in the yield assessment system.

Information System

Report 1:
In the following screen shot, the user selects the required information about the wheat crop. The information contains the wheat varieties, pests, diseases, symptoms, nutrients, pesticides, climate and soil types.

Discussion: This Screen shot contains user selected the pests. The pests listed are armyworm, cutworms, gujhiaweevil, shootfly, stemborer, thrip, surface grasshopper.

Fig. 4 Information System for Wheat Crop

Report 2:
In this screen shot, the user selects the pest shootfly which affects the wheat crop. It contains the ontological description of shoot fly.

Fig. 5 Ontology Description for Shoot Fly

Discussion: The screen shot contains the scientific name of the pest with the pesticides and the description for the pest Shoot Fly.

Sensor Interface in Yield Assessment System

Report 3:
In this screen shot, the user enters the valid inputs in the user interface to calculate the yield of the wheat crop. Sensor interface is also observed.

Fig. 6 Sensor Interface

Discussion: The screen contains the inputs of the wheat yield assessment are water supplied, nitrogen, phosphorous, humidity and temperature. Humidity and temperature provide sensor interface by the button specified as Click for Sensor Value, which gives the average of the temperature and humidity values.

Yield Assessment

Report 4:
In this screen shot, the user can find the optimal yield of the wheat crop from different inputs and sensor interface.

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Fig. 7 Yield Output

Discussion: The screen displays the target yield of wheat crop in tonnes per acre for the inputs entered by the user.

Sensor data from Hyper Terminal

Report 5:
In this screen shot, the user can view the result of sensor temperature data captured from the hyper terminal.

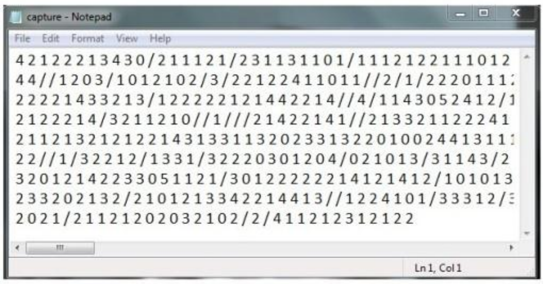

Fig. 8 ASCII Values

VII. CONCLUSION AND FUTURE SCOPE

Semantic Web based Wheat expert system is developed using Java, JSP, Jena, Netbeans IDE, Protégé ontology editor. Sensor interface is developed using Keil uVision software, Super-pro programmer and hyper terminal program. The wheat expert system is developed dynamically using Semantic web. Data acquisition system for temperature has been developed and temperature sensing unit is tested successfully. The system overcomes the drawback of traditional web-based expert system, which lacks in dynamism by implementing the semantic web-based expert system with better inferencing mechanism. Its main aim is to inform the farmer/user about wheat yield for better marketing. The future scope of the work is to place two or more sensor nodes in the agricultural field and monitor data by performing data aggregation.

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