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AASRI Procedia 3 (2012) 732 – 738

AASRI Procedia

www.elsevier.com/locate/procedia

2012 AASRI Conference on Modelling, Identification and Control

Study on precision agriculture knowledge presentation with ontology

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Abstract

Agriculture is a complex system science and the knowledge of it is consisting of much concepts and relationships. In order to find out the important domain knowledge from complex agriculture knowledge system, we need to concept modelling effectively, so as to better supporting distributed information retrieval, analogy inference and data mining based on knowledge system. As a kind of classical knowledge theory of the ontology, it can be used to solve the knowledge presentation problem.

*Keyword:*Precision Agriculture, Ontology, knowledge presentation

1. BACKGROUND

Precision agriculture is a kind of modern agriculture concept and it was an emerging interdisciplinary science in the early stage. It means that through the variable scale difference between field management way, it can determine the economic, reasonable investment, efficient use of agricultural resources, so as to achieve economic, environment and other aspects of the highest returns a management strategy and technology system

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doi:10.1016/j.aasri.2012.11.116

it is through the variable scale difference between field management way, to determine the economic, reasonable investment, efficient use of agricultural resources, so as to achieve economic, environment and other best aspects return a management tactics and a system for technology [1-2].With the development of internet and computer information technology, the reasons for the weakness of the industry changing turn to the degree of difference the highly fragmented agriculture, spatial and temporal variation of large-scale quantitative and, small scale production, low level of stability and controllability.

The combination of internet and computer information technology is changing the weakness of the industry due to the highly fragmented agriculture, small scale production, spatial and temporal variation of large-scale quantitative and the degree of difference, low level of stability and controllability.

There have been many researches on agricultural ontology field at domestic and overseas.The organization FAO started an agricultural ontology service plan in the year 2001[3], and the original ontology consisted of three parts that the safety food, the fishery and nutrition. A bio-security ontology model was proposed by Lauser [5], and at the first, the core ontology was constructed, then according to the heuristic method, the core ontology was extended. A research of Kokla and Kavouras is about geographic information ontology, which emphasized on heterogeneous geographic data heterogeneity's building in the aspects of classification and integration [4] made research. The first Ministry of Agriculture Ontology research monographs, Study and Application of Agricultural Ontology [6], introduced the researches and applications of agricultural ontology from three points: system of basic theory, technical methods and practical application respectively. National Academy of Agricultural Information Institute has done some prospective studies on Agricultural Ontology, and published many papers.

In this paper, we firstly review the related theory, and then propose the knowledge representation of agriculture method in the foundation of ontology, which including several steps. At last, we make an application on Tomato; it shows that in the foundation of ontology, knowledge representation of agriculture is a useful way to represent the knowledge of agriculture.

2. Related theory-- ontology

Ontology is a concept of philosophy in the first time, and then with the development of computer, ontology has been widely applied to the semantic web, intelligent information processing, information integration, etc. Gruber [7] thought ontology is equal with the sharing concept. Sharing concepts include domain knowledge modeling to the conceptual framework, the related agreements of interoperability need the interaction between the subjects and contents, and the theory is used to represent specific areas of common agreement. Studer [8] and other scholars thought that the ontology has four characteristics: explicit, formal, shared, and conceptualization.

Define agricultural ontology as "the science of agricultural have a set of identity, the concept of system clear and formal specification". Agricultural ontology mainly by the agricultural knowledge of the concept, the relationship between the concept and the computer can identify the formalization description language composition. Building agricultural ontology goal is to form for agricultural information organization structure of the common understanding, understanding and analysis of the agricultural domain knowledge, in order to further the establishment agriculture semantic network laid the foundation. Therefore, agricultural ontology is about computer language of agriculture concept of knowledge representation, carrying on the agricultural knowledge organization, developing agriculture knowledge service of scientific methodology. Define the agricultural Ontology as follows [9]:

Agri_Onto= (Onto_Info, Agri_Concept, Agri_ConRelation, Axiom)

the ontology name, design time, creator and other information as the ontology's basic information description are all involved in Onto_Info; Agri_Concept is a set of agricultural knowledge concept; Agri_ConRelation, the ontology concepts' relationship set, involves hierarchical and non-hierarchical relationship; A collection of existing ontology is contained by Axiom.

