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Research Article

DEVELOPMENT OF COTTON CROP ONTOLOGY: A CONCEPTUAL AND CONTEXT APPROACH

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A B S T R A C T

The Farming generally relies on techniques to promote cultivation and maintain the lands suitable for domesticated species. Farmers have many questions regarding the type of soil/climate for a particular crop, type of pests within crop, different diseases, timelines associated with each activity related to crop. So for handling such queries we need two things:

1) Knowledge based system to convert the queries from farmers which may be in non understandable form to an understandable form. This knowledge based system is called Ontology which is the key element for this project.

2) Searching mechanism which will perform search on the reformed query and display the list of matched documents.

This project is focused on building ontology that will be consumed by such a system, which takes input query from farmer, search database as well as ontology and displays the list of matched documents through which farmer can get enough information on the query he raised.

INTRODUCTION

The intent of developing an Agro-Advisory System developed from the idea of designing an expert system for farmers to pose their queries to the system and getting the best solutions to their problems.

Farmers express their queries in a natural language which are usually answered by human experts. It is desired to enable the data or knowledge captured in the system to understand the query as exactly as farmers see and ask questions. Hence a need arises for developing a knowledge-based system which captures significant aspects of the reality that farmers are likely to mention, that is, answer to the queries dealing with what farmers mean, not what farmers say.

Queries over the system can be defined to be of two categories. One is described as queries over the databases. The other category is the queries over knowledge bases. Database applications are the applications which help in retrieving information from a relational database and queries over the database facilitates this. One such application which helps users in extracting information from the database without having knowledge of it is BANKS [18]. It is a system which enables keyword-based search on relational databases, together with data and schema browsing.

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BANKS enables users to extract information in a simple manner without any knowledge of the schema or any need for writing complex queries.

Knowledge-based applications on the other hand are applications which require retrieving information from a knowledge based like ontology. They are developed on the domain knowledge of a system and require understanding and answering of the queries over it. Query posed by the user should not restrict him to the domain knowledge and rather should provide him the ease of querying it as a natural language keyword query. It should enable the user to query the system without worrying about the domain knowledge of it.

Agro-Advisory system needs to be a flexible querying system which allows users to give the flexibility of querying the system as they like. It basically encourages keyword based query where user enters his query in simple keywords which is interpreted and analyzed by the system and advices the farmer based on its context and severity.

Agro-Advisory System [8] is a query-answering support for farmers, which is nothing but an ontology based knowledge system. Knowledge acquisition is done with the aid of Agro experts. Farmers encounter many questions on these cropping systems depending on climate, diseases on crops, pests, preventions, timelines of various activities etc. To handle these queries, the old procedure was to collect the questions from farmers and record these questions, then search for the answers to these questions manually from documents provided by

agricultural experts. Sometimes lack of experts and their expertise creates problem, so we choose expert system approach to solve this problem.

Ontology is defined as generic ontology and specific ontology. Generic ontology gives details of the practices of any crop. Basically it defines the classes of the ontology and the relations existing between them. It explains how any two classes are related with the properties. Crop ontology is a generic ontology. Specific ontology is the ontology built over the generic ontology and defines the instances of the ontology classes related by properties defined by the generic ontology. Cotton ontology is a specific ontology.

Research Motivation

Agricultural has an important role in Indian Economy. About 70% population who lives in rural is doing agricultural activities. In order to help farmers and handling other agricultural issues related to Cotton Crop, we are proposing a system having concept-based search for knowledge navigation, inferencing or reasoning capability. Agropedia Indica initiated to incorporate intelligent services with the usage of semantic technologies for agricultural related information.

The objective of my project is to make Knowledge repository of Knowledge models for various farmers needing information about crop, pests, diseases, climates, timelines and associated timelines with various activities involved for Cotton Crop. The key element for this system is

Knowledge Model (KM):-It is designed mainly to browse agricultural knowledge and structure the agricultural content. KMs are the structural representation of knowledge that uses different symbols to depict different pieces of knowledge and relationships between them. KM for cotton crop basically aims to represent more in detail about the information related to local fertilizers, soil, cropping techniques and methods, etc. After that applying this Ontology (Knowledge Model) to Information Retrieval Mechanism.

