INTERPRETATION AND RECOMMENDATION TASKS SUPPORTED BY CERES SYSTEM

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Keywords: Knowledge Representation, Ontology, Soil Chemical Analysis, Agricultural Domain.

Abstract: This article describes the interpretation and recommendation modules of the Ceres system, an Expert System that supports the interpretation of soil samples, recommendation for lime, fertilizer and data management using resources from expert system and database technologies. Among the requirements of the application domain, it is the information analysis resulting from the interpretation process, which has the purpose of finding the causes of productivity variation. This analysis makes possible human interaction in the sense of preserving proprieties that favor the developing of vegetables. In this way, the Ceres system has been proposed to assist experts on possible actions to be implemented to improve soil quality. The system is compound by several modules that implement tools to analyse the different soil properties. The focus of this paper is to analyze soil chemical aspects and the analysis tasks related to them. The modules proposed were conceived with a knowledge base formed by ontology, an inference engine and an interface for external access.

1 INTRODUCTION

Precision Agriculture is a set of procedures that aims to manage a productive field, meter by meter, considering the different characteristics of each piece of the property (Roza 2000). In order to do so, several techniques are applied, such as productivity maps (Molin 2000), geological information systems (Fileto 2005), and analysis for fertility, with the objective of obtaining precise information about the conditions of the property in the period before the production cycle.

More specifically, the analysis for fertility involves the study of the causes of the variation of productivity and the development of vegetables in the agricultural fields. For this, different factors involved in the development of plants are examined individually. Each study results in different sets of analysis to be interpreted by specialists in the field. In this way, the specialist is able to make decisions related to the necessary actions for maintaining the properties of soil fertility, to increase the productivity and the environment preservation.

In this context, is proposed the Ceres System - an expert system that supports the activities of interpretation of the soil proprieties and recommends the use of fertilizing. It integrates the benefits of the database and expert system technologies to provide facilities to information management by making storage, access, data and knowledge application easier in this domain.

The system is compound by 5 expert modules, being presented in this paper the interpretation and recommendation modules related to the soil's chemical aspects.

The next sections are organized as follows. Section 2 describes the main characteristics of the Ceres System and their architecture. Section 3 presents the knowledge representation emphasizing the knowledge modeling involved in the interpretation and recommendation modules and the ontology implemented. Section 4 presents the prototype developed. The main conclusions of the work are presented in section 5.

2 THE CERES SYSTEM

Ceres is an expert system that automatizes the activities of interpretation of the soil proprieties and recommends the use of fertilizing, when necessary. In this manner, the system receives soil's descriptions and makes interpretation according to the knowledge acquired and formally represented in the correspondent modules. Therefore, the inference resultant of the interpretation process is used by the recommendation module to indicate the actions to be taken for the maintenance of soil fertility's

Santos C. and da Silva D. (2009).
INTERPRETATION AND RECOMMENDATION TASKS SUPPORTED BY CERES SYSTEM.
In *Proceedings of the International Conference on Knowledge Engineering and Ontology Development*, pages 464-467
DOI: 10.5220/0002309304640467

properties. The data and information are preserved to queries and used in the future.

The Ceres system is compound by three main components: a symbolic processing; a database system and a visual interface. The symbolic system is the core intelligent of the system and consequently is the main component of the architecture. The function of this component is decomposed in five modules, as presented in Figure 1. The modularization of this layer allows the implementation of specific knowledge to develop the tasks related to each type of analysis.

The database system component stores all descriptions managed by the system and the structure of the knowledge base of the application domain. This component is supported by a RDBMS (Relational Data Base Management System) that controls the access of the sample descriptions and implements the integrity constraint of the model. There is no domain knowledge in the system which is not managed by the database module.

The third component – the user interface supports the new soil sample description that will be stored in the database system. The integrated environment of multiple windows offered by the system to the user allows the standardization and facilitates the process of soil chemical analysis.

