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Ontological Engineering Based Model for Classifying Maize Diseases

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Abstract-Classifying maize diseases is regarded as uncertain, dynamic and dependant on many factors. This paper uses OWL DL language to build a maize diseases ontology. The knowledge representation gives formal specification for the different ways of classifying maize diseases. The results show that development of the ontology and use of the Protégé 5.0 tool led to development of an intelligent and shareable Ontology which can be used to classify maize diseases which leads to enhanced productivity and yield.
Keywords-Ontology, Maize Diseases Classification, Knowledge Modelling and representation.

1. INTRODUCTION

Maize (Zea mays L.), also called corn in some countries is a domestic and one of the most cultivated plants on earth. Scientifically, According to the (Food and Agriculture Organization of the United Nations, FAO, 2015), maize is grown for food, feed and as an economic activity. Statistics from department of agriculture in South Africa depict that maize serves as a staple food for more than 2 million families in the developing countries, among them Kenya.

U.S.A is the leading producer of Corn followed by china as illustrated in the figure below. This contributes heavily to the Gross Domestic Product of a country. Approximately 12 million tons of maize grain are produced in South Africa annually. Half of the production consists of white maize, for human food consumption (Department of Agriculture, South Africa, 2014). In Kenya, maize is majorly grown for feed and food in regions like rift valley, central highlands and western Kenya. Depending on the region climatic conditions, certain varieties of maize will be preferred. Key among the climatic conditions is moisture levels, type of soil and amount of rainfall.

Globally, production of maize is hampered by many factors, key among them is (Li ma et al, 2013) diseases which account for about 6% - 10%. New diseases continue to emerge whereas some of the diseases that existed previously have not been fully understood. Currently, many farmers widely base evaluation, diagnosis and treatment of maize diseases on expert experience which is used to build the database and an expert systems is used to complete the diagnosis.

(L. Cao et al, 2012), notes that efficient monitoring and evaluation of diseases affecting maize, ability to forecast and warn farmers against diseases which their crops are prone to and the capacity to diagnose and treat corn diseases in a timely and accurate manner. As such, the existing mechanisms cannot sufficiently deal with this problem holistically; they have deficiencies in on demand efficient knowledge sharing and reuse. Resulting in the need for scientific tools which are guided by empirical data to aid in development of knowledge bases which help in understanding maize diseases between heterogeneous systems (Li ma et al, 2013).

This paper seeks to build a special purpose upper ontology called Maize Diseases Ontology for understanding maize diseases. The paper intends to bring out the distinct attributes of the diseases in a bid to create a taxonomy which can be used to classify the diseases.

2.0 MAIZE DISEASES AND ONTOLOGICAL ENGINEERING

2.1 State of the Art

Research on maize diseases has been on fore front due to the myriad of problems they cause and these has led to publication of different taxonomies for classifying the diseases, their causes and potential remedies for controlling the diseases. (R Shrestha et al, 2010: H Qi et al, 2010: L Yao et al, 2006), have all acknowdged the vital role played by classifying maize diseases using ontology. They argue that use of ontology creates effective methods and ways of describing maize diseases. However, they are quick to note the indispensable role played by existing knowledge and the vital role played by domain experts in the construction of domain specific ontologies.

2.2 Maize Diseases

Cultivars differ in their susceptibility to diseases such as ear rot, maize streak virus disease, grey leafspot, rust, cob-and-tassel smut, stemrot as well as root rots. Cultivars with the best levels of resistance or tolerance to a disease should be selected for planting where a specific disease occurs.

2.3 Ontological Engineering

Ontological engineering is technique for representation for abstract concepts like events, beliefs, physical objects and time. Of late, domain experts come up with standardized ontologies which can be used for information sharing and understanding information their fields. Fields like Medicine, for instance, have developed large, standardized, structured vocabularies such as SNOMED (Price and Spackman 2000) and the semantic network of the Unified Medical Language System (Humphreys and Lindberg 1993). Furthermore, general-purpose ontologies have continued to emerge like the

United Nations Development Program and Dun & Bradstreet UNSPSC ontology which provides terminology for products and services (www.unspsc.org).