Ontology Search Problem: The search problem describes answering a user query by performing a keyword search over the ontology. Result of this search is the optimal path which maximum explains what the user has queried for. Examples of few queries which can be answered are:

- Symptoms of cotton leaf curl disease
- Drying of leaves and color changing to red. What is the disease?
- Cure of blight disease in Cotton

LITERATURE SURVEY

This research topic focused on Cotton Crop ontology development. Mainly, the reviewed literature is divided in two sub parts Cotton Crop Production Practices and Ontology.

Ontology has been developed in the artificial intelligence community to describe a variety of domains, and has been suggested as a mechanism to provide applications with domain knowledge and to facilitate the sharing of information [2] . Ontology is a formal, explicit specification of a shared conceptualization [5]. A conceptualization of some phenomenon in the world identifies and determines the relevant concepts and the relations of that phenomenon. Ontology is typically defined as an abstract model of a domain of interest with a formal semantics in the sense that they constitute a logical theory. These models are supposed to represent a shared conceptualization of a domain as they are assumed to reflect the agreement of a certain community or group of people. In the simplest case, ontology consist of a set of concepts or classes which are relevant for the domain of interest as well as a set of relations defined on these concepts. Ontology is a kind of concept model that could describe system at the level of semantic knowledge as agreed by a community of people. It serves as semantic reference for users or applications that accept to align their interpretation of the semantics of their data to the interpretation stored in the ontology [6]. As a new kind of knowledge organization tool, ontology has attracted more and more attention.

Ontology has been widely used in many fields, such as knowledge representation, knowledge sharing, knowledge integration, knowledge reuse, information retrieval, and so on. Hence the development of ontology is seriously impeded [5]. In the field of knowledge engineering, different scholars give different definitions of ontology according to the content of ontology, the form of ontology or the purpose of ontology [7]. Different types of ontology may exist, ranging from sophisticated dictionaries to rich conceptual and formal descriptions of concepts with their relationships and constraints. N. F. Noy and D. L. McGuiness in [8] describe the need for ontology as:

1. To share common understanding of the structure of information among people or software agents.
2. To enable reuse of domain knowledge.
3. To make domain assumptions explicit.
4. To separate domain knowledge from the operational knowledge.
5. To analyze domain knowledge.

Ontology development process is an iterative process that will continue in the entire life cycle of the Ontology. The basic steps for building Ontology are:

1. Determine the domain and scope of the ontology.
2. Consider reusing existing ontology.
3. Enumerate important terms in the ontology.
4. Define the classes and the class hierarchy.
5. Define the properties of classes-slots.
6. Define the facets of the slots.
7. Create Instances.

When ontology is applied to specific field, it refers as domain ontology and is the specification of a particular domain conceptualization. Ontology together with a set of individual instances of classes constitutes a knowledge base. In reality, there is a fine line where the ontology ends and the knowledge base begins. We have proposed Cotton Crop ontology based mining which uses the ontology structure as an essential part of the feature extraction process by taking relationship between concepts.

Cotton Crop Production Practices

We have extracted and summarized knowledge related to various cotton production practices which will be useful for farmers in future. It has several classification quantities, listed below, based on production practices, characteristic, symptoms, timelines etc.

Soil:-Cotton has a wide range of soil adaptation and is grown on a wide range of soils. Highest yield of cotton is usually

obtained on Loamy and Sandy Loam soils under irrigated conditions.

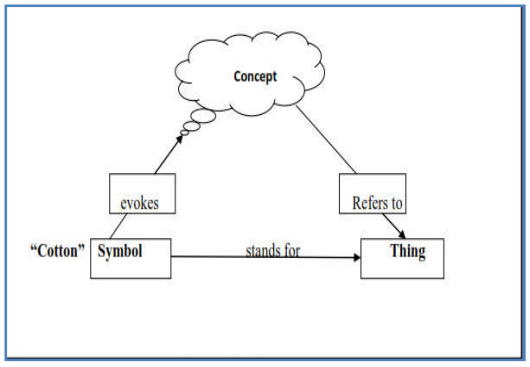

Figure 1 Triangle of Communication

Morphology and Growth Stages:-Cotton plant is characterized by different parts namely Roots, Leaves, Boll, Stem, Seedling etc. The symptoms observed on cotton plant are part dependent so as to predict disease, causing pests and respective measures.