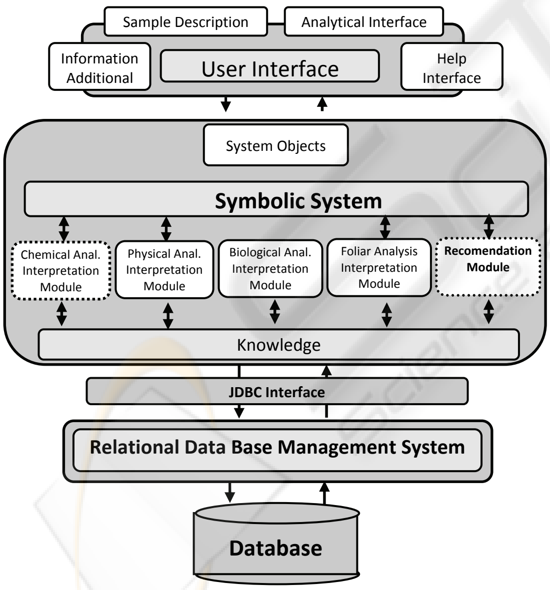

Figure 1: Ceres System Architecture.

The interpretation and recommendation modules described were included in the symbolic system and are represented in Figure 1 by dotted lines.

The system's architecture supports expert system and database functionality with high flexibility, providing a reliable environment to help specialists in reasoning with big amount of data. Besides, the system is able to represent the knowledge preserving the necessary semantic richness of the domain and offers a user-friendly environment to accomplish the complex task of soil analysis.

3 THE KNOWLEDGE REPRESENTATION

The knowledge acquisition was realized using the following techniques: (a) Interviews with specialist more than ten-year-experience, (b) bibliographical study of the liming and fertilization manual (Sociedade Brasileira de Ciência do Solo 2004) and, (c) analysis of a database containing 5,000 reports of soil chemical analysis.

The studies, analysis and interviews enabled the development of the ONIACHES - an ontology that supports the systematization of the interpretation and recommendation processes related to soil chemical analysis task. The ontology created provides a reference domain model that human and software can refer to for several different purposes. A more detailed description about the ontology ONIACHES can be found in (SANTOS 2007).

To construct the ONIACHES it was used the METHONTOLOGY (Gómez-Pérez 2003) and CommonKADS (Schreiber 2000) methodologies. METHONTOLOGY was adopted since it is more expressive, predicts the integration of ontology, provides good tools where it can be applied and it is recommended by the FIPA (*Foundation for Intelligent Physical Agents*). Inference structures are used in order to describe the reasoning process, according to CommonKADS methodology, which allows the representation in knowledge level of the relationship between rules for execution of the task. In addition, to further specify the inferences realized in knowledge level, knowledge graphs were modelled (Leão 1990).

In summary, the following activities were developed: (1) knowledge acquisition; (2) elaboration of specification document; (3) elaboration of terms glossary; (4) concepts taxonomy modeling; (5) concepts dictionary elaboration; (6) detailed definition of the relationship (relation's diagram and relation's dictionary); (7) detailed definition of the attributes (attribute's dictionary); (8) definition of instances (instance's dictionary); (9) inference structures modeling; (10) definition of axioms and rules; resulting in 17 elaborated documents.

The elaboration of these documents allows the verification of the complexity and the real dimension of the ontology. It also provided detailed and well documented models contributing to a better understanding of the area.

3.1 The Interpretation Module

The input data for the interpretation module are derived from laboratory analysis performed on soil samples. The laboratory analysis allows extract soil's chemical properties, such as PH, content of clay, boron, copper, magnesium, potassium, phosphorus and others. These properties should be correlated to allow its interpretation.

To specify in detail the inferences realized in knowledge level, 24 graphs were modelled, each one representing different relations between the elements involved in the interpretation process.

The knowledge base is formed by 125 instances of concepts of the ontology to interpret the 15 attributes related to the interpretation task. The inference employed in the process was represented by rules definition. Ten rules were defined for the representation of the inference inherent to the interpretation process. In the documentation generated, each rule has a name, a formal expression, and the description of the variables used.

3.2 The Recommendation Module

The recommendation process supported by the Ceres system involves the tasks of recommendation of fertilizers and recommendation of liming. In order to be possible to incorporate the recommendation process in the system, it was necessary to extend the ONIACHES integrating new concepts and giving origin to a new version of the ontology.

As a whole, 634 new instances of concepts related to recommendation process were created, being 445 instances used to represent the task of recommendation of fertilizers and 189 instances to represent the task of liming recommendation. All the instances are documented, including, to each one of them, attributes, concepts and associated values.

The inference employed to the recommendation process was represented by the definition of 27 rules. These rules handle the instances of concepts of the ontology.

