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Implementation of Cuckoo Search Optimization Algorithm using Semantic Web-Based Coconut Expert System

Prof. M. S. Prasad Babu, B. Jyothsna
Department of CS&SE, A.U.
Visakhapatnam, India

Abstract—An expert system is a computer program, with a set of rules encapsulating knowledge about a particular problem domain. The present paper deals with the design and development of Coconut expert system to advise the farmers in villages through online. This is a Semantic web-based application, developed using machine learning techniques. In Expert Systems Knowledge is presented as a set of rules collected human expert. In the present paper, Cuckoo search optimization has been considered and applied to generate a new set of rules using the existing rules. In the present paper a Semantic web-based expert system and a machine learning systems are integrated to form the Coconut advisory system. A feature namely 'yield assessment' was implemented for evaluating the annual yield of the crop. The system works as follows: At First, the input parameters are taken from the farmer in order to assess the yield. This expert system is a Semantic web-based application for online users with Java as front end and Semantic web as the back end.

Keywords: Expert system, cuckoo search optimization, Semantic web, OWL, Coconut crop.

I. INTRODUCTION

Coconut is one of the plantation crops in India, grown in more than 18.95 ha in the country. Even though coconut is cultivated in all over India, the states like Kerala, Tamilnadu, Karnataka, Andhra Pradesh, Goa, West Bengal etc., are the premium producer states of the coconut. Copra making, oil extraction, coir manufacture etc., are the major products of the coconut crop. The yield assessment of the crop is done by taking basic information such as the soil types, crop types, fertilizers used, pH values etc. By the turn of the twentieth century, the World Wide Web will be the information highway to access the information from the internet. It is very difficult to access relevant reliable information from the existing unstructured unlimited material and therefore Semantic Web has been used instead of World Wide Web because it represents the information in a structured format. It stores the information in the form of records or tuples (subject, object, attributes). Ontology is a part of the semantic web which consists of definitional aspects such as high-level schemes and assertion aspects (entities, attributes, an interrelationship between entities, domain vocabularies etc.,) connect in a semantic manner. Swrl rules, RDF, XML, URI etc., are also implemented in Semantic Web implementation. In optimized design, the design objective could be to minimize the cost or to maximize the efficiency of the product. It is an act of obtaining best result under given circumstances. In the present paper, meta-heuristic algorithm, called Cuckoo Search Optimization algorithm(CSO) is used to estimate the optimum yield of the coconut crop per acre. Meta- heuristic algorithm have two important characteristics namely, intensification and diversification. When compared to other Optimization techniques, this algorithm is more efficient and more faster.

II. LITERATURE SURVEY

An expert system is applied in agriculture domain from 1970's. Salfur Rahman(1988)[1] discussed algorithms based on expert systems for short term load forecasting. A.J.Castro-tendero(1995) [2] discussed the expert system for weed control of sunflower. It evaluate the potential yield reduction from multi-species weed infestation and determine the appropriate selection of herbicides. In collaboration with ANGR Agricultural University, Prof M.S.Prasad Babu (2005) [3] introduced indiakesan.net web portal for farmers. In this Web portal number of rule-based expert systems were developed and implemented using machine learning algorithm. Pinaki Chakraborty, Dilip kumar chakrabati (2008) [4] discussed computerised expert system for different sectors of agriculture in India. J.L.Gonzalez-Andujar(2009) [5] presents an expert system for Olive oil crops. These system provide information for pests, diseases and weed identification. In these systems Knowledge-base is represented in terms of series of IF-THEN rules. M.S.Prasad Babu et al(2012)[8] designed an expert system for maize crop using a machine learning algorithm namely, the Ada-boost algorithm. Latifur Khan el at[9] used semantic web technologies such as RDF(resource description framework) to incorporate the ability to record such provenance information through the process of reification. G.Madhu et al[10] presented a survey on the search engine generations and the roles of search engines in intelligence web and semantic web technologies. C.H Liu, et al[11] presented Ontology-based approach for employing web ontology (OWL) to describe context knowledge and to represent rule-based inferences for context reasoning by using semantic web rule language(SWRL). Rafael Valencia-Garcia, et al. [17] presented a natural- language-query editor namely, OWL Path using Multilanguage OWL-formatted Ontologies. They stated that this application allows non expert users can easily

interact with the system and to receive more information from ontology storage systems. Ehsan et.al [19] have proposed the Improved Cuckoo Search (ICS) for optimizing the network weights to enhance accuracy and convergence rate.

