# Semantic Web-based Turmeric Expert System using IWD Algorithm

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***Abstract*—** Semantic web is a structured way of re-usable data representation that can be used for inferring new knowledge. It provides a common data format for data representation. And it also provides semantics through structured information. Agriculture involves a vast variety of unstructured information. Normally agricultural experts, with their vast experience, provide critical advice in their farming activity. Machine learning algorithms acquire knowledge in the same manner as that of a human expert acquires knowledge with experience. In the present paper, an expert advisory system is simulated using machine learning algorithm for providing expert advice to the end users. A critical study is conducted for understanding the semantic web stack and an attempt has been made to design and develop an expert system namely, "Semantic Web-based Turmeric Expert System using IWD Algorithm". The proposed system has two modules namely, expert advice module and information system module. The Advisory system takes certain details from the end users, regarding their crop and provides the suitable advice. In the present paper, only yield assessment module was considered. Yield estimation system uses Intelligent Water Drops (IWD) algorithm to estimate the yield for each crop variety. Information system provides information about Turmeric crop varieties, parts, pests, pesticides, symptoms and diseases. Protégé is used to develop Ontology. JENA framework is used to retrieve information from Ontology. SWRL rules are implemented to infer rules from the data.

***Keywords*-** *Turmeric, Semantic Web, Machine Learning, Intelligent Water Drops, SWRL, JENA.*

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## I. INTRODUCTION

At present web contains huge data. Data representation is dependent on the data model used for a particular application. Data reusability can be achieved by providing a common structure for the data. Semantic Web is an extension of the current World Wide Web, in which a layered structure is used data representation, provides information with a well defined meaning.

In semantic web, each resource is represented with Uniform Resource Identifiers (URI) and Extensible Mark-up Language (XML) provides a structured view for the URI's and facilitates to interchange the data over the web. Resource Description Framework (RDF) provides a triple (Subject, verb, Object) format for XML data and extends the relations of the Web to use URIs to name the relationship between things as well as the two ends of the link. Using this model, it allows structured and semi-structured data to be mixed and shared across different applications. This linking structure forms a directed graph, where the edges represent the relationship between two resources denoted by the nodes of the graph.

RDFS consists of set of vocabulary terms, classes and certain properties which provide basic elements for the ontology. Here vocabulary specifically refers to the single meaning of the triple body. These vocabularies are stored in the RDF schema namespace so that other RDF schema vocabularies may reuse. Ontology represents complex knowledge about subjects, group of subjects and relations between these subjects. Web Ontology Language (OWL) is used to develop an Ontology. Protégé tool provides the framework to build Ontologies. It provides a flexible environment for application development.

Knowledge of agricultural data in present web is vast and unstructured. In order to take decisions in farming a past knowledge or experience is desirable. In the literature computer based expert systems in agriculture are appearing since 1997[12]. In the present paper a Semantic Web-based Turmeric Expert system is developed to represent data in structured format so that information retrieval and re-usability could achieved. In this system inference may be done by using SWRL rules and a machine learning algorithm is used to assess the yield of a crop. Yield assessment is done based on the important parameters like variety, soil type, no of diseases effected the crop and plant information etc. This system is developed by using java. The main of this work is to give the possible solution to the users and data re-usability.

## II. LITERATURE SURVEY

Tim Berners Lee, et al(2001) [1] introduced the Concept of Semantic Web and proposed new technologies like XML, RDF and Ontologies to provide well-defined meaning to the links of a web document. Ian Horrocks, et al. [3] proposed Semantic web Rule Language (SWRL) based on a combination of OWL Lite and OWL DL. Wei Yuanyuan, et al. [6] interdicted agricultural intelligent information system using ontology's, and explains mapping knowledge levels to the ontology levels. M. Surendra Prasad Babu et al, [2] proposed garlic expert system using ABC algorithm. This paper specifies how bees allocated to the agricultural Expert system. Prof. M. S. Prasad Babu, et al [4] designed a Web-Based Soya Bean Expert System Using Bagging Algorithm with C4.5 Decision trees. M.S Prasad Babu, et al [5], Development a Maize Expert System Using Ada-Boost Algorithm and Naive Bayesian Classifier, this approach explains how to apply rules to the data. Hamed Shah_Hosseini

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[7] proposed swarm based Intelligent Water Drops Algorithm inspired by a natural river system. And he tested this algorithm with standard TSP problem.