3. KNOWLEDGE REPRESENTATION OF AGRICULTURE BASED ON ONTOLOGY

3.1. Knowledge representation

1. Concept presentation of AO: modeling the agricultural system based on the ontology

In order to model the agricultural system based on the ontology, we need to classify the agricultural knowledge according to certain criteria. In this paper we divide the agricultural knowledge into three parts: the subject of labor, the means of labor and the agricultural production process, as shown in figure 1.Among them, the subject of labor is the center of the agricultural ontology system, it's a kind of static knowledge and entrenched generally. The means of labor, it means that the material and the material conditions which can influence the subject of labor in the agricultural production process. The agricultural production process can be regarded as production cycle combination of the subject of labor in different stages.

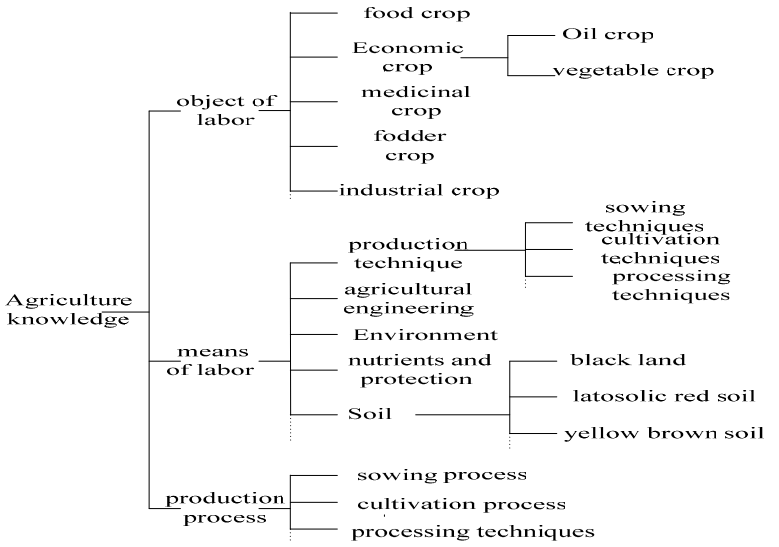

Figure 1 agricultural knowledge system

With labor object for system center connected other agricultural knowledge through the relationship. In other words, starting from the labor object, we can find out the relevant knowledge, such as corresponding policy, regulations and well-known experts.

2. Attribute presentation of AO

Attribute of AO is used to describe the concept of agriculture ontology; it has a function of limiting concept and examples. Attribute of AO can be summarized from different knowledge as follows: first of all, the crop belong to plant, it inherits related properties of plant, such as genetic property class, shape and structure property class, distribution property class and so on; besides, the crop have their own property class, for example, the growth environment property class including weather and other growing conditions. Each properties class including several properties, so they can form a full property description of the crop in a sense.

In order to manage ontology expediently and reflect the hierarchy relationship among the properties, we describe the property and relationship as an ontology system and called it the crop property ontology. The

structure of the crop property ontology can be shown in the following figure 2.Except considering the definition of properties from domain ontology, we must consider the relationship among properties from the total ontology base at the time of implement a property class, so that the property can be reused, classified, integrated and combined.

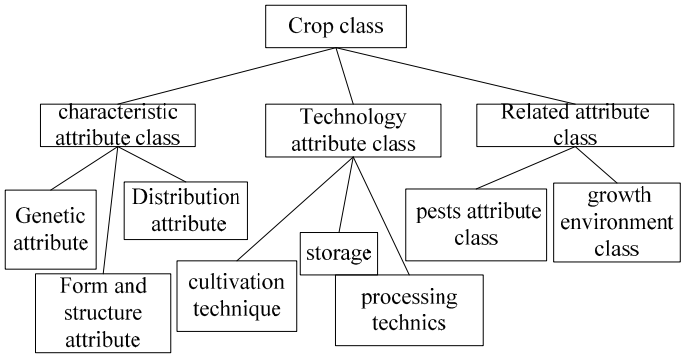

Figure 2. Crop attribute classes

3. Relationships and functions of agriculture ontology

The relationships among ontology express the relevance among the concept; it can be describe as the hierarchical structure such as typical binary relations. Generally, we use $R: C_1 \times C_2 \times \cdots \times C_n$ to express the relationship among classes C_1、C_2、…、C_n . The functions are special relationships; we use $F: C_1 \times C_2 \times \cdots \times C_{n-1} \to C_n$ to express the function, in which the *n*th element is the only map to the former *n-1*th elements. The mapping relation whom the function defines can make reasoning from a concept point to another concept.

The agriculture ontology has following relationships:

part_of: it can express the relation between parts and whole;

kind_of: it can describe the inheritance relationship among the concepts, it is similar to the relation among super class and subclasses whom defined by object-oriented;

instance_of: it can express the relation between instance of concept and the concept;

attribute_of: it can describe a concept is a property of another concept;

is_a: it can be used to express the relation of a instance to the concept, it can combines the class and the instance, so as to form a tree hierarchy structure;

cause_by: it can express the cause relationships among concepts.