III. DESIGN OF SEMANTIC WEB BASED EXPERT SYSTEMS

The proposed architecture is given in figure1. The present system has two interfaces namely, (1) Farmer interface, (2)Expert interface. *Farmer Interface is* consists the details of basic information about coconut crop such as Varieties, Diseases, Pests etc. All the information is available in OWL files and gets data dynamically fetched from that files. *Expert Interface is used to* organize knowledge base, Coconut ontology design, and Cuckoo search optimization algorithm(CSO). The Details of each component are described here under.

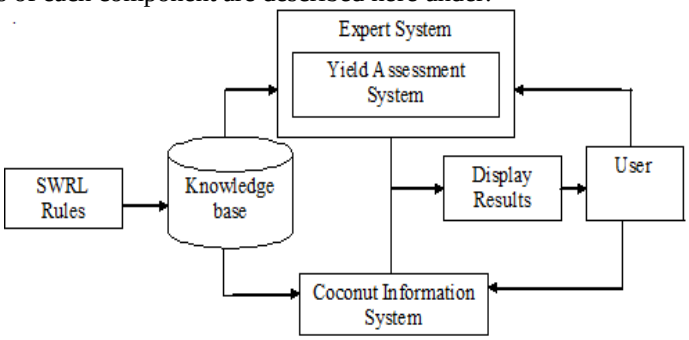

Fig1:Structure of the Proposed Coconut Expert System

A. Knowledge Base:

In this knowledge base, the system collect the information regarding the coconut crop and its cultivation details from the domain expert and stores in OWL files in the form of SWRL rules. SWRL means Semantic Web Rule Language. SWRL is a language proposed for semantic web that can be used to implement the rules as well as logics. The Design of the Ontology for this information is described below:

i. The ontology with specific domain information represent the meaning of the term in the same domain and using the meaning it organizes the collection and make search more accurate.
ii. In Coconut ontology design, there is single main class called Coconut, which interrelates the other subclasses like pests, diseases, Symptoms, fertilizers etc.,
iii. In the Fig2, the different relations between the main class and its sub classes and also one sub class to another subclass are displayed. Linking between classes and sub-classes like hasSymtomof, hasDiseaseof, isSymptomof, isDiseaseof etc.,. are the objectProperties.
iv. Symptoms, diseases, pests and pesticides are discribed in the description box using dataPropterty. Results, name of the individuals, values etc are added using this dataProperty.

B. Inference engine:

Inference engine for the proposed Semantic Web Based Expert System follows the forward chaining. It collects the relevant observations from the farmers about their crop problems, consults the knowledge base and determines the advisory decisions for the relevant crop problems. It actually evaluates different conditions, if all the conditions return true. it reaches the goal. In the process it derives the new relationships from the existing rules with some additional information in the form of rules for the semantic web. Domain vocabularies give the additional resources.

C. Cuckoo Search Optimization algorithm(CSO):

CSO algorithm is a nature- inspired meta heuristic algorithm introduced by Xin-She Yang and Suash Dehin [] in 2009. CSO works based on the breeding behaviour of cuckoo bird. Cuckoo Search Optimization algorithm has three basic rules:

1. Each bird lays one egg at a time, each egg is placed in randomly chosen nest.
2. The best nest with highest fitness value will get carried over the next generation .
3. The number of available host bird nest is fixed, and the probability $P_a \in [0,1]$, of discovering laid eggs in hosts nest by the host bird. Where the host bird can either throw the egg away or abandon the nest and build a completely new nest, which can be treated as new best solution.

