Modeling Competency Questions Based Ontology for the Domain of Maize Crop: SIMcOnto

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Abstract. In this present time, there is rapid increase of various forms and structures of information across different domains of real world; for instance, agriculture. Because of this development, information is readily available; however, to retrieve the relevant information becomes a research issue to contend with. This identified research issue is on one hand attributed to the unstructured representation of data and on the other hand attributed to the problem of word mismatch. Consequently, and in lieu of this; to retrieve relevant soils and irrigations data for maize crop in a more efficient structure becomes a challenge. Therefore, this research work aims to model soils and irrigations data for maize crop ontologically; which is christened as SIMcOnto. In other to achieve this objective, Ontology which is a data modeling technique for complex knowledge representation is exploited. At the end, rule based Ontology is developed using the combined methodologies approach and written using OWL2 (Web Ontology Language) in the syntax of RDF/XML. The rules leverage on the validated Competency Questions (CQs) which are modeled in First Order Logic (FOL). During the course of the ontology development, the terminologies and the semantic rules are validated and verified by the domain experts and evaluation techniques. Therefore, the proposed SIMcOnto provides a machine represented knowledge-based modeling for soils and irrigations knowledge of maize crop. It is promising in retrieving a more precise and efficient information.

Keywords: Maize Ontology, Soils and Irrigations Knowledge, Competency Questions, Semantic Web Rule Language, OWL Properties.

1 Introduction

Maize (*Zea mays* L.) also referred to as corn, is undoubtedly an economic viable crop alongside with rice and soybeans [1]. It remains a key food crop in Africa, Asia and Latin America where it is largely used as human food; and in developed nations, maize is one of the most vital raw materials for animal feed production and biofuels [2]. Therefore, the need to advance research on essential agricultural knowledge such as soils, irrigations, and fertilizers is essential as they have influence on maize yields [3].

Soils and Irrigations are very important agricultural inputs and are interoperable with each other as amount of irrigation's water or methods to apply on maize would be determined by the soils type [4]. When moisture or rainfall is not adequate, the plants require additional water from irrigation. However, an increasing or decreasing level of appropriate irrigation water to maize crop will inadvertently has implication on the crop yield [5]. More so, precision irrigation knowledge forms a significant factor in terms of crop yields [6]. But retrieving these heterogeneous agricultural knowledge from the existing information retrieval systems; and the ambiguities of natural language become a challenge. Thus, the need to implore a top-notch data modeling technique is inevitable. Consequently, ontology as a data modeling approach is exploited in this research because of its potentiality to adequately represent complex knowledge. This would inadvertently makes the knowledge more meaningful to researchers and other agro-allied stakeholders [7][8].

Several literature proves ontology as a reliable mechanism in providing solutions to the ambiguities of natural languages. Ontologies largely utilize semantic web's technologies for modeling [9]. Ontology is an explicit and formal specification of shared conceptualizations [10]. The definition is key because it portray ontology as a semantic data modeling technique for developing knowledge systems in the area of information system, information management

and natural language processing [11]. Gruber categorized ontology into four types considering the scale of details. These are: Upper-level ontology, domain ontology, task ontology and application ontology [9]. Thus, this research focuses on application ontology, which is the combination of domain and task ontologies. Domain ontology models a given knowledge area taken its semantic expressivity into consideration. Task ontology models the define activities in form of Competency Questions (CQs) in addition to the modeled concepts of domain ontology in axioms and rules.

Furthermore, ontology design is premised on methodology [12] and implemented using knowledge representation tools of languages and editors [13]. The importance soils and irrigation knowledge to any crop and more importantly, to a foremost leading cereal crop such as maize cannot be over estimated. However, lack of structured repositories affect the quality of information retrieval. Therefore, this research work is motivated to ontologically model a repository for the crop but considering soils and irrigations data based on the adopted revised six step iterative ontology methodology [14]. The methodology is implemented using Web Ontology Language (OWL2)'s RDF/XML syntax on protege5.5.0 edition. In addition, the total CQs collected via questionnaire were studied and 44 CQs finally validated by the domain experts; 24 soils knowledge and 20 for irrigation knowledge. First-Order-Logic (FOL) was exploited to model the CQs and Semantic Web Rule Language (SWRL) formally encoded the rules in machine represented formats. The remaining sections of this paper is organized as follows: section 2 presents the related studies and section 3 presents the adopted ontology engineering process for SIMcOnto. The modeling of the ontology is contained in section 4. While section 5 discusses the results, section 6 concluded the work along with some suggestions for further work.