To establish the relationships between the concepts involved in the ontology, a relation's diagram has been elaborated. It allows the visualization of the existing independence between the interpretation module and the recommendation module. That is, the interpretation module can be used without any relation to the recommendation module. However, this is not the case of the recommendation module, which has dependence of the data come from the interpretation module. The diagram has been elaborated with a schematic approach, allowing a clearer vision of the concepts and their roles in the application domain.

3.3 The Ontology Implementation

It was possible to instance the knowledge base from the modelled and documented knowledge. The base has been constructed with the support of the Protegè Edition Tool (Noy 2003) version 3.3, which supports the methodology chosen, allows automatic documentation, facilitates the integration of ontology and gives support to the importation and exportation in several formats, as OWL (Web Ontology Language) and RDF Schema. The use of Protégé made it possible the edition of concepts taxonomy, relationships and attributes of the ontology and the instantiation of 759 concepts related to interpretation and recommendation processes.

To realize the inference process, Algernon (Hewett 2004) has been used, an inference engine which uses a rules-based language capable of manipulating the knowledge bases instantiated in the Protégé. Algernon was chosen for the following reasons: (i) it is an open source tool; (ii) it has good documentation available; (iii) it supports the backward chaining and forward chaining methods; (iv) it is developed in the same language that Protégé and, (v) it has maturity enough to be used and encapsulated in an application.

The characteristics described above about Protegé and Algernon tools enabled the development of software that encapsulates the complete structure of symbolic data processing in an expert system able to realize the task in accordance with the knowledge modeled in the ontology.

4 THE PROTOTYPE DEVELOPED

With the aim of modelling the system's prototype, it was used UML language, which has enough representativeness and wide documentation available. The use case diagram, component diagram and class diagram were elaborated to document the system's prototype. The prototype was implemented in Java language allowing the encapsulation of Protégé and Algernon technologies in a single application. The component's structure supported by prototype is presented in Figure 2.

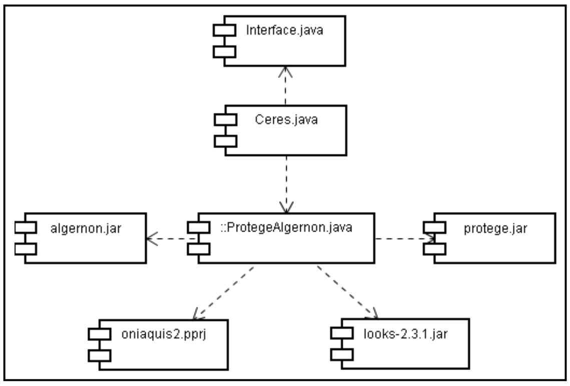

Figure 2: Component's Structure.

After the implementation of the specialist system, usability and functionability tests were performed in order to validate the prototype. In this sense, tests evidenced, satisfactorily, validity and reliability in the tool use.

5 CONCLUSIONS

The use of geoprocessing techniques and Global Positioning System, along with traditional techniques to collect data is providing a new view on the agricultural process. In this context, this work provides relevant contributions to the application domain. The contributions can be described in two senses:

a) By Ceres System - The application developed is capable of assisting specialists by providing facilities to interpret soil analysis and to recommend the use of fertilizers and limestone, quickly and reliably. This contribution should be highlighted in view of the lack of computational solutions in the application domain, especially in the region where the system proposed is being used. In this way, the existence of computational solutions to facilitate the process is a valuable contribution to the application domain. Another benefit of the system is the viability of the use associated to the technologies used. This allows the development of other ontologies that will integrate the knowledge base similarly as presented.

Besides, the knowledge base handling and instantiated in Protégé through Algernon has resulted in a reduced number of necessary rules to inference. This occurs due to the direct use of the ontology in reasoning execution and by semantic representativity between the terms defined in the ontology.

b) By knowledge formalized - The ontology proposed will allow the development of other computer applications where the knowledge modelled also may be used, i.e. the ontology may provide, as many would hope, the needed methodology and standard to achieve the objective of building flexible solutions. Actually, the ontology has 759 instances of concepts that address of the interpretation and recommendation processes, considering the soil's chemical aspects.

Finally, the work proposed presents benefits in the computational context by providing modelled, formalized and validated knowledge contributing to the development of the new applications in the agricultural domain. Also, it provides a framework already validated using technologies combined that produces good results. On the other hand, to the agricultural domain, this work contributes by providing a powerful tool to help the specialist in the recommendation and interpretation processes, making them faster and more reliable.

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