The growth stages of cotton plant are divided into 2 partitions i.e. Early and Later. Early stage comprises of Pre Sowing, Sowing, Early Fruiting and Vegetative Growth Stages; Later stage comprises of Reproductive and Maturity stages. Diseases within crop are dependent on stages at which it occurs.

Varieties:-The cotton varieties grown in Punjab belong to three distinct species, namely Gossypium hirsutum (American cotton), Gossypium arboreum and Gossypium herbaceum (Desi cotton).

Diseases:-Cotton Diseases are classified on the basis of infective organisms or inherent defects of the plant. Diseases are broadly classified as Bacterial, Viral, Fungal and Physiological disorder including Bacterial Blight, Leaf Curl Virus Disease, Anthracnose, Grew Mildew, Leaf Blight, Root Rot, Parawilt and Tirak .

Pests:-Cotton is the main crop during kharif season and is infested by about 134 insect and mite species in the country. Pests are broadly classified as Sucking Pests, Bollworms, Folliage Feeders, Stainers including Jassids, Aphids, Thrips, Whitefly, American Bollworms, Pink Bollworms, Spotted Bollworms, Red Cotton Bug and Spider Mite. Of the listed five viz. jassid whitefly, spotted /spiny bollworms, American bollworms and Pink bollworm are severe threats responsible for about 30 to 40 percent yield loss or even more in the cotton production in certain years.

Activities:-Timelines related to various activities involved in Cotton Production are taken into account for proper management and good yield. Apart from this frequency; amount of spraying of insecticides, fertilizers etc. For example:

Time of sowing:-Cotton is grown in Kharif season in the State. Time of sowing spread over a period of April to first fortnight of June. However, in case of American cotton optimum time of sowing is May for better yields. Delay in sowing results in yield reduction.

Method of Sowing:-Before sowing seeds should be dipped in water upto 5-6 hours for better germination. Sowing in 4-5 cm depth. Seeds treated with 5 gm Emission, 1 gm streptocyclin and 1 gm succinic acid in 10 litres of water. Seed treated with carbendazim @2 gm /kg in the root rot affected areas.

Seed treated with Imidacloprid @ 7.5 gm / kg seed to escape the crops from sucking pests upto 40-60 days.

Ontology and knowledge management

Ontology is an explicit specification of a conceptualization, where a conceptualization is an abstract, simplified view of the world that we want to represent for some purpose (Gruber, 1992). Concept is a thought or notion. Ogden and Richards (1923) said that the three components for communication are concept, symbol, and thing, as indicated by the Meaning Triangle below:

Ontologies are organized in hierarchical structures: a set of concepts describing a domain serving as skeleton foundation for a knowledge base.

Ontologies is considered as conceptual schemata, intended to represent knowledge in the most formal way. Formal ontologies are represented in logical formalisms, such as Web Ontology Language (OWL), which allow automatic inferencing over them.

In the context of database systems, ontology is viewed as a level of abstraction of data models with an intention to model knowledge about individuals, their attributes, and their relationships to other individuals. Ontologies are said to be at the "semantic" level, whereas database schema are models of data at the "logical" or "physical" level.

Types of Ontology

Ontologies are typically classified depending on the general conceptualization behind them, their coverage, and intended purpose (Davies, 2006):

1. Upper-level ontologies represent a generic model of the world, suitable for large variety of tasks, domains, and application areas.
2. Domain ontologies represent a conceptualization of a specific domain, for example Pests, Diseases of Cotton Crop.
3. Application and task ontologies are such suitable for specific ranges of application and tasks.

Components of Ontology

Gruber (1993) identified five kinds of ontology components: classes, relations, functions, formal axioms and instances.

1. Classes represent concepts, which can be considered generic entities.
2. Relations represent a type of association between concepts of the domain.
3. Functions are a special case of relations.
4. Formal axioms serve to model sentences that are always true. They are normally coherent description between Concepts/ Properties/Relationships ia logical expressions.
5. Instances are used to represent elements or individuals in an ontology. An ontology can be characterized as comprising of four tuples :O= <C,R,I,A.>

C is a set of classes representing concepts we wish to reason about in the given domain, such as: Pests, Diseases, Prevention, and Observations etc.

R is a set of relations holding between those classes, such as: relation 'Harmed_By'

I is a set of instances, where each instance can be an instance of one or more classes and can be linked to other instances by relations, such as: Angular, Red, Bacterial_Blight etc.