In agriculture, ontology has been extensively to share common understanding of agricultural information among people or software agents as well as to enable analysis and reuse of domain knowledge. In particular, ontology has been used to model maize diseases (Liying Cao et al, 2012: Li Ma et al, 2012). In their studies, they argue that using ontology is prudent in bringing out the differences in classifications of maize diseases.

3. APPLICATION OF ONTOLOGY IN MODELLING MAIZE DISEASES

Special purposes ontologies can be used to create a means for researchers to define a common vocabulary in a particular domain so as to create a knowledge base. Ontologies are mainly concerned with explicit description of concepts in terms of classes, and showing the roles and properties of each concept describing its various features and attributes.

3.1 Knowledge Modelling and Representation

Ontological engineering is regarded as a field that is still in its infancy stage and hence lack widely accepted methodologies (Fernández, 1999). There exist no definite methodology of modelling an ontology, however, many authors agree on certain aspects of the development process like the iterative nature of the process, initiating the process by describing nouns which later become a class, attribute or instance and the verbs which will be relations.

In order to build the ontology, maize diseases in this paper are classified as follows; on the basis of the cause, symptoms, organ they attack and occurrence and distribution of the diseases. Protégé, an ontology engineering tool developed by Stanford University will be used to develop the ontology.

3.2 Methodology

There exist different methodologies for developing ontologies which can be assessed based on the IEEE 1074 standard. The choice of a particular methodology is informed by the domain of the ontology in question. The figure below shows Different methodologies used in developing ontologies. In this paper, METHONTOLOGY methodology which is mainly used for building domain ontologies (Rizwan et al, 2013) is used. Different from the ontology development methodologies (Uschold and King, 1995): (Gruninger and Fox, 1995); (Barnaras, 1996) and (SENSUS, 1997), METHONTOLOGY is more detailed in terms of the activities and techniques.

It proposes seven stages; Specification, Knowledge acquisition, Conceptualization, Integration, Implementation, Evaluation and Documentation in the development life cycle of ontologies hence following an evolving prototype approach, in addition, it supports the concept of reuse which is time consuming and eases the tedious job. According to (Rizwan et al, 2013), METHONTOLOGY has been used and tested extensively in development of domain ontologies like chemicals (Fernández, 1996; Gómez-Pérez, 1996; López et al., 1999), environmental pollutants (Rojas, 1998; Gómez-Pérez and Rojas, 1999), monatomic ions , Silicate ontology, to name a few (Fernández-López and Gómez-Pérez, 2003; Arpírez and Gómez-Pérez, 2000).

3.2 Classification of Maize Diseases

Maize is prone to many diseases that affect either the leaf, stalk, cob or the ear. Various classifications have been proposed and depending on the environment the maize is growing, the diseases vary from bacteria, fungi to virus infections.

3.2.1 Classification of Maize Diseases Based on the Environment

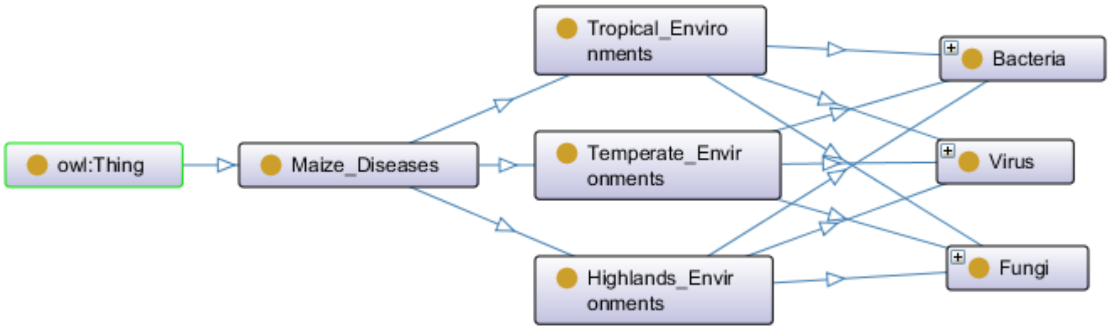
On the basis of environment, maize can be classified as either being grown in the tropical climate, temperate or highland environments.

