Research on the Inconsistency Checking in Agricultural Knowledge Base

Nengfu Xie

Agricultural Information Institute, The Chinese Academy of Agricultural Sciences, Beijing, P. R. China
Key Laboratory of Digital Agricultural Early-warning Technology, Ministry of Agriculture, P. R. China

nfxie@caas.net.cn

Abstract. The paper will propose a method to check the knowledge inconsistency in the agricultural knowledge Base, which is one the main measures to evaluate the agricultural knowledge base. This paper will pay attention to analyzing main types of knowledge inconsistencies and factors arousing it, and then discuss possible solving strategies which reduce agricultural knowledge inconsistency, so that agricultural knowledge is utilized correctly. In our practical application, it is very effective to find the inconsistency.

Keywords: Agricultural ontology; Inconsistency; Agricultural knowledge

1 Introduction

People have realized that ontology is an important for knowledge reuse, knowledge share and modeling. In philosophy, ontology is a systematic explanation of existence, and is about the essence of description [1]. In cyberspace, lowercase letter “o” represents ontology, which means an entity, the consequence of analyzing and modeling by ontology. That is, to abstract a group of concepts and relationship between concepts from one field in the objective world [2]. Nowadays ontology is widely used in information systems, natural language understanding and knowledge systems. In agriculture, knowledge will be made use of effectively if we use ontology to organize agricultural knowledge. Agricultural knowledge is a production factor of high quality, which can improve the labor force and capital production in agriculture and accelerate agricultural informatization. What’s more, agricultural knowledge is a kind of special knowledge, which lays the foundation of agricultural information application. Systems in agriculture education, language processing and expert systems all depends on agricultural knowledge.

On the other hand, in the process of organizing agricultural ontology based knowledge, differences will arise on concepts when people cooperate to construct knowledge base. And in the process of agricultural knowledge formalization, individuality error and editing error exist. Because of the large quantity of agricultural knowledge, text knowledge itself has inaccuracy, which leads to knowledge inconsistency. In philosophy, as time goes on, correctness of knowledge may be not right. It is easy to know the consequences of knowledge inconsistency. In military, knowledge inconsistency may cause wrong missiles launch and disability of aircrafts. In agriculture, farmers cannot grasp the right time of fertilization and reliable market information.

The paper will discuss the problems in the process of agricultural knowledge construction, and concludes the corresponding strategies of checking.

2 Definition of Inconsistency

In general, the knowledge consistency means some judgment accords with both history's judgments and the current facts. On the other hand the inconsistency means the contradiction between history's judgments and the current fact. From the aspects of ontology, the consistency means logic relations of terminology are consistent, while inconsistency means conflicts existing between some parts of ontology. For example, we define grain crops and cash crops as disjoint classes that have not the same instances. If the class wheat belongs to both grain crops and cash crops, the inconsistency will occur.

In the paper, agricultural ontology consistency includes the consistency of the definition of ontology and knowledge based on ontology, which means we can not get the conflict knowledge from knowledge base. Generally, whether knowledge base exists conflict knowledge depends on the following conditions:

1) The consistency of concept defining. That is to say, the formal definition contains the same means with informal one. Take the concept dogs as an example. If the formal definition of dogs goes with that of the concept cat, it brings inconsistency.

2) The consistency of concept extension. In terms of formal or non-formal concept definition, it can bring out conflict knowledge by concept explanation (include reasoning). For example, cats can catch mice, but we cannot say that mice can catch cats.

3) The consistency of axiom. The axiom system will not reason the conflict knowledge.

In the view of knowledge application, knowledge base can guide users to make the right decisions and ensure no confusion conclusion arising. In brief, the consistency is an important criterion to evaluate an ontology-based knowledge base. Knowledge inconsistency will lead to unreliable service, which threatens the knowledge correctness [4]. The paper will propose a method of ontology consistency checking.

Definition 1: Given knowledge base K, knowledge inconsistency problem is a 3 triple KI=(K,Y,Q), which satisfies that

- ♦ $Y=\{y_1,y_2,\ldots, y_n\}$ is Knowledge operation set.
- ♦ Q is a given knowledge query.

Definition 2: knowledge inconsistency problem KI=(K,Y,Q). If there exist knowledge conflict in K, it satisfies the following conditions:

- ♦ $\exists$ k, k_{11}, k_{22}, …, k_{1j} $\in$ K, y_{11}, y_{12}, …, y_{1j} $\in$ Y,

$\sum_{1}^{j} y_{1l}(k_{1l}) \models k \wedge$ k→Q. the Symbol |= indicates "reason out" and → represent " can satisfy" .

- $\exists$ k, k_{11}, k_{22}, …, k_{1m} $\in$ K, y_{21}, y_{22}, …, y_{2j} $\in$ Y, $\sum_{1}^{j} y_{2l}(k_{2l}) \models \neg k \wedge$ ¬k→Q。 And then we judge out that the knowledge base has inconsistent knowledge.

From the above definition, the knowledge base has inconsistency if there are two pieces of contradictory knowledge. It is very import to find a mechanism or method to checking the inconsistency of knowledge base.