## III. DESIGNING OF SEMANTIC WEB-BASED EXPERT SYSTEM

The proposed architecture is given in figure1. The present system has two interfaces namely, (1) Farmer interface, (2) Expert interface. Farmer Interface consists the details of Turmeric crop such as Varieties, Diseases, Pests etc. This information is available in OWL file and gets data dynamically fetched from file. Expert Interface is used to organize knowledge base. Turmeric ontology design, Intelligent Water Drops (IWD) is used to estimate Yield. The Details of each component are described here under.

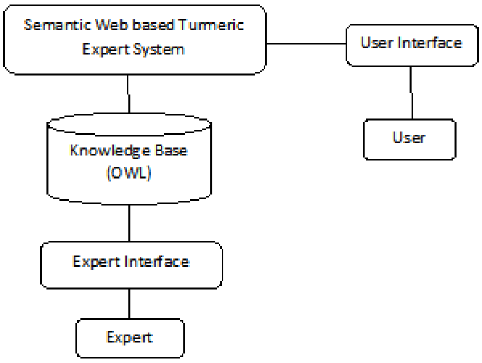


Fig. 1 System Architecture

### *A. Semantic Web-based Expert System*

This system contains inference engine, and Yield assessment system. Semantic Web Rule Language (SWRL) is used to infer knowledge from data.

#### *1. 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.

#### *2. IWD Algorithm*

IWD is a swarm based optimization technique [7]. This algorithm was developed based on the behaviour of Natural River water drops. A natural river often finds good paths among lots of possible paths in its ways. How the water drops are obtaining optimal path or near optimal path is taken in this algorithm. Every water drop flows in the environment with two properties.

- The amount of soil carries now, Soil
- The velocity that water drop movies with, Velocity

The environment depends on the problem specification. Velocity of the water drop is an inverse proposition to gain soil in the path. If the velocity is high, then the amount of soil added is less. If velocity is a low amount of soil will be added as high. The water drop which is having a high velocity at the end that water drop travelled path is optimal or nearly optimal path. If we know the position of the destination, the goal is to find the best path from the source to the destination. The IWD algorithm gets a representation of the problem in the form of a graph (N, E) with the node set N and edge set E. Then, each IWD begins constructing its solution gradually by travelling on the nodes of the graph along the edges of the graph until the IWD finally completes its solution.

One iteration of the algorithm is complete when all IWDs have completed their solutions. After each iteration the iteration best solution velocity $Vel_i$ is found and it is used to update the best solution Yield. Then, the algorithm begins another iteration with new IWDs but with the same soils on the paths of the graph and the whole process is repeated. The algorithm stops when it reaches the maximum number of iterations itermax. The IWD algorithm has two kinds of parameters. One kind is those that remain constant during the lifetime of the algorithm and they are called ‘static parameters’. The other kind is those parameters of the algorithm, which are dynamic and they are reinitialized after each iteration of the algorithm.

The algorithm of IWD specified in the Follw1ing steps:
Step1: Initially the velocity refers the quality. InitVal=∞.the maximum no of iterations IMAX is specified by the user. The iteration count x is set 0. InitSoil=0.1, soil(i,j)=InitSoil. The number of water drops NIWD is set to a positive integer value, which is usually set to the number of nodes Nc of the graph. For velocity updating, the parameters are av =1, bv =0.01 and cv = 1. For soil updating, as =1, bs =0.01. The local soil updating parameter ρn=0.9, which is a small positive number less than one. The global soil updating parameter ρIWD=0.9, which is chosen from [0, 1].
2. Every IWD has a visited node list Vc(IWD), which is initially empty: Vc(IWD)= . Each IWDs velocity is set to InitVel.
3. Spread the IWDs randomly on the nodes of the graph as their first visited nodes.
4. Update the visited node list of each IWD to include the nodes just visited.
5. Repeat Steps 5.1 to 5.4 for those IWDs with partial solutions.
5.1 For the IWD residing in node i, choose the next node j, which does not violate any constraints of the problem and is not in the visited node list Vc (IWD) of the IWD, using the following probability

$$p_i^{IWD}(j) = \frac{f(soil(i,j))}{\sum_{k \notin vc(IWD)} f(soil(i,k))} \qquad (1)$$

Such that

$$f(soil(i,j)) = \frac{1}{\varepsilon_s + g(soil(i,j))} \qquad (2)$$

K++;
And

$$g(soil(i,j)) = \begin{cases} soil(i,j) & if \ \min_{l \notin vc(IWD)}(soil(i,l)) \geq 0 \\ soil(i,j) - \min_{l \notin vc(IWD)}(soil(i,l)) & else \end{cases} \qquad (3)$$