There are following functions in agriculture ontology:

Table 1 function in agriculture ontology

Function	Meaning
Reciprocal(A)	work out the reciprocal of *A*
Cardinal(A)	work out the number of elements the set *A* contains
Equals(A,B)	the value of *A* and *B* are the same
Belongs(x,*A*)	The element *x* belongs to the set *A*
Greater/lesser(A,B)	The value *A* isgreater/lesser than *B*
Earier/later(A,B)	Time *A* is earier/laterthan the time *B*
Synonymy(A,B)	*A* and *B* have the same meaning
Completely_contains(A,B)	set *A* completely contains the set *B*

4. Axioms of the agriculture ontology

After building the agriculture ontology and the agriculture knowledge-base, there is a very important work we need to do, that is checking and reasoning on the knowledge. But it will be fantastic based on the existing ontology. So we should construct a consistency of axiom base.

The axiom of the agriculture ontology is tautologies in logic which do not need to be proved. There are many axioms in the agriculture ontology; some of them can be composite a set to explain the specific class, relationship, connection and restriction among attributes in the agriculture science. Some of the axioms will be used to check and reason on the ontology knowledge. We list following axioms in table 2.

Table 2 Axioms of the agriculture ontology

Axiom 1	All crops *X*, existing pest *Y*, Belongs(*Y*, insect_pests(X)) $\leftrightarrow$ Belongs(*X*, insect_pests(X))
Axiom 2	All crops *X*, all character strings *Y*, existing character string *Z*, Belongs(*Y*, yieldly(X)) $\rightarrow$ Belongs(*Z*, cultivation_technique(X)) $\wedge$ Belongs(*Y*,adapt_place(*Z*))
Axiom 3	All crop *X*, all character strings *Y*, existing character string *Z*, Belongs (*Y*, insect_pests(X)) $\rightarrow$ Belongs(*Z*, control_method(*Y*)
Axiom 4	All crops X, all character strings Y, existing character string Z, Belongs(Y, insect_pests(X)) $\rightarrow$ Belongs(Z, control_method(Y))
Axiom 5	All pests *X*, Equals(years(*X*), Reciprocal(Generation_long(*X*)))
Axiom 6	All crops *F*,*O*,*C*, List_belongs(*F*,*O*) $\wedge$ klass_belongs(*F*,*C*) $\rightarrow$ klass_belongs(*O*,*C*)
Axiom 7	All crops *X*, Synonymy(*X*, scientific name(*X*))

5. Application

If the knowledge representation for agricultural production wants to achieve the service of the integration knowledge level, with no ambiguous existing and same information in the same field and the diffidence application system, the help of ontology is necessary. The organization Agriculture Ontology (AO) manages the system resources and makes foundation for information exchanging. [10] As the knowledge resources of agricultural classification and description of the conceptual system, AO is defined as the five elements of ontology approach{c, a^c, r, a^r, h}, and c stands for a set of concept; a^c stands for a set of each attributes of concept; r stands for relationship set; a^r stands for a set of each attributes of relationship; h stands for Concept hierarchy. Take tomato pest control ontology for example:

$$Tomato\_AO=\{c_t, a^c, r_t, a^r, h_t\}$$

c_t ={thing, biology, chemistry, plants, insects, Solanaceae plants, pests, pesticides, gall mite tomato,

yellow tea mite, tomato, eggplant no net aphids, mites special cream}

r_t ={kill(pesticides, pests), damage (pest, tomato)}

h_t ={(Tomato, Solanaceae), (Solanaceae plants, plant), (yellow tea mite, insect), (tomato gall mites, pests), (EC special mites, pesticides), (organic phosphorus insecticides, pesticides)}

When describe the relationship of properties and concepts belonging to the tomato pest ontology concepts, use RDF / RDFS constructor and get the basic contents of the resource model.

4. Conclusions

This paper puts forward a kind of agriculture domain knowledge ontology representation method. Agricultural ontology is a include agriculture terms, definitions and regulate the relationship between terms system, is the agricultural field concept, the concept and the concept of the relationship between formal representation of each other. Through the crop planting information that expression and integration unity, transform the natural language description or unstructured information into formal, structured knowledge records. And use that knowledge to support agricultural problem solving and decision support effectively. United ontology evaluation standards' building and extracting the universal ontology knowledge are significant. By studying methods with the adjusting ability, it can increase It is can increased the adaptive learning efficiency.

Acknowledgment

This research is supported by Major Technology Plan Project of Hangzhou(Grand No. 20112311A09).

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