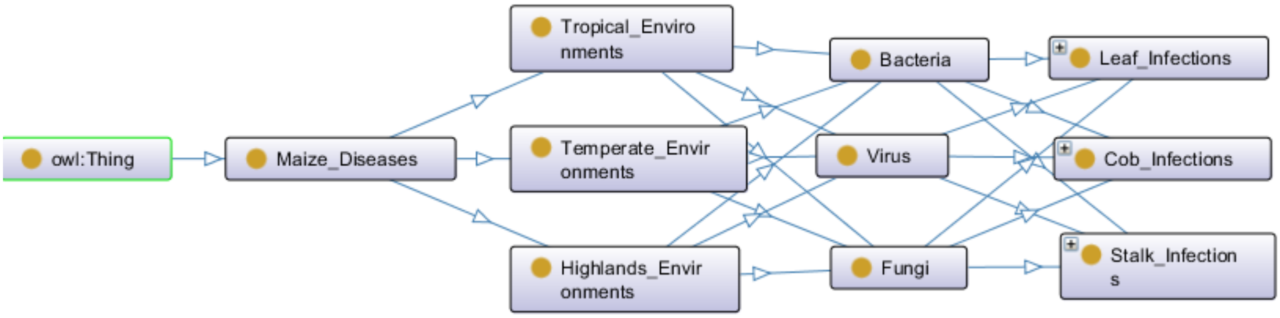
3.2.2 Classification of Maize Diseases Based on the Pathogen Identity

Pathogen identity is one of the most fundamental classification of maize diseases because it indicates the cause of the disease as well as appreciating the host pathogen.

Table 3.1: Summary of Ontology Development Methodologies (Adopted from D. Li et al, 2013)

	Inheritance from Knowledge Engineering	Detail of the methodology	Recommendations for formalization	Strategy for building applications	Strategy for identifying concepts	Recommended life cycle	Differences from IEEE 1074-1995	Recommended techniques	Ontologies and applications	Collaborative and distributive construction
Uschold y King	Partial	Very little	None in particular	Application-independent	Middle-out	None	- Processes missing - Activities missing	Not known	One domain only	Not documented
Grüninger y Fox	Small	Little	Logic	Application-semidependent	Middle-out	To be detailed	- Processes missing - Activities missing	Not known	One domain only	Not documented
Bernaras	Big	Very little	None	Application-dependent	Top-down	None	- Processes missing - Activities missing	Not known	One domain only	Not documented
METHONTOLOGY	Big	A lot	None	Application-independent	Middle-out	Evolving prototypes	-Pre-development process missing - Activities missing	Some activities missing	Several domains	Not documented
SENSUS	None	Medium	Semantic networks	Application-semidependent	Not specified	To be detailed	- Processes missing - Activities missing	Not known	Several domains	Not documented





