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Research Article

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Construction and application of the expert system of diagnosis for orchard pests and diseases

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ABSTRACT

As the rapid growth in computer technology, agricultural informatization is becoming a powerful tool that overcomes the weakness of conventional agriculture, and the agricultural expert system will be the impulsive factor as well. The expert system of diagnosis for orchard pests and diseases developed in this paper is based on the research in expert system, production rule reasoning, Web technology etc.,integrating the characteristic of pomology. This system combines the knowledge framework of orchard pests and diseases diagnosis with expert system technology, enabling the users to diagnose orchard pests and diseases, and acquire the related information and controlstrategies of these pests and diseaseswhich has highly comprehensiveness and value in use. Using this system, the level of prevention from diseases will be improved, so will the agricultural technology.It can also prevent or reduce disaster losses, and then improve the economic, ecological and social benefits.

Key words: orchard pests and diseases, diagnosis, expert system, economic benefit

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INTRODUCTION

Recently, the expert system for agriculture developed rapidly, which can be used to solve the laggard consultation problems in the agriculture [1]. At present in China, however, the diagnosis, recognition and prevention technologiesof orchard pests and diseases are mainly impartedby the agricultural technicians. Lacking technicians method is limited since it is distributed and not systematic, leading to that the knowledge are hard for fruit growers to possess. Therefore,the expert system of diagnosis for orchard pests and diseases is developed to help agricultural experts and to become a new service mode for training technical staff in agriculture and guidance for orchards.

Since 1980s, agricultural information technology has been applied into all kinds of fieldsof agriculture, and the agriculture expert system, as one of those technologies, has been applied widely [2-3]. In 1978, the researchers in University of Illinois, USA developed the expert system Plant/DS for soybean pests and diseases diagnosis. In 1983, the researchers in Chiba University, Japan developed MICC – the expert system for tomato pests and diseases diagnosis [4]. In China, there are several diagnosis systems as well, such as the practical litchi pests diagnosis expert system developed by Horticultural Research Institute, Guangxi Academy of Agricultural Sciences, the expert system of grape rooting zone restriction precision culture developed by ZhengpingXue et al. and the orchard-oriented decision support system for pest control on apple and pear developed by Shuhua Liu et al. [5-8]. But those technologies are not well-developed since they are too specific to be applied generally, so they need to be developed with pomology and agriculture.

This paperdesigns the reasoning rules for orchard pests and disease diagnosis based on production rule reasoning, and implements the system using JavaScript and SQL Server. Combining with pomology, this system utilizes advanced computer theory and technology to effectively imitate and assist experts to complete parts of their works. Additionally, this system providestechnical guidance andservices for fruit growers via Internet. The research in this

paper implements the integration and innovation of orchard pests and diseases and information technology, builds a modern expert system intelligent service platform as well which can disseminate knowledge in orchard pests and diseases quickly, extensively and effectively. Using this system can reduce disaster losses and the use of pesticides.The level of diagnosis and prevention of pests and diseases can be improved. Furthermore, good economic, ecological and social benefits will be obtained.

EXPERIMENTALSECTION

Production RuleReasoning

The production rule reasoning can be formed as follows: IF A THEN B (A → B), where A is the antecedent, used to indicate whether production is available, B is a group of conclusion or consequent, which can be got when conditions in A are met [9, 10]. We present an example to illustrate theproduction rule reasoning.

Problem: Given the rules: A∧B→C; A∧C→D; B∧C→G; B∧E→F; D→E. If A and B are known, how could we get F?

Solution: We rewrite the rules above in the forms of production rule reasoning:
(1) IF A AND B THEN C;
(2) IF A AND C THEN D;
(3) IF B AND C THEN G;
(4) IF B AND E THEN F;
(5) IF D THEN E.

According to the problem, we see that A and B satisfy rule (1), and then we get C by executing rule (1), and get A, B and C by updating the database. Then, we see that rule (2) and (3) are satisfied.According to the strategy that rules in the front execute first, we choose rule (2) to get D. Then update the database and repeat such steps. Rule (3), (5) and (4) are executed successively, and we get F finally. The detailed process is shown in the Table 1.

Table 1. Reasoning process of production rules

Comprehensive database	Rules can be triggered	Rule being triggered
A，B	（1）	（1）
A，B，C	（2）（3）	（2）
A，B，C，D	（3）（5）	（3）
A，B，C，D，G	（5）	（5）
A，B，C，D，G，E	（4）	（4）

The diagnosis service in our system is based on IF-THEN production rule reasoning, whose reasoning relationship can be described as: Select illness symptoms → Species of fruit trees →Diseased parts →Symptom description →The results of the diagnostic reasoning. The production rule is: IF Species of fruit trees AND IF Onset position (Pest Genus) AND IFSymptom THENOrchard pests and diseases. The system uses this production rule and AND operator to connect the input information from the webpage, and finally complete the process. Surely, in this process, no step should be ignored and the reasoning order should not be reversed as well, otherwise, the diagnostic results would be affected.

The Design of the Database

Our system contains five tables:Users, Basic Information of Fruit Diseases,Basic Information of Fruit Pests, Picture Information of Fruit Diseases and Picture Information of Fruit Pests. The relations between them are shown in the Figure 1.

