Agriculture Activity Ontology : An ontology for core vocabulary of agriculture activity

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Abstract. This paper proposes Agriculture Activity Ontology(AAO) as a basis of the core vocabulary of agricultural activity. Since concepts of agriculture activities are formed by the various context such as purpose, means, crop, and field, we organize the agriculture activity ontology as a hierarchy of concepts discriminated by various properties such as purpose, means, crop and field. The vocabulary of agricultural activity is then defined as the subset of the ontology. Since the ontology is consistent, extendable, and capable of some inferences thanks to Description Logics, so the vocabulary inherits these features. It is expected to use in the data format in the agricultural IT system.

Keywords: ontology, agriculture, agronomic sciences, knowledge representation, core vocabulary, vocabulary management

1 Introduction

The various IT systems have been introduced in farm management to realize better management, i.e., more efficient resource management, finer production control and better product quality. Now data management is indispensable in farm management. Data in farm management is also used in own purpose but the aggregated data is used for statistics, analysis and prediction for area agriculture.

Data in agricultural IT systems is nonetheless not easy to federate and integrate since the languages to describe data are not unified. Terminology in agriculture such as names of activity, equipment, and crop has not been well standardized mainly because agriculture has been *local*. Some of locality comes from diversity of culture and environment and others from the way of business, i.e., farms are small and run independently. But introduction of IT systems changed the situation; farms can be connected beyond the barrier of individual farms, regions, and even culture. But un-unified terminology exists as the problem. Without unified terminology, smooth data exchange cannot be enabled. So standardization of terminology is the key to enhance agriculture with IT systems.

We focus on agriculture activity in this paper. Agriculture activity is the most basic element of farm management and also the most difficult to standardize since it is more abstract than other types of terminology like equipment and crop.

2 An Existing Resource: AGROVOC

AGROVOC[1] is the well-known vocabulary system which has international interoperability and it contains many terms. However, There are some insufficient features in order to use as the core vocabulary. First of all, the relationship between concepts is not clear. Most of narrower/broader relationship is attached only by considering the pair-wise relationship. Thus hierarchy by these relationships are not so consistent. This vague relationship between concepts makes the problem when adding a new term; it is difficult to define the relation with concepts in AGROVOC, i.e., to find the best position to the new term. In addition, the number of activity names about rice farming, which is important in Asia including Japan, are insufficient.

3 Overview of AAO

Agriculture Activity Ontology(AAO) is the basis of the core vocabulary of agriculture activity, and it provides semantics for agricultural activity names. Also, AAO is formalized by Description Logics[2] in order to define and classify the agricultural activities clearly.

The Structuralization of the Agricultural Activities Our strategy to structuralize agricultural activities is the top-down, i.e, starting from the most general activity and expanding it to more specific activities. The important criteria for the top-down approach is how we can classify more specific concepts consistently. We define more specific concepts by specifying attributes and their values. We furthermore define the general rule for specifying attributes.

We start with the top concept *Agriculture Activity* which denotes all kind of activities related on crop and/or fields. Then we break down the concept into more concrete concepts. When farmers plan or do a certain agricultural activity, the first decision is what for they would take the action, i.e., *purpose* is the first attribute to distinguish agriculture activities. After the purpose is well specified, we use other attributes, i.e., *act*(type of action), *target*, *place*, *means*, *equipment*, and *season* in this order. *Crop* is also introduced so as to define the activity for a specific crop. These eight attributes are used to define the concept and to form the hierarchy of the agricultural activity. For exmaple, *Direct seeding in flooded paddy field* can be expressed with DL as follows;

$$Direct\_seeding\_in\_flooded\_paddy\_field \equiv Agriculture\_activity \sqcap \forall purpose.seed\_propagation$$

$$\sqcap \forall act.sow$$
$$\sqcap \forall target.seed$$
$$\sqcap \forall crop.rice$$
$$\sqcap \forall place.paddy\_field \quad (1)$$

Polysemic Concepts There are many activities conducted for the multiple purposes in the agricultural activities. The typical case is *Puddling*. it is to plow the bottom of a rice field, but it is also intended to conduct for the purpose of water retention, i.e., preventing from the water leak, and for the purpose of land leveling, i.e., flattening the soil.

$$\begin{aligned} Puddling \equiv\ & Pulverization \\ & \sqcup Land\_leveling \\ & \sqcup Activity\_for\_water\_retention \end{aligned} \quad (2)$$

In our formalization, these concepts are interpreted as polysemic concept and modelled as disjunction of multiple concepts since none of multiple concepts are mandatory rather optional. The polysemic concepts defined with multiple concepts can properly express features for the activities conducted for multiple attributions in the Agriculture Activity Ontology.

Reasoning by Agriculture Activity Ontology Since the purpose of AAO is to keep the agriculture activity terms consistent and well-organized, placing new terms at the appropriate location in the ontology is mandatory. The main task of Description Logics is to compute truth value in subsumption checking. However, it cannot discover subsumers or subsumees for a given subsumee or subsumer in a given ontological hierarchies. Therefore, we introduced Schank's algorithm for Case-Based Reasoning(CBR)[3] into our OWL[4] reasoning engine named SWCLOS [5][4], whereby an appropriate position of a given collection of pairs of attributes and values can be automatically discovered in coherent hierarchies of concepts and their attribute values, starting from a given domain top concept and descending subsuming chains to specific ones.

Web Services based on AAO AAO is hosted on CAVOC(Common Agricultural VOCabulary, `www.cavoc.org`). CAVOC allows browsing and searching concepts of AAO. The key feature of CAVOC is that it provides URIs for names of agriculture activities. In the page, the hierarchical structure is represented in order to indicate the narrower concept, the broader concept, and the relationship between concepts. Also, the data of AAO can be downloaded in the RDF/Turtle formats from `cavoc.org/aao/`. This format is well supported by many semantic

[4] SWCLOS is a lisp-based OWL Full processor on top of Common Lisp Object System (CLOS). It is downloadable from `https://github.com/SeijiKoide/SWCLOS`.

tools, and it is possible to convert it into other RDF formats if needed. Also, we provide a SPARQL endpoint for users to explore AAO data using SPARQL queries.

4 Conclusion and Future Work

We provide the Agriculture Activity Ontology(AAO) so as to standardize the vocabulary for agricultural activities. By using the ontology, it is possible to define concepts of agriculture activities beyond the linguistic diversity of the vocabulary for agricultural activities. The agriculture activity ontology was adopted as the part of "the guideline for agriculture activity names for agriculture IT systems" issued by Ministry of Agriculture, Forestry and Fisheries (MAFF), Japan in 2016, which is one of the achievements of this study[6].

We are now working to extend our idea to other agriculture domains, i.e., the standardization of vocabulary for agriculture such as the crop, distribution, and agricultural pesticide. Also, international interoperability is next to do. We have already connections with other activities for agricultural ontologies(for example Crop Ontology Group[5]). Our research has begun from the purpose of establishing the core vocabulary for the field of agriculture of Japan, although it can be independent regardless of language culture so that it can be applied to various languages and cultures.

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[5] https://sites.google.com/a/cgxchange.org/cropontologycommunity/