An Ontology-Based Decision Support System for the Diagnosis of Plant Diseases

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ABSTRACT

There are several cities and countries whose population depends on agriculture. Crops demand close monitoring regarding diseases because these ones can affect significantly both production and post-harvest life. The identification of disease symptoms plays a crucial role in the successful cultivation of crops. The diagnosis of diseases is a challenging task since many symptoms should be considered, which makes a proper diagnosis becomes a knowledge handling problem. This paper specifies an ontology-based decision support system that promotes the knowledge of experts for the plant disease diagnosis to farmers. This system takes advantage of ontologies in two ways, to exploit the knowledge contained in the ontology for decision support purposes, in this case, the diagnosis of diseases, and to provide a standard vocabulary for integrating phytopathology data sources. The system was evaluated for the diagnosis of diseases presented in short-cycle and perennial crops achieving promising results based on the F-measure metric.

KEYWORDS

Agriculture, Crops, Disease Diagnosis, Ontologies, Symptom

INTRODUCTION

There are several cities and countries whose population depends on agriculture. The management of short-cycle and perennial crops demands close monitoring especially regarding disease management because these ones can affect significantly both production and post-harvest life. In fact, it is well-known that diseases cause heavy crop losses amounting to several billion dollars annually. The identification of disease symptoms plays a critical role in the successful cultivation of crops. A symptom is a phenome accompanying something, in this case, a plant disease, and is regarded as evidence of its existence (Patil & Kumar, 2011). Some of these symptoms are visually observable on the leaves or stems of plants, which allows farmers to diagnose the specific disease their crops are facing, and to take proactive actions aiming to avoid the spread of the disease. However, the diagnosis of diseases is a challenging task since many symptoms should be considered and there are diseases that share some symptoms. This situation makes a proper diagnosis becomes a knowledge handling problem. Therefore, there is a need for farmers to know which disease is related to a specific set of symptoms aiming to avoid a bad diagnosis that causes the application of wrong control measures, thus aggravating the state of the crop rather than controlling the disease.

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Plant pathology, also known as phytopathology, is the study of the living entities and the environmental conditions that cause disease in plants, the mechanisms by which these factors produce them, the interactions between the causal agents and the plant, and the methods of preventing or controlling this kind of diseases (Agrios, 2012). In this sense, there is a clear need for new ways in which scientific knowledge, in this case, phytopathology knowledge, can be incorporated into tools that assist farmers in making farm management decisions (Jakku & Thorburn, 2010). An outstanding example of this kind of tools are the decision support systems (DSSs). DSSs makes agricultural science more accessible to and useful for farmers (McCown, 2002) thus helping them to overcome knowledge handling problems because they can take advantage of the knowledge that experts use to diagnose a disease.

The semantic web has emerged as a new approach which main goal is to provide to Web information with a well-defined meaning and make it understandable not only by humans but also by computers (Berners-Lee, Hendler, Lassila, et al., 2001). Thanks to this, computers can automate, integrate and reuse high-quality information from distributed information sources. In the Semantic Web, ontologies are the main tool for tasks above mentioned. An ontology is a formal and explicit specification of a shared conceptualization (Studer, Benjamins, & Fensel, 1998). The use of ontologies has significantly grown and is being successfully applied to different domains such as question-answering over Linked Data (Paredes-Valverde, Valencia-García, Rodríguez-García, Colomo-Palacios, & Alor-Hernández, 2015), finances (Salas-Zárate, Valencia-García, Ruiz-Martínez, & Colomo-Palacios, 2016), cloud services (Rodríguez-García, Valencia-García, García-Sánchez, & Samper-Zapater, 2014b), opinion mining (Peñalver-Martinez et al., 2014), recommender systems (Colombo-Mendoza, Valencia-García, Rodríguez-González, Alor-Hernández, & Samper-Zapater, 2015), and human perception (Prieto-González, Stantchev, & Colomo-Palacios, 2014).

Based on the described above, farmers need clear guidelines to effectively perform crops monitoring, and then make decisions based on right recommendations. In this work, a decision support system for plant diseases diagnosis is presented. This system takes advantage of semantic technologies, more specifically of ontologies, to model the domain of plant pathology through the description of concepts related to plant diseases, their symptoms, and the living agents and environmental conditions that produce them. In fact, this system is based on the experience of domain experts. In this way, when a farmer detects warning signs of the presence of a disease, he/she provides the system the symptoms detected. Then, the system diagnoses the disease based on the list of symptoms provided by the user. For this purpose, the system uses the knowledge contained in the semantic repository and a rule-based engine to infer both the diseases and disease-specific recommendations that help farmers to counteract the disease.

The rest of this paper is arranged as follows. Section 2 describes the state-of-the-art concerning technologies involved in this work. Section 3 outlines the overall architecture of the system and provides a description in detail of each of its components. Section 4 introduces a case study that was established to evaluate the effectiveness of the system. Finally, conclusions and future work are presented.

STATE-OF-THE-ART

There is an increasing interest in the development of DSSs to improve practice in different domains. For instance, in the clinical domain there are works such as (García-Crespo, Rodríguez, Mencke, Gómez-Berbís, & Colomo-Palacios, 2010; Kuo & Fuh, 2011; Rodríguez-González et al., 2012) that proposed DSSs to assist the interpretation of health examination results of healthcare receivers and perform medical diagnoses. These systems are based on rules and semantic technologies that aims
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