***3.2.3* Classification of Maize Diseases Based on the Plant organ they Attack**

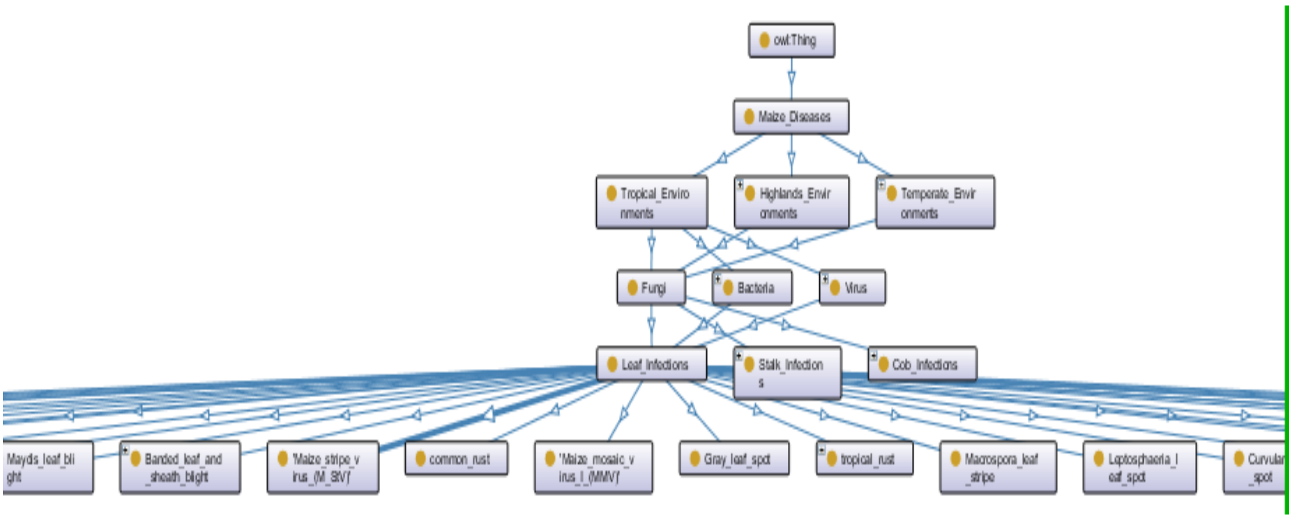
Maize diseases can be classified according the organ they attack. The attacks cause infections on the stalk, cob and leaves mainly. However, most of the diseases affect the leaves.

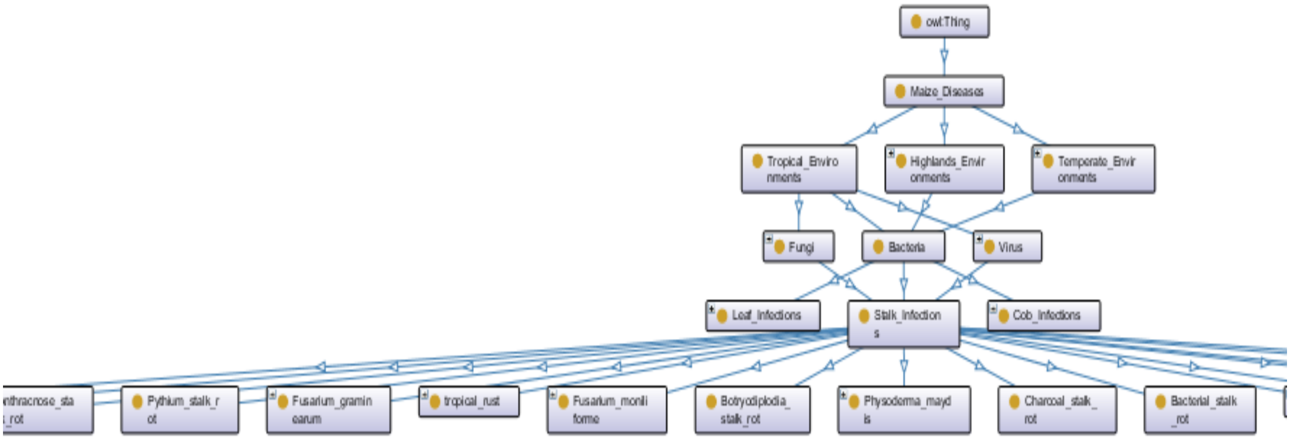
***3.2.4* Classification of Tropical Bacterial Maize Diseases that affect the Leaves**

Maize diseases in the tropical areas caused by bacterial infection which affect the leaves are shown below. Due to the width of the ontology, only a portion of the diseases is show vividly.

3.2.5 Classification of Tropical Bacterial Maize Diseases that affect the Stalk

Maize diseases in the tropical areas caused by bacterial infection which affect the maize stalk are shown below. Due to the width of the ontology, only a portion of the diseases is show vividly.





3.2.6 Classification of Tropical Bacterial Maize Diseases that affect the Cob

Maize diseases in the tropical areas caused by bacterial infection which affect the maize cob and ear are shown below. Due to the width of the ontology, only a portion of the diseases is show vividly.

3.2.6 Comprehensive Classification of Maize Diseases

The proposed ontology for maize diseases classifies maize diseases intitally from the environmental conditions they are grown, the pathogen, the organ that is affected and lastly the diseases are spread on all the above classifications creating relationships. The diagram below depicts a portion of the comprehensive ontology, due to the magnitude, the whole ontology can not be shown.