A is set of axioms, such as: if plant‘s leaves turns yellow to brown causing defoliation, spray Carbendazim (1g).

Ontology building process

Ontology building is a process that aims at producing an ontology. The Methodology to produce it includes various stages like specification, conceptualization, formalization, implementation, and maintenance.

Specification:- Identify the purpose and scope of the ontology. The purpose is obtained by answering the question -Why is the ontology being built? and the scope is obtained by answering the question-What are its intended uses and end users?

Knowledge acquisition:-Acquire knowledge about the subject either by using elicitation techniques on domain experts or by referring to relevant bibliography. Several techniques can be used to acquire knowledge, such as brainstorming, interviews, questionnaires and text analysis.

Conceptualization:- Structure a conceptual model that describes ontology to be built, so that it meets the specification found in the previous step. The conceptual model of an ontology consists of concepts in the domain and relationships among those concepts. Concepts can be organized with a class hierarchy, including super classes and subclasses concept. Relationships between concepts can be grouped in two main groups: hierarchical relationships and associative relationships. Hierarchical relationship identifies the hierarchy between superclasses, subclasses. Associative relationship connects concepts which are not in the same hierarchy. A generic ontology structure model can be represented as indicated by the pictures below:

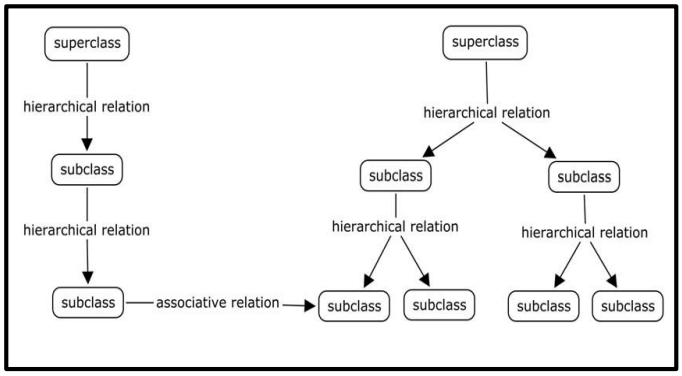

Figure 2 Ontology Structure Model

Formalization:-Transform the conceptual description into a formal model, that is, the description of the domain found in the previous step is written in a more formal way, although not yet its final form. Concepts are usually defined through axioms that restrict the possible interpretations for the meaning of those concepts. Concepts are usually hierarchically organized through a structuring relation.

Implementation:-Implement the formalized ontology in a knowledge representation language. For that, one chooses a representation language and writes the formal model in the representation language (OWL) using the representation ontology.

Evaluation:-Process of technically judging the quality of the ontology.

Documentation:-Report what was done, how it was done and why it was done. Documentation associated with the terms represented in the ontology is particularly important, not only to improve its clarity, but also to facilitate maintenance, use and reuse.

Maintenance:-Updation and correction of the implemented ontology. Three basic approaches to construct Ontology, namely;

a. Manually-driven by domain-experts: This approach relies totally on experts of the area. The experts will set the rules and concepts and sort of relationships based upon experts knowledge and experience of the knowledge domain.
b. Automatic approach: This approach will construct ontology by using a computer program, whereas the program will be produced according to rules and conditions posed by developer with the help of experts and the computer.
c. Semi-automatic approach: This approach also uses computer program but the ontology builder will have product‘s accuracy and rules verified and confirmed by expert who created the rules.

Cotton Crop Ontology Development

Agro Ontology is basically Formal, Explicit specification of a Shared Conceptualization wherein Formal means machine-understandable; explicit specification means concepts, properties, functions axioms are explicitly defined; Shared means Consensual Knowledge and finally Conceptualization means abstract model of some phenomenon in real world. Developing and ontology is a complex task that requires a high degree of analytical and abstract thinking.

Knowledge Resources:-All of the knowledge resources used for developing the Cotton Crop ontology can be described as follows:

Domain specific knowledge materials

1. Cotton (Kharif) Crop production and related subject textbooks.
2. Farmers data (past records & current data)–As relational database
3. General ontology construction guideline
4. Related relationship schemes.
5. Cotton Information Hub

Tools and Applications

1. Protégé-OWL ontology editor and knowledge-base framework.
2. Cmap Tools version 4.08 COE
3. Oracle 11g database management for Cotton Database.
4. Jena Adapter for Oracle Database
5. Eclipse IDE

Equipments

1. Computers servers
2. Computer for processing

Ontology Implementation Language

They are several semantic languages that have been used in the semantic web applications.

