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# 基于语义本体的柑橘肥水管理决策支持系统

# A decision support system for fertilization and irrigation management of citrus based on semantic ontology

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中文摘要:

利用信息技术实现柑橘精准生产管理是果树信息化管理的重点和难点。该文针对山地果园肥水信息化精准管理问题，研发了基于语义本体的柑橘肥水管理决策支持系统。柑橘肥水语义本体是决策支持系统的核心，它以资源描述框架三元组整合涉农信息。系统实现了施肥、生理病害防治和排灌监测3个功能。系统验证结果表明：1）施肥查询模块能够根据树龄、施肥时期、土壤质地、地形和产量5个因素计算氮、磷、钾施肥量，经216组数据验证其输出正确率100%；2）经100组涵盖12种营养素缺乏和过剩生理病害数据验证，病症查询模块能够根据输入病症正确判断生理病害；3）排灌检测模块能根据不同土壤质地对排灌实时监测，经小型气象站获取的土壤含水率数据验证，系统正确预警率达100%。经361组性能测试数据结果表明系统平均响应时间在0.23 s(浏览器端应用)和0.58 s（手机端应用）内，具备较优性能。该研究为农业领域知识建模和异构多源数据整合等问题提供了可行方案。

英文摘要:

Abstract: The key problems for realizing precision agriculture include integrating heterogeneous and multi-source agricultural information, developing localization agricultural resources, and providing personalized and active information services for individual farmers. In this paper, we present an approach to precision farming in citrus production management by using semantic technology.In our work, the first step was to transfer the expert knowledge existing in technical reports and books into the citrus fertilization and irrigation ontology that could be understood and directly computed by computer systems. By developing the ontology based on the semantic technology such as the resource framework description triples graph, heterogeneous and multi-source information was integrated into computable localization resources. We described how knowledge in the form of texts, pictures, and tables were encoded into resource description framework triples respectively. In addition, we also discussed how to establish properties, which is a difficulty in ontology development. Our ontology development process was supported by a set of professional tools: TopBraid Composer, the world's most powerful modeling environment, and Gruff, a graphical triple-store browser. We created 31 properties in total and used another five standard properties from the Semantic Web standards. As our aim for building the ontology was to support the decision making for citrus production management, our citrus ontology was not just taxonomy for the citrus management knowledge compared to the existing agricultural ontologies.Then we developed a personalized decision support system for citrus fertilization and irrigation management, based on the ontology. Different from the existing agricultural information services, our system can actively provide personalized production management instructions for individual farmers via multiple terminal devices, including mobile phones and Web browsers. The demo application was implemented using JSP/Servlet. The citrus ontology was loaded into a high performance semantic database system: AllegroGraph 4.10. Applications accessed semantic data via the Java Sesame application programming interface. The real time data from orchards, such as soil sensor records, were stored in relational databases. The demo decision support system had three major functionalities: fertilization management, physiological disease control, and irrigation management. The fertilization management functionality helps farmers fertilize their citrus orchards in the four major lifecycles of citrus. The physiological disease control functionality helps farmers react to nutrient deficiency or excess. The irrigation management functionality provides a real time monitoring and instructions for orchards watering and drainage.We have conducted system validation for the three modules. By testing the fertilization module with 216 data, it generated correct outputs according to the 5 factors: age, lifecycle, soil type, terrain and yield. The physiological disease control module was validated by 100 data, which covered 12 nutrients excess and deficiency diseases. The results showed that the system could correctly detect diseases. The drainage and irrigation monitor module was tested using historical soil moisture data, and the results showed that the system could correctly alarm for abnormal conditions. Finally, the system performance was tested with 361 inputs. The average response time is within 0.23 s for Web browser application and 0.58 for mobile application.This research provides a feasible solution to the problems of precision agriculture. We have demonstrated how expert knowledge in different forms can be transformed into a computable localization resource -- semantic ontology. This kind of transformation solves the problem of integrating and modeling heterogeneous and multi-source agricultural data. In addition, the semantic ontology and triple-store have a good scalability that can be continuously extended during the interaction with farmers and experts. The developed demo system can provide active and personalized instructions for individual farmers to guide them in orchard management with expert knowledge. Our research puts forward a solution to intelligent agriculture. Although this research focused on Chongqing citrus farming, the presented results can be applied to other crops and regions in China.