Let $x_i^{(t)}$ be the nest where the Cuckoo bird lives initially and $x_i^{(t+1)}$ be the new nest with highest fitness value. Then In generating new solution $x_i^{(t+1)}$, the random-walk is best performed by using Lévy flights. The performance of cuckoo *i* using Lévy flight is given by

$$x_i^{(t+1)} x_i^{(t)} + s \text{ Lévy}(\lambda) \text{----------[1]}$$

□ □ □

Here, □ is a standard normal distribution with mean '0' and with standard deviation '1'. □ □determines the direction of the moment, s is the step size and levy flight refers to a levy motion, which stands for a class of non-Gaussian random processes whose stationary increments are distributed according to a levy Stable distribution.

Levy flight was first introduced by French mathematician Paul Pierre Lévy as levy~u=$t^{(-\lambda)}$. ----------[2]
According to this formula[2], cuckoo bird consecutive jumps (or steps) forms a random walk process with a power-law step-length distribution which has heavy tail as highest probability.

D. Cuckoo Search Optimization algorithm for Coconut crop yield Estimation(CSO CE):

Cuckoo search optimization algorithm is a meta-heuristic algorithm. Cuckoo eggs mimic like host bird eggs. each egg is placed in randomly choose nest. Here input parameters are taken has eggs which have to be placed in a randomly chosen nest. The best values of each input parameter are stored in the knowledge base using expert interface. By using levy flight equation, we are calculating the best optimal value to reach the target value. Levy flight is a standard distribution function which is used to calculate the random walk between the input value and best nest value. For each parameter, Evaluate the optimal value using Levy flight equation and calculate step size for the next value.

IV. DEVELOPMENT OF SEMANTIC WEB-BASED COCONUT EXPERT SYSTEM

Semantic web-based coconut expert system is divided into two parts namely. Information System and Expert system. The information system dynamically inferences the SWRL rules and displays the inferred ontological information about the coconut crop. Expert System provides advisory measures for user queries. But in the present paper one module namely, yield assessment module for estimating coconut yield has been developed using Cuckoo search optimization algorithm. The yield assessment system takes different input parameters that affect the yield of the coconut crop from the farmer and advices accordingly. In this module Coconut Ontology design, Inference Engine for Coconut Crop and Cuckoo Search Optimization algorithm(CSO) for Coconut crop are the major steps.

A. Coconut ontology design :

In coconut ontology design, The OWL file consists of one main class and seven sub-classes. Coconut is the main class and the sub-class of Coconut class are coconut varieties, diseases, pests, pesticides, fertilizers, Symptoms . For each sub-class there is a list of instances described with the object Property or data Property. Instances are related to property function. In Disease class there are again Seven instances.