Resource Description Framework Schema (RDFS):-It is a semantic extension of RDF which is vocabulary description language. It provides mechanisms for describing groups of related resources and the relationships between these resources. These resources are used to determine characteristics of other resources, such as the domains and ranges of properties.RDF differs from many such systems in that instead of defining a class in terms of the properties its instances may have, the RDFS which describes properties in terms of the classes of resource to which they apply.

DARPA Agent Markup Language (DAML):-It is a simple language for expressing more sophisticated RDF class definitions than permitted by RDFS. After some efforts the DAML group came up with Ontology Inference Layer (OIL), providing more sophisticated classification, using constructs from frame-based AI. The result of these efforts is DAML+OIL, a language for expressing more sophistication in classifications and properties of resources than RDFS.

Web Ontology Language (OWL):-It extends RDF and RDFS, and added more vocabulary. Earlier XML provided a surface syntax for structured documents and didn't imposed semantic constraints and after that XML Schema which is the language for restricting the structure of XML document and also extends XML with data types. But the primary aim of OWL is to bring the expressive and reasoning power of description logic to the semantic web.

We have decided to use OWL (Web Ontology Language) as it is a W3C recommended language for semantic-based systems. Also, we have seen that OWL supports processing with many available APIs (Jena, Protégé, Sesame, Swoop, etc.) and permits easy data transfer, reuse and hence ontology mapping and linking.

Three Variants of OWL

1. ***OWL Full :-***An extension of RDF Allows for classes as instances, modification of RDF and OWL vocabularies
2. ***OWL DL:-***The part of OWL Full that fits in the Description Logic framework known to have decidable reasoning.
3. ***OWL Lite:-***It is a subset of OWL DL. It is Easier for frame-based tools to transition to. It is easier reasoning.

Components of OWL

Individuals:-Individuals are also known as instances. Individuals can be referred to as being instances of class.

Properties:-Properties are roughly equivalent to slots. They are also known as roles in description logics and relations in UML and other object oriented notions and attributes in other formalisms.

Classes:-The word concept is sometimes used in place of class.Classes are concrete representations of concepts.

RESULTS

Information about the cotton crop represented as ontology completely describes the practices and farming techniques for cotton. It gives complete information on good and bad practices of cotton. The concepts which have been elaborated for cotton are the soil and climatic conditions for cotton; recommended varieties of cotton which can be location specific; disease affecting the crop, reasons for their occurrence, their symptoms shown, and cure for those diseases; similarly information on pests attacking the crop, their precautions and cure. The ontology also contains knowledge concepts on the various activities of farming, like, hoeing, sowing, irrigation, fertilizing, spraying and harvesting, along with their timelines.

In order to make the cotton ontology, two tools were explored. Initially we used Cmap Tool to structure the ontology but It needed to explicitly import the ontology and export it when finished. But, it does not support the consistency checking. Due to some problems with Cmap we switched to Protégé Ontology Editor to capture conceptual and relational domain knowledge as ontologies. The Protégé is an Open Source, java based and extendible framework. It supports lot of plug-ins like Jambalaya, Data Master, OWLViz etc. which adds extra functionalities. It also exports ontology in many formats (RDFS, OWL).

The system is using crop pest ontology as a knowledge base. The constructed crop ontology is shown in Fig.2 The concepts with its name are represented with rectangle. We have used different types of concepts such as Pest, Insecticide, Pesticide, Disease, Cultivation, sowing, Irrigation, Fertilizer, Cropping system, Postharvest Process, Climate etc. We have used protégé tool for constructing ontology. To collect information regarding cotton farming practices we have refereed various resources such as handbook of cotton [13], agropedia [12], and website for Central Institute for Cotton Research (CISR), etc.