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5.2 For each IWD moving from Node i to j update $\Delta Soil(i,j)$ with following formula

$$\Delta Soil(i,j) = \frac{as}{bs+cs-(av(j)-uv(j))} \quad (4)$$

cs= max(av(j)-uv(j))

5.3 Update the soil (i, j) of the path from node i to node j

$$soil(i,j)= (1- \rho_n)*soil_{IWD}-\rho_n*\Delta soil(i,j) \quad (5)$$

$$soil_{IWD} = soil_{IWD} + \Delta soil(i,j) \quad (6)$$

5.4 calculate the velocity for IWD from node i to node j

$$Vel_i(t+1)=Vel_i(t)+\frac{a_v*c_i}{c_v*soil_i} \quad (7)$$

6. Update the best solution BS with following formula

$$BS= Vel_i(t) \quad (8)$$

7. Update the best solution using following formula

$$TBS=\begin{cases} BS & if\ BS > TBS \\ TBS & esle \end{cases} \quad (9)$$

8. Increment the iteration number by Itercount = Itercount + 1. Then, go to Step 2 if Itercount < Itermax.
9. The algorithm stops here with the total-best solution TTB.

### B. Knowledge Base

The Knowledge base represents the information about Turmeric crop. Information is collected from experts and knowledge base is designed using Web Ontology Language (OWL) [17]. Ontology is key component of Semantic Web. OWL file is created with Protégé Framework. Ontology follows the class hierarchy. Everything in Semantic web is "thing". In ontology "thing" is a super class. Relations specified between classes or attributes.

## IV. DEVELOPMENT OF SEMANTIC WEB-BASED TURMERIC EXPERT SYSTEM

Semantic web-based Turmeric 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 Turmeric crop. Expert System provides advisory measures for user queries. But in the present paper one module namely, yield assessment module for estimating turmeric yield has been developed using Intelligent Water Drops algorithm. The yield assessment system takes different input parameters that affect the yield of the turmeric crop from the farmer and advices accordingly. In this paper implementation of knowledge base and Turmeric expert system is done.

### A. Development of Knowledge Base

Ontology development in Semantic Web is a process of classifying data by representing in classes and properties [18]. Parts, Symptoms, Diseases Fertilizers, Pests, Pesticides, Fertilizers, Soil_types, Land_Proerties and Plant_Properties classes represent concepts in a domain while growsFrom, hasPesticide and hasSymptom properties represent relations between these concepts or attributes of classes. Each relationship holds their inverse relationships. It also contains some extra information about properties and restriction on these property values. Concepts help to understand the domain and the classification of data while properties help to find the relation between different parts of data. The properties that are defined as attributes are used during data retrieval. Fig 2 shows the overall class hierarchy.

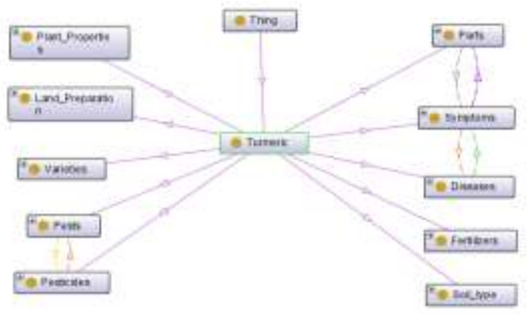


Fig. 2 OWL file class hierarchy

### B. Development of Semantic Web based Turmeric Expert Systemg

In this system SWRL rules are used to infer knowledge from knowledge base. This system provides expert advice to the farmers. Yield estimation is done in two ways. One is considering soil type, and crop information (variety, number of leafs, length of the plant, width of the leaf, planting distance). Another way is by considering soil type, crop variety, planting month and land permeability. These modules are done by using IWD algorithm. To retrieve the data from OWL file Apache Jena Framework has been used. It provides API to extract data from and write to RDF graphs.

*1. SWRL Rules/Inference Engine:* The engine inference paradigm is the search strategy that is used to develop required knowledge. Rules are defining new things that can be inferred from existing dataset. Some inferences can be done from the ontology model itself. 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. Following rules are implemented in this system.