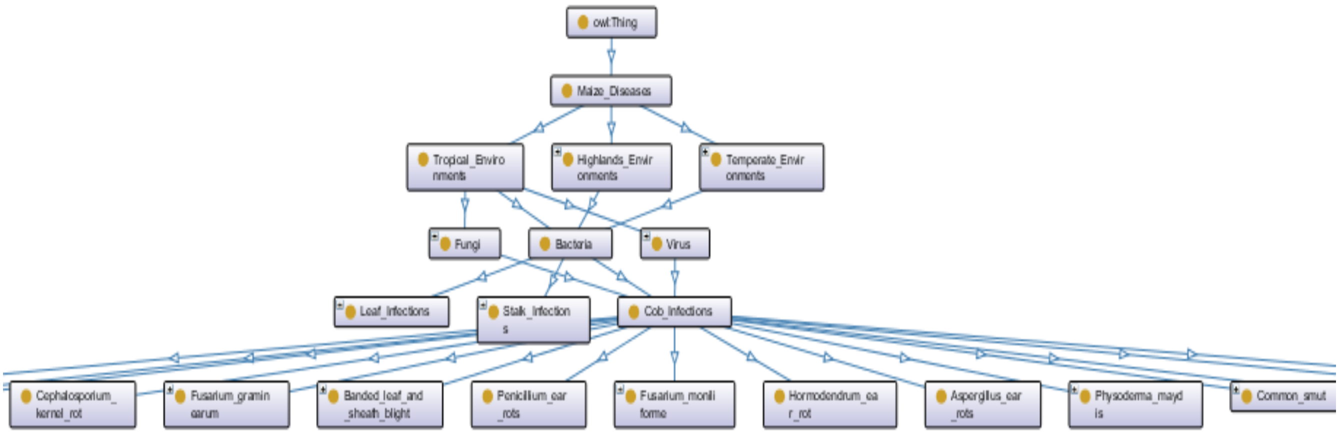


Table 3.2: Maize Diseases Ontology Properties

Object properties	Domain	Range	description	Inverse properites
is_time	time	disease	Onset period	
is_part	part	symptoms	Incidence of parts	
hassyptom	disease	symptoms	Onset of symptoms	issyptomof
is_disease	thing	disease	The name of the disease	
issyptomof	symptoms	disease	The symptoms of the disease	hassyptom