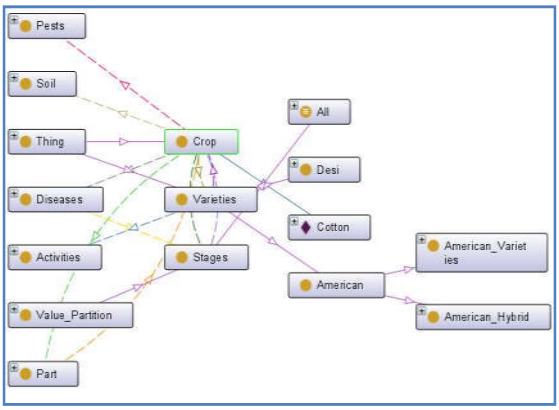

Figure 3 Snapshot of Crop Ontology Concepts

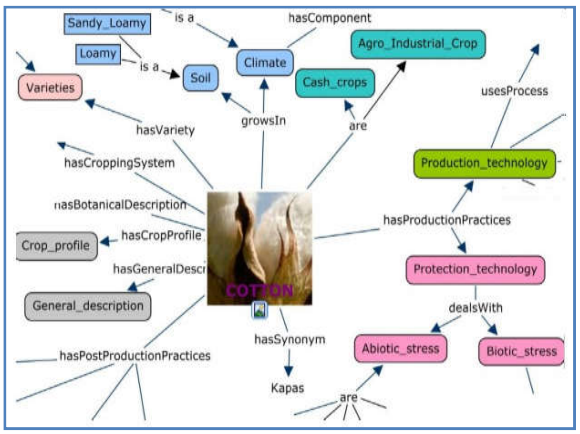

Figure 3 Snapshot of Cotton Ontology Concepts

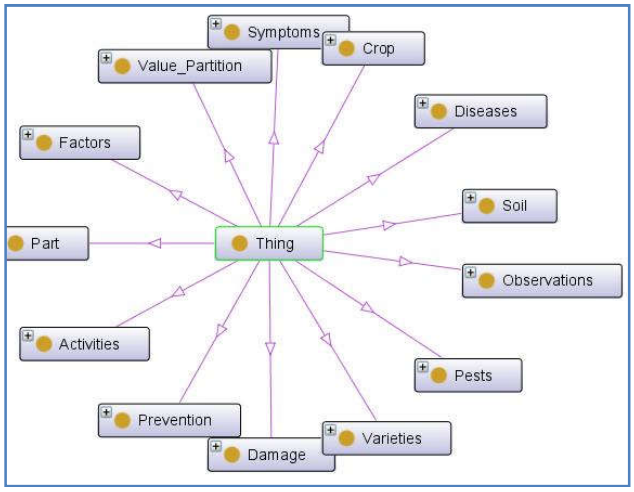

Figure 4 Snapshot of Cotton Ontology Concepts

The cotton ontology shown in Fig 3 and Fig 4.The cotton ontology stores the information about the varieties of cotton crop such as desi cotto,bt cotton etc and different types of soil such as loamy,sandy loamy soil where the farmers can get more yield of cotton. It also stores the information about the climate condition which affects the cotton crop.

There are different kinds of pest affecting cotton crop in India. The dangers of cotton pests in cotton production process have been a more prominent issue, seriously affecting the cotton production. In order to effectively diagnose and control pests we have carried out many different aspects of studies and explorations.

The pest ontology for cotton crop shown in Fig 5.The pest ontology is constructed which contains knowledge base of different types of pests is affecting cotton crop at different stages which are from sowing of seed to maturity of cotton crop. There are

The concepts are created for pest such as insect pest, sucking pest, stem_ feeder, strainers, semi loopers which are affecting cotton crop. The regional name and scientific name of all pests were stored in the ontolgy.

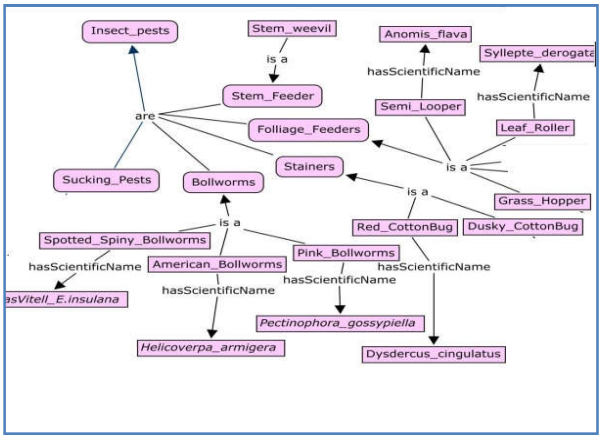

Figure 5 Snapshot of Pest Ontology.