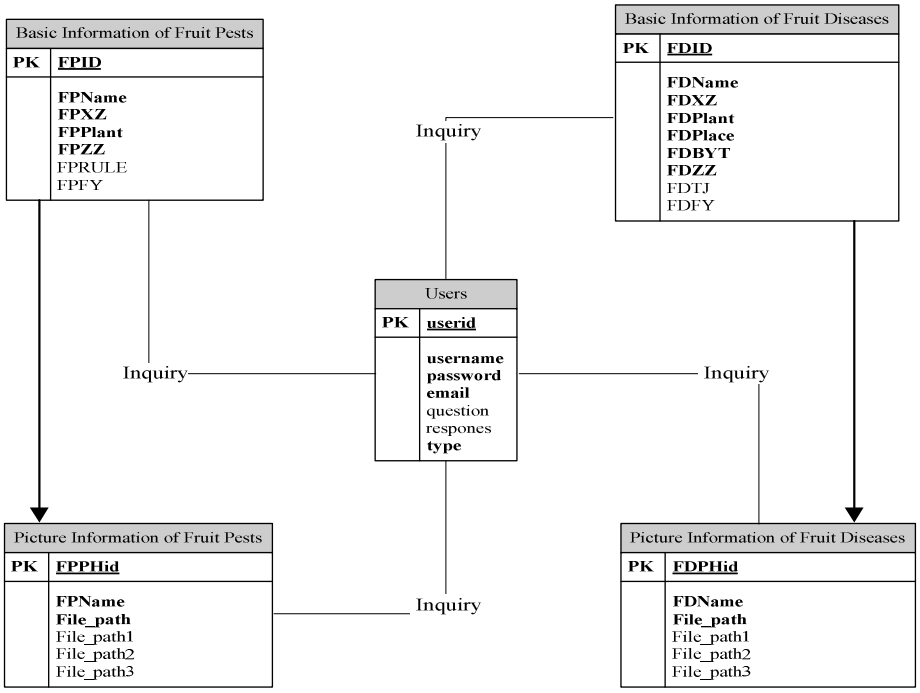

Figure 1: Data model diagram

Overall Framework of the System

System Service

This system has two services which are shown in Figure 2: foreground and background management.

(1) Foreground management: Users can browse into this interface after log in. Then they can inquire some orchard pests and diseases, browse pictures and diagnose certain diseases. Additionally, they can modify and restore their passwords.

(2) Background management: Only managers can log in this interface where they can modify and delete regular users' information. Whatever the basic information or pictures of orchard pests and diseases can be added, deleted and modified.

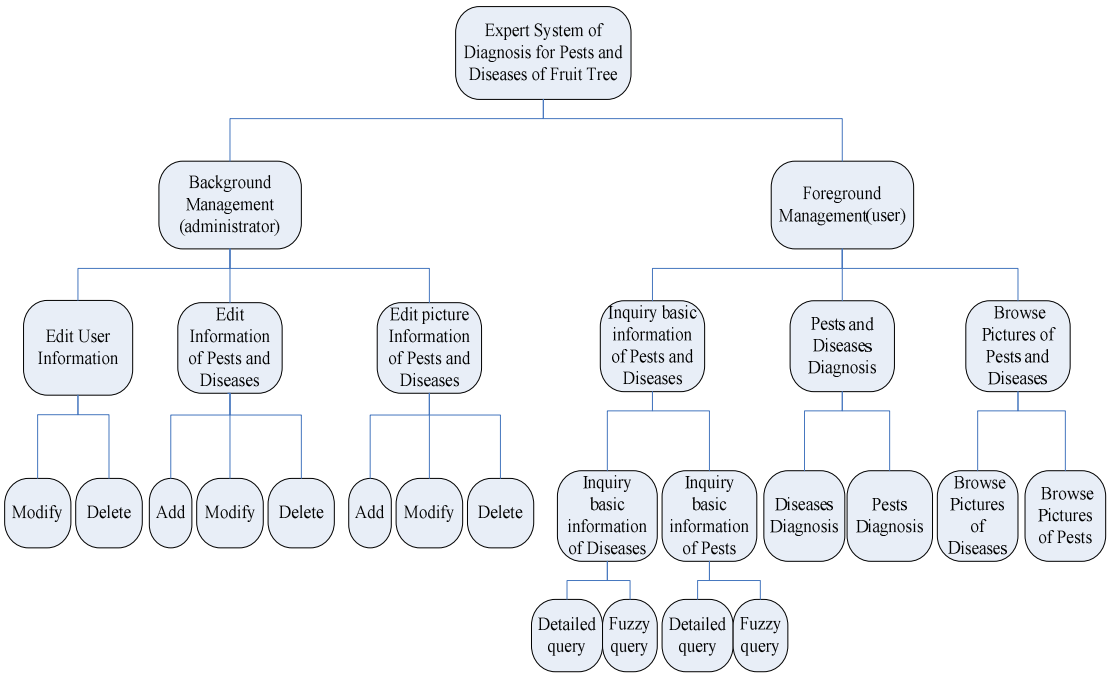

Figure 2: Overall framework

Logical Structure of the System

Our system consistsof knowledge base, interfaces, database and inference engine [11, 12]. First of all, the experts load the knowledge into the database and the knowledge base, and then users choose a certain fact.The inference engine will be used to match the knowledge base and database, andfinally it shows the result as feedback to the users. This structure is depicted in the Figure 3.