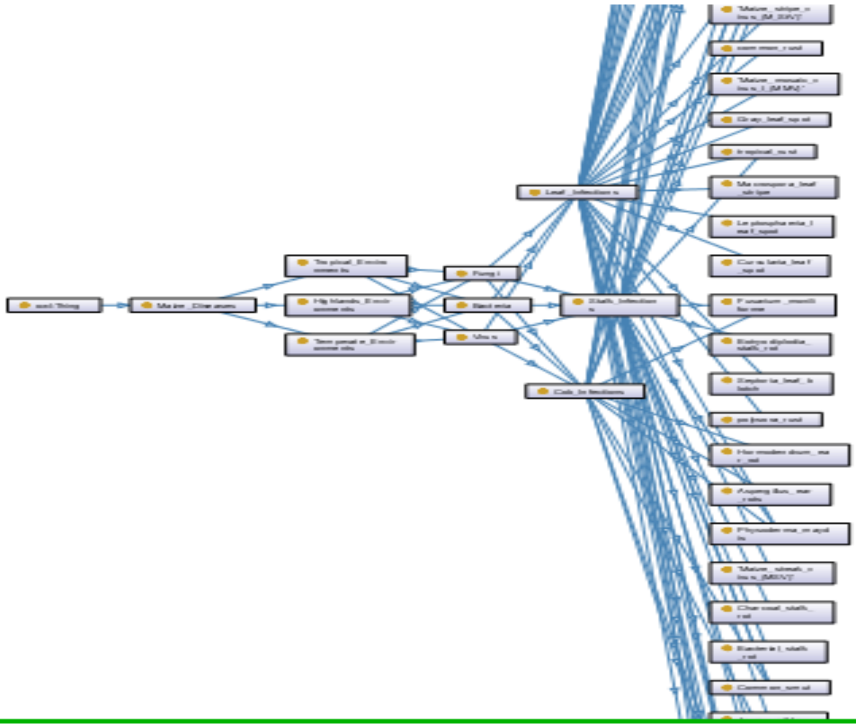


Table 4.1: Analysis of the METHONTOLOGY methodology

	Inheritance from knowledge engineering	Detail level	Knowledge formalization recommendations	Ontology building strategy	Concepts identification strategy applied	Recommended life cycle	IEEE 1074 Differences
METHONTOLOGY	compliant	Partially compliant	Compliant	Application independent	middle-out strategy	Evolving prototypes	Missing processes: project initiation, installation, support, retirement and training

4. Evaluation And Validation Of The Methodology And The Ontology

4.1 Analysis of the METHONTOLOGY Methodology

(Fernández, 1999) proposes a generic method for analyzing ontology development methodologies. He argues that for a comprehensive analysis of a methodology to be executed, the following process should be followed; Inheritance from Knowledge Engineering, the level of detail of the methodology, recommendation for knowledge formalization, strategy for building ontologies, strategy for identifying concepts, recommended life cycle, differences between the methodology and IEEE 1074-1995. The following table show an analysis of the METHONTOLOGY methodology using the above criterion.

4.2 Analysis of the Maize Diseases Ontology

The analysis of the ontology will be carried out through creating of relationships between classes, relations attributes, formal axioms, functions and individual instances using Protégé 5.0. Descriptive and First order logic will be used to generate Subclass-of, Instance-of, class partition and dis – joint decomposition relationships.

5.0 Summary And Future Work

5.1 Summary

This paper has presented an ontology engineering approach for building a Maize Diseases Ontology. As argued in section three, it is clear that many merits could accrued from creating ontologies of this kind. However, it is prudent to note the inhibiting aspect of lack published work specifically on maize diseases ontologies and the subsequent agreed and standardized techniques of validating ontologies.

5.2 Future work

From the above cited challenges in section five, there exist potential and rich research areas into;

i. Future attention on Validation techniques for domain specific ontologies
ii. Focus on use of METHONTOLOGY to support design of ontologies in distributed environments

REFERENCES

1. D. Li and Y. Chen (Eds.): Research on Construction and SWRL Reasoning of Ontology of Maize Diseases. CCTA 2012, Part II, IFIP AICT 393, pp. 386–393, 2013. IFIP International Federation for Information Processing 2013
2. Chen, L., Wang, L.: Probabilistic neural network in the maize leaf department of the application of the disease recognition. Farm Machinery Research (2011)
3. Ma, L., Yu, H., Wang, Y., Chen, G.: The Knowledge Representation and Semantic Reasoning Realization of Productivity Grade Based on Ontology and SWRL. In: Li, D., Chen, Y. (eds.) CCTA 2011, Part I. IFIP AICT, vol. 368, pp. 381–389. Springer, heidelberg (2012)
4. Liu, C.: The Research of Corn Disease and Pest Prevention and Cure Semantic Searching System Based on Ontology. Jilin University (2007)
5. Du, X., Li, M., Wang, S.: A Survey on Ontology Learning Research. Journal of Software 17(9), 1537–1847 (2006)
6. Xu, Z., Huang, K., Zhang, W.: The Methodology of Ontology Building. Computer Science 29(1) (2002).
7. Fernández López, M.: Proceedings of the IJCAI-99 workshop on Ontologies and Problem-Solving Methods (KRR5) Stockholm, Sweden, August 2, 1999.
8. The CIMMYT Maize Program. 2004. Maize Diseases: A Guide for Field Identification. 4th edition. Mexico, D.F.: CIMMYT
9. Rizwan Iqbal, Masrah Azrifah Azmi Murad, Aida Mustapha and Nurfadhlina Mohd Sharef. Journal.: Research Journal of Applied Sciences, Engineering and Technology 6(16):, 2013.