ONTAgri: Scalable Service Oriented Agriculture Ontology for Precision Farming

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Abstract – Although the advancement in sensor technology made inch-by-inch monitoring of agricultural field achievable but precision farming requires monitoring of several context attributes with context modeling to cope up with several distinct problems. Ontology is considered as most promising technique for context modeling. Despite several efforts towards developing agricultural domain ontology, lack of scalable ontology is still a concern. This paper describes scalable service oriented agriculture ontology (ONTAgri) that comprises over several small groups of concepts. The two major groups are system and agriculture. Agriculture group is further divided into core and services (like irrigation, fertilization) concepts. The notation of service oriented ontology made scalability and distribution possible which is the basic need of agriculture domain modeling.

Index Terms – Ontology, Context modeling, Precision farming, Sensor, Agriculture.

I. INTRODUCTION

Sensor technology is used to acquire context information from real world environment which is further utilized for monitoring, decision making and control actions for the betterment of situation under consideration. Advancements in sensor technology raised its involvement in several domains [1]. Agriculture is one of such domains where sensors and their networks are in effective use [2, 3]. Sensor oriented agriculture is given several names like precision agriculture, smart agriculture [4], inch-by-inch agriculture, precision farming etc.

To visualize the situation based on related acquired data, context modeling is an essential requirement. A number of context modeling and reasoning approaches have been developed over the last decade ranging from very simple early models to the current state-of-the-art context models. Key-value modeling, graphical modeling, object oriented modeling, markup scheme modeling, logic based modeling and ontology based modeling are major available context modeling approaches. Among all mentioned modeling techniques, Ontology based modeling is considered as most promising technique for context modeling [5].

Ontology is the formal representation of domain knowledge. It also defines the relationships among the domain concepts. The main goal of using ontology is sharing and reuse of the knowledge. Ontologies for several domains are built due to its power of eloquence, classification of knowledge, reasoning and inference. Agriculture is one of such domains where several initiatives to construct specific ontologies are taken [6-8]. FAO’s initiative towards the construction of agricultural ontologies based on their multilingual thesaurus (AGROVOC) and Advanced Ontology Service (AOS) project were also promising endeavor [9-11].

Literature review reveals that the available ontologies either only providing domain vocabulary for semantic interoperability of systems or dealing with limited situations and are not scalable. Some scalable and distributed ontologies are available for agriculture domain but they are component oriented like ePlant, eGadget that generates complexities in case of multiple service requirement at a time.

Due to distributed and context rich environment, dynamic and time variant attributes and variety of requisites for basic services, agriculture domain demands scalable, distributed and service oriented modeling. The ONTAgri initiative is the result of such requirements.

II. ONTAGRI: SCALABLE SERVICE ORIENTED AGRICULTURE ONTOLOGY

Agricultural domain is a context rich environment. It possesses several distinct requirements due to variety of land, weather and crops all over the world. Sensor technology supporting this domain in acquisition of real time context values in an effectual manner. The collected information can be effectively utilized only when it could model the situation in a well mannered way. Ontology is one of the modeling techniques that offer power of expression and disciplined way of knowledge representation.

ONTAgri ontology is defined to support agriculture domain. Several services support farming practice that includes irrigation, fertilization, pesticides spraying etc. Application of these services depends on various factors. To critically analyse such factors inch-by-inch information of farm land is needed. Sensor network is utilized to acquire such information which is then combined and inferred to get some useful knowledge for a particular service requirement and its pattern of utilization. Every service requires diversified knowledge which can only be modelled through service oriented ontology.

ONTAgri is service oriented agriculture ontology which comprises over two major parts:
(i) System ontology
(ii) Domain ontology
Domain ontology is further divided into core and services group of concepts (refer Fig. 1). Several related domains’ ontology can also be linked to support agricultural requirements. Such approach of defining ontology introduces scalability feature. Separating system concepts from domain reduces dependency which make easier to add any other required service utilizing the same system components. Ontology is an evolutionary process and goes through several stages of development. It is not a small task but a collaborative work which requires a team of technologist, agriculturists and sociologists. Proposed scalable service oriented ontology structure is presented in Fig. 1 incorporating initial level of agricultural concepts to support precision farming.

ONTAgri is composed on the following subgroups:

A. System Ontology

System ontology contains the definition of basic components (hardware and software). It comprises over sensors, actuators, interfaces, timers, counters, packets and others’ concept definitions, their attributes and instances.

B. Domain Ontology

As ONTAgri is developed for agriculture domain to support precision farming practices so the domain knowledge contains description about major parts of a land, crop and their related objects. It may also contain the vocabulary about domain to provide semantic interoperability and understanding.

1) Core: It comprises over description of several core concepts of agriculture like plant, soil and pest. Semantic description of each concept, detailed attributes and relationships are the basic need of this core part so that it could be used in different application requirements.

2) Services: This group of concepts is specifically defined to enable service oriented scalability. Introduction of new services without disturbing other defined portions of ontology is become possible due to separation of services’ concepts. This group may comprise over basic services like irrigation, fertilization, pest spraying or any other advanced service. Information service may also be introduced for semantic web based applications. Every service concept utilizes core concepts for which the service is introduced. To interlink domain ontology for a service to the required system components described in system ontology carefully defined relationships are needed. Addition of rules to the ontology may add power of identification for event initiation as well as decision making for actuation.

III. CONCLUSION

Considering the need of agricultural ontology that could provide adeptness as per the agricultural domain structure persuaded us in developing ONTAgri Ontology. Service oriented aspect of ontology development made scalability and distributiveness possible which is the basic demand of agricultural domain modeling. The proposed architecture of ontology offers ease in introducing new agricultural services without disturbing the former ontology.

We are working on the development of detailed ontology based on ONTAgri architecture. The developed ontology will then be applied on context-aware sensor grid framework [12, 13] to built precision farming applications.

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