- Rule for List of Symptoms: Part(?p) ∧Symptom(?p,?sym) → sqwrl:select(?p,?sym)
- Rule for List Symptoms of Leaf_Spot: Parts(?p) ∧ Symptom(?p, Leaf_Spot) ∧ isSymptomOf(?p, ?Symp) → sqwrl:select(?p, ?Symp)
- Rule for Root diseases : Parts(?p) ∧ name(?p, "Root") ∧ hasSymptom(?s, ?symp) ∧ growsInto(?symp, ?grow) → sqwrl:select(?p, ?symp, ?grow)

*2. IWD Algorithm:* In the Turmeric yield calculation, first field test id conducted to determine crop variety, diseases that affected the crop length of the leaf, width of the leaf, distance between plants row and column wise. For crop and soil matching advisory system crop verity, soil variety, planting month and soil permeability values are needed. These fields are taken as $uv_i$ in algorithm. Corresponding values in ontology takes as $av_i$. For crop and soil matching advisory system $uv_i$ =0 if i corresponding to diseases

IWD algorithm is used in back tracking approach. And Soil value is 0.In this expert system mean yield [20] is initVal for water drop and corresponding soil values will be updated from Knowledge Base. BS and TBS are initially 0. To travel current position to next position j value will be calculated using Equation 1.When water drop is travelled in specified path water drop gains some amount of soli and velocity value varies based on the soil amount added or decreased. The final velocity is the estimated Yield. For each user input Δsoil is calculated using Equation 5 where as=10, bs=.01, $av_i$ is taken from OWL file and $uv_i$ is input value. The total soil carried by water drop till now is updated using Equation 6 and vel(i,j) is updated using Equation 7. If any path remains unvisited then this process will continue else it updates best solution using Equation 8 &9, and the whole process is done for every water drop. The flow chart of the proposed IWD algorithm is fig.3.

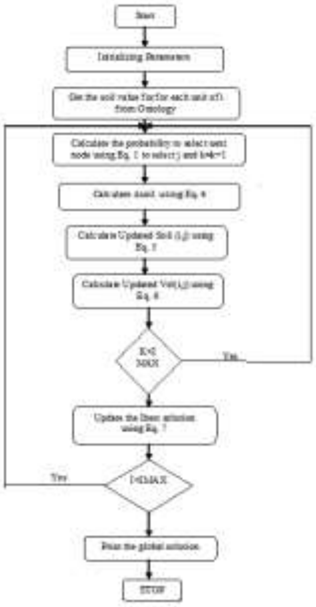

Fig. 3 Flow chart of the proposed IWD Algorithm

## V. RESULTS AND DISCUSSIONS

In this section the results of the information system and yield assessment system of the Turmeric crop, which are two main modules of the proposed system are shown..

*A. Information System*

*Report1:* Semantic web based Information System

The users of the proposed system access the details relating to turmeric crop such as varieties, plantation methods, possible diseases and symptoms etc. through information system interface.


Fig 4. Information System for Turmeric Crop.

Description:. The Symptoms listed are Hard Rizomes, Root Infection, Drying along Margins, Leaf Spot, and Yellow Leaves

*B. Yield Assessment System*

*Report 2:* The main part of the proposed system is to estimate the yield of turmeric field based on the essential factors that influence the yield and quality of the turmeric, like soil characteristics, leaf width and length, number of leaves, and distance between the plants etc. The users who wish to know the yield of their turmeric field need to enter the above mentioned characteristics as shown in the following screen shot..

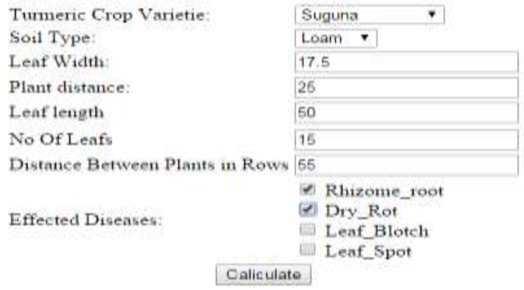


Fig. 5.a User Interface for Yield assessment System

*Discussion:* The screen contains the inputs of the Turmeric yield assessment are Variety, soil type, leaf length, leaf width, no of Leafs, plant distance, distance between rows, and disease effected the Turmeric crop. The inputs are given as Crop type: Suguna, Soil Tye: Loam, Leaf width: 17.5, Plant distance: 25. Leaf Length: 50, No of Leafs: 15, distance between plants in Rows: 55, Effected Diseases: Rizome_root, Dry_Rot.

*Report 3:* Yield Assessment system estimates the yield based on the input characteristics using IWD algorithm and presents the expected yield to the users through yield assessment interface as shown below.


Fig. 5.b Yield Output

*Discussion:* The screen displays the target yield of Turmeric Crop. Estimated Yield: 30.176 T/ ha

## VI. CONCLUSIONS AND FUTURE SCOPE

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 turmeric yield assessment module estimates the yield of the turmeric crop using Intelligent Water Drop optimization technique when the user enters relevant information. 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 turmeric crop during the cultivation process. The system can be extended further by incorporating the modules to estimate the quality of the yield, market price etc.

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