There are different types of disease such as bacterial, fungal, viral affects cotton crop. The disease ontology constructed which stores the information about different types of disease, symptoms of disease, and pesticide and insecticide which needs to used to cure and prevention of disease. The disease ontology is shown in Fig.6. The concepts in disease ontology are connected to other concepts by using more than one relational name. e.g. is_prevent_by is relation name connects disease and prevention concept. Here disease is domain concept and prevention is range concept.

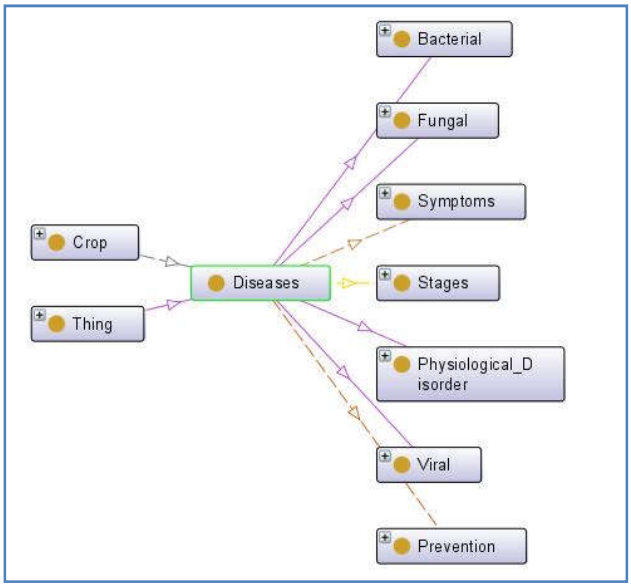

Figure 6 Snapshot of Disease Ontology

Semantic Technologies features support storing, loading and operations on RDF/OWL models. Each model contains a set of subject object relationship triples organized as an RDF/OWL graph of directed labeled edges. The edge is the link (or relationship) that connects a subject node to an object node and is labeled by a predicate [21]. The relationship between concepts is shown in Fig. 7.

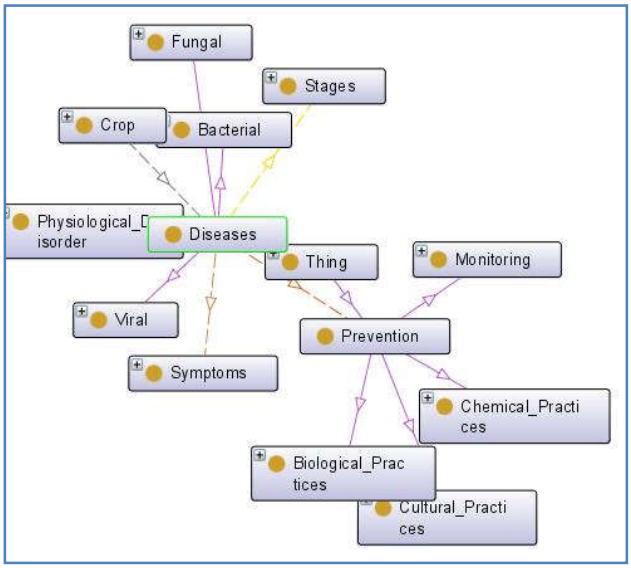

Figure 7 Snapshot of Concept Relation

CONCLUSION AND FUTURE SCOPE

We have presented paper which introduces building cotton crop ontology for cotton crop farmers to improve cotton farming practices.

Many advisory systems were developed to perform search on documents but with the involvement of Ontology into picture very refined way of searching mechanism can be achieved. This work mainly focuses on process of building cotton crop ontology

For farmers. Show how much effective the final results of queries are by adding knowledge to such systems in terms of Ontology. And here ontologies play important role to provide schemata or intelligent view over information resources. Therefore, ontologies for Cotton plant production, as the one generated by this study, may be a very useful resource for processing Cotton agricultural knowledge base. Therefore it was a pioneer and pilot work to develop an ontology prototype for plant production using the Cotton production as a test case study. This prototype will be a model for other agricultural ontology development in the future and through this efficiency of agricultural knowledge management will be improved.

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