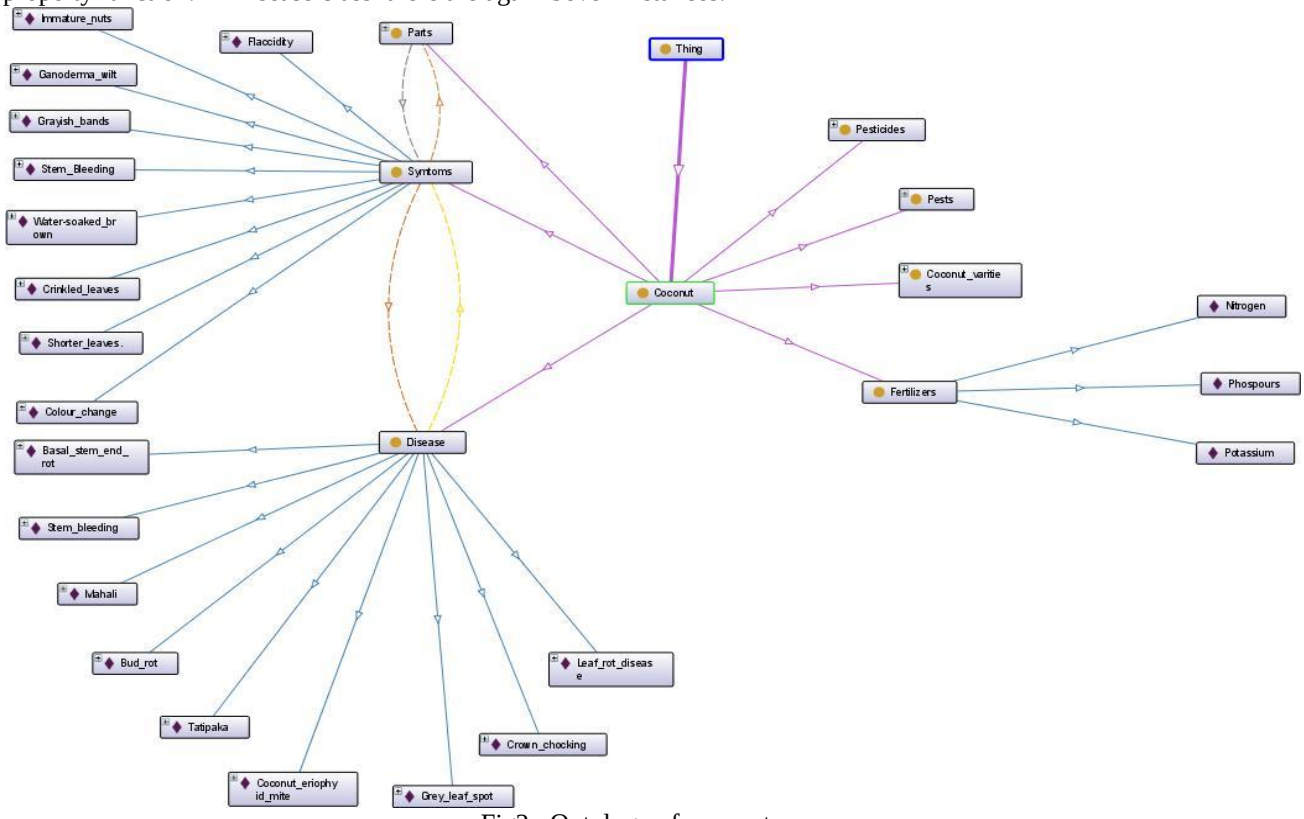

Fig2 : Ontology of coconut crop

For Example:

Disease → hassub-class → Coconut.
Disease → hasindividual → Basal stem end rot,
Disease → hasindividual→Bud rot,
Disease → has individual→ Coconut eriophyid etc.,

In a similar way, different instances for different sub-classes in this ontology are mentioned. Some relations between subclass are also established in order to interrelate the classes. The relations between subclasses are mentioned below:

Disease → isDiseaseof → Symptoms,
Symptoms → hasDisease → Disease
Pest → hasPesticide → Pesticide ----[3]

B. Inference Engine for Coconut Crop:

Inference engine follows the forward chaining mechanism while inferencing the knowledge contained in the knowledge base. First, it evaluates different conditions, if all the conditions return true. it reaches the goal. Pellet reasoner is an OWL DL reasoner for the Semantic Web. It supports full expressivity using SWRL rules.

Some sample SWRL rules are:

Rule1: List Symptoms: Part(?p) ∧ hasSymptom(?p, ?sym) → sqwrl:select(?p, ?sym)

Rule2: Nitrogen**:** Fertilizer(?f) ∧ hasName(?f,"Nitrogen") ∧ hasValue(?f, ?Val) → sqwrl:select(?p, ?val,).

Rule3: Water_Content: Part(?p) ∧ hasName(?p, "water") ∧ hasValue(?p, ?Val) ∧ result(?val, ?result) → sqwrl:select(?p, ?val, ?result).

Rule4: Yield: Croptype(?c)∧Water_Content(?w,?val) ∧pH(?p,?Val) ∧Sandy(?p,?val) ∧ organ_carbon(?p,?val) ∧ CEC(?p,?val) ∧ yield(?c,?val,result) → sqwrl:select(?y). ----[4]

*C. Cuckoo Search Optimization algorithm(CSO) for Coconut Crop***:**

In coconut crop yield estimation, first soil test is conducted to determine pH value, nitrogen, phosphorus, potassium, organic carbon, water content and then based on these values yield estimation is determined. Normal / standard values for the above attributes are collected using expert interface and are stored in the knowledge base. Cuckoo search optimization algorithms evaluate the yield based on user inputs given above and with the information stored in the knowledge base. The system compares the inputs with the existing values in the knowledge base and identifies the optimal or nearest optimal yield value using the steps mentioned in III (C) with the following interpretation:

1. Here nitrogen, phosphorus, potassium, pH values, organic carbon represents as an egg. corresponding input values will be the nest.
2. The best nest value is already specified in the knowledge base using expert interface.
3. In this work, we took □ □as variation between the expert value and user input values, $x_i^{(0)}$ initially mean yield, for each iteration x*i* value, will be updated. After completion of all iterations, the optimal value is taken as estimated yield value. s represents the range.

D. Environment:

Coconut expert system is developed using Java, JSP, Jena, Eclipse, NetBeans IDE. Ontology is developed using Stanford university tool protege4.3. To accesses data from ontology Jena API is used.

V. RESULT AND DISCUSSION

The results of the main modules namely coconut crop information System and yield assessment system of the proposed system are shown below.

A. Report 1: Information System- Displays the diseases Of crop and description of the diseases

The information system contains the information regarding coconut varieties, pests, diseases, fertilizers, symptoms, pesticides etc. The users access the requried information about the coconut crop from Information system interface.

Figure 3a: List of Diseases

Figure 3b: Disease description

Discussion:

Screen shot 3a displays the list of diseases of coconut that user can select a diseases. They are: leaf rot, Gray leaf spot, Tatipaka, Stem bleeding, Basal stem end rot, Mahali, Coconut eriophyid mite, crown chocking, Bud rot. Screen sho 3b is obtained when user selected the Gray leaf spot which is highlighted in the screenshot 3a. Disease description corresponding information about gray leaf spot is presented in screen shot 3b.

Screen Shot 3b consists of :

Description: completely dry leaf with spots.
isSymptomof: Leaf
Name: Gray_Leaf_Spot

B. Report 2: Advisory System- Yield assessment for coconut crop:

The Yield assessment module estimates yield of the coconut crop using the Cuckoo Search Optimization technique based on the coconut field characteristics like pH value of the soil, percentage of nutrients etc. supplied by the user. This module accepts the inputs from the users through Yield Assessment Interface and displays the estimated yield as well as the advices to improve the yield.

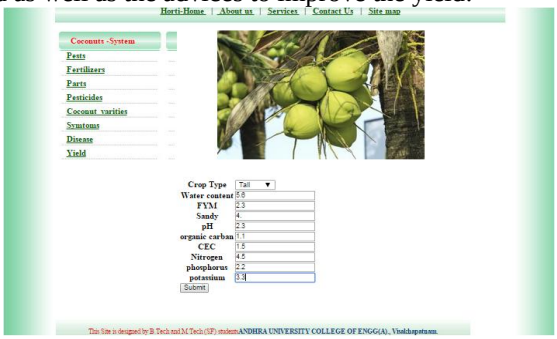

Figure 4a: Input values for yield calculation

Figure 4b: Result of yield

Discussion:

Screen shot 4a displays the input for the coconut yield assessment. They are crop type, water content, sandy, pH, organic carbon, Nitrogen, Phosphorus, potassium. These inputs are given as crop type= tall, water content= 5.6, sandy=4, pH= 2.3, organic carbon=1.1, Nitrogen=4.5, Phosphorus=2.2, Potassium=3.3. Screen shot 4b displays the estimated yield is 87 coconuts per tree.

VI. CONCLUSIONS

In this paper knowledge base is developed in a structured manner so that crop information may be dynamically updated by the expert whereas traditional systems knowledge engineer updates information periodically. The Coconut yield assessment module estimates the yield of the coconut crop using Cuckoo search optimization technique when the user enters relevant information after getting the soil test reports. The estimated crop yield is very nearer to the actual yield of the crop. Better estimation can be achieved by incorporating the better optimization techniques. The yield assessment system also suggests the remedial measures to enhance the yield of the coconut crop during the cultivation process. The system can be extended further by incorporating the modules to estimate the quality of the yield and coconut market.

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