3 Agricultural knowledge Inconsistency Problem Analysis

To explain inconsistency problems, we assume that agricultural knowledge adopts frame-based representation and organized by agricultural ontology. Firstly, some definitions is written as the following:

Definition 3: individual-of(i,C) means that i is a unit of category C. instance-of (i,C) means i is an example of category C.

Definition 4: IsRParent(A,B) means A is the direct father category of category B.

Definition 5: IsRSubclass(A,B) means A is the direct sub category of category B.

Definition 6: IsParent(A,B) means A is the father category of category B.

Definition 7: IsSubclass(A,B) means A is the sub category of category B.

Definition 8：if C_1 is called the sub-class of C_2, we write if as subcategory(C_2, C_1). We can get the fact that instance-of(i,C_2)→instance-of(i,C_1) and for each i individual-of(i,C_2) → individual-of(i, C_1) is true for each i。

Definition 9: IsHParent(A,B)means that A is the sub category of category B, or B is the sub category of category A.

Definition 10:IsHasBaseParent(A,B) means that A and B is the sub category of a category, and IsHParent(A,B) is true.

3.1 Category Error

In agricultural ontology, the most important and basic semantic relationship is inheritance. Ontology constructed by this relationship can be taken as a description of a hierarchical model. It can also be taken as an information category system. Therefore, category error checking is the most basic requirement.

3.1.1 Loop Error

When classifying a concept, we usually take sub class as a partition of the concept. Though this method satisfies the integrity of concept definition, sub category error arises. We call it ownership contradiction of categories, shown as Fig. 1. We assume

$A=\Sigma P_i$ represents category B has sets as IsRParen(P_i， B). To any P_k、$P_j \in A$, if IsHasBaseParent(P_k， P_j) is true, ownership contradiction of categories arises. For example, to IsRParent(grain crops， rear crops) and IsParent(cash crops， rear crops), if IsHasBaseParent(grain crops， cash crops) is true, contradiction arises.

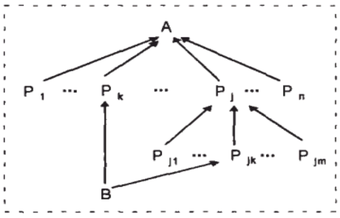

Fig. 1. The Class ownership contradiction

The checking algorithm is described that for each class B, finding $A=\Sigma P_i$ with IsRParen(P_i， B). If there exists P_k， $P_j \in A$, IsHasBaseParent(P_k， P_j) will be true. The method will find out conflict knowledge and mark it so that knowledge developers can delete error relations.

3.1.2 Classifying Category

When classifying a concept, we usually take sub class as a partition of the concept. Though this method satisfies the integrity of concept definition, sub category error arises. We call it ownership contradiction of categories, shown as Fig.2. We assume $A=\Sigma P_i$ represents category B has sets as IsRParen(P_i， B). To any P_k、$P_j \in A$, if IsHasBaseParent(P_k， P_j) is true, ownership contradiction of categories arises. For example, to IsRParent(grain crops， rear crops) and IsParent(cash crops， rear crops), if IsHasBaseParent(grain crops， cash crops) is true, contradiction arises.

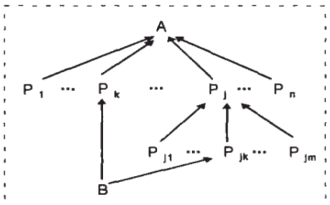

Fig. 2. The Class ownership contradiction

The checking algorithm is described that for each class B, finding $A=\Sigma P_i$ with IsRParen(P_i， B). If there exists P_k， $P_j \in A$, IsHasBaseParent(P_k， P_j) will be true. The method will find out conflict knowledge and mark it so that knowledge developers can delete error relations.

3.2 Class Definition Error

Class definition of ontology should be correct and have clear semantic. Naturally, inconsistency of class definition may cause ambiguity and knowledge inconsistency of instances. Therefore before acquiring knowledge, we must ensure the consistency and integrity of class definition. Particularly, under cooperation of several engineers, different agricultural terminology of the same concept may arise, which causes redundancy of category definition. So we must define clearly to ensure one concept with one terminology in ontology, and defining synonyms is allowed. In another situation, the same terminology may represent several concepts. It is also caused by unclear class definition, and it is reflected in the relation, attribute and facet definition.

3.3 Axiom Inconsistency

Axiom is used to limit contacts between categories, attributes and relations, to ensure consistency of frame-based knowledge. Besides, axiom is used in reasoning, to supply the system with intellectualized judges. Axiom Inconsistency means axiom stands reasoning in different situations, while inconsistency is the opposite. Any axiom system should satisfy the consistency, otherwise geometric systems built by it will be conflict and such system is Worthless. Formally, we can take axiom system as a logic system with first-order logic. In that sense, axiom inconsistency means the axiom "yes=no" arises in the logic system. For example, such axiom P and Q are conflict, if

Axiom P: $\forall X \in$ plantation crops) , GreaterThan (MaturityDate(X), SeedingDate(X))).

Axiom Q: $\forall X \in$ plantation crops), LessThan (MaturityDate (X), SeedingDate(X))).

Formally, we can take the axiom defined by ontology as first-order logic. Then axiom consistency checking can be translated to first-order logic operations.

3.4 Definition&Description Error

3.4.1 Contradiction of Case Ownership

If there exists an instance i and category A and B, which satisfies instance-of(i, A)$\wedge$ instance-of(i,B) $\rightarrow$IsHparent(A,B), then instance inconsistency arises, shown as Fig. 3. For example, for IsParent(grain crops, rear crops) and IsParent(cash crops, rear crops), if instance-of(Ararat wheat, grain crops) and instance-of(Ararat wheat, cash crops) are true at the same time, then contradiction arises. Because IsHparent(grain crops, cash crops) is false.

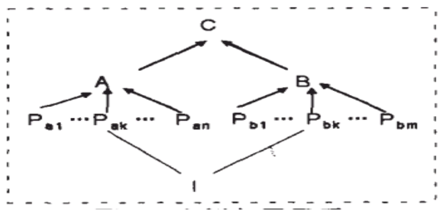

Fig. 3. The instance ownership contradiction

Checking Operations: for each case i, if there exists category A ≠B, which satisfies instance-of(i,A) ∧ instance-of(i,B), then check IsHparent(A,B). Assume IsHparent(A,B) is false, and knowledge developers should delete relation error. Besides, if there is IsParent(A,B), delete instance-of(i,B) too.

3.4.2 Instance level Contradiction

We can use a tree to represent ontology category structure. If there is IsRParent(A,B), node B serves as son node of A. Thus all leaf nodes consist the biggest partition of the tree root. We call the leaf set as the ideal category of the tree root, and nodes as the leaf category, shown in Fig.4. Atypical cases arise when it is not the instance of ideal category, but of non-leaf nodes. For example, divide horticultural crops into three categories as fruit trees, vegetables and flowers. If we define lilies as an instance of the concept crop, then the relation as IsInstance(lily, P_i) in the categories.(P_i is a leaf category)

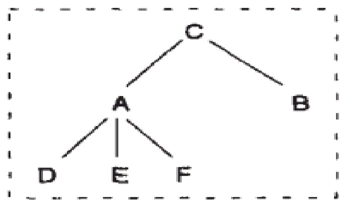

Fig.4. The concept tree.

The checking algorithm is described that this operation is relatively easy. For each case i, find category A which satisfies instance-of(i,A), and judge whether A belongs to the non-leaf category. If it is yes, then we mark the error.

3.4.3 Description Contradiction of Instances

Instance description should be clear. Xiong et al. [4] define a language in which it is possible to specify the inconsistency rule and the possibilities to resolve the inconsistencies. Egyed et al. [5] define such an approach for resolving inconsistencies in UML models. They take into account the syntactical constraints of the modeling language and they only consider the impact of one consistency rule at a time. Xie et al.[3] design a fused method to solve the inconsistency. In the fact, But in the process of formalization, sometimes different names represent the same instance. Therefore we need to describe and analyze synonyms to judge whether they are the same instances. This method reduces redundancy and error caused by one name with different instances. Besides, in the process of realizing cases, we need to check attribute values and relation constraint error. For example, the instance wheat describe that it has main producing countries: China and Russia and the number of its main producing countries is less than 2". We can use axiom system to check such error.

4 Conclusions

From the point of inconsistency, this paper discusses the possible situations and causes of the agricultural knowledge inconsistency in the process of building agricultural knowledge. It also discusses the corresponding processing strategies to reduce knowledge inconsistency as much as possible. It is very important to check the knowledge inconsistency for knowledge base-based application and make full use of agricultural knowledge. In the future, more studies should be focused on the effective and quick algorithms to check inconsistency of agricultural knowledge bases and the method should be put into the practical application for find new method to solve the inconsistency in the knowledge base.

Acknowledgment

The work is supported by the special fund project for basic science research business Fee, AIIS "Tibet agricultural information personalized service system and demonstration" (No.2012-J-08) and The CAAS scientific and technological fund project "Research on 3G information terminal-based rural multimedia information service" (No.201219).

References

1. Gill, Y., Blythe. J.: PLANET: a shareable and reusable ontology for representing plans. In Proceedings 17th International Conference on AI, 2000.
2. Valentina, A.M., Tamma, Trevor, J.M. : A knowledge model to support inconsistency management when reasoning with shared knowledge. In Proceedings of the IJCAI'01 Workshop on Ontologies and Information Sharing,2001.
3. Xie,N.F., Wang, W.Sh., Yang, X.R., Jiang, L.H.: Rule-Based Agricultural Knowledge Fusion in Web Information Integration. Sensor Letters, 10 (2): 635-638, 2012.
4. Xiong, Y., Hu, Z., Zhao, H., Song, H., Takeichi, M., Mei, H.: Supporting automatic model inconsistency fixing. In H. Van Vliet and V. Issarny, editors, Proc. ESCE/FSE 2009, p 315-324, ACM,2009.
5. Egyed. A., Letier, E., Finkelstein, A.: Generating and evaluating choices for fixing inconsistencies in UML design models. In Proc. Int'l Conf. Automated Software Engineering, Pages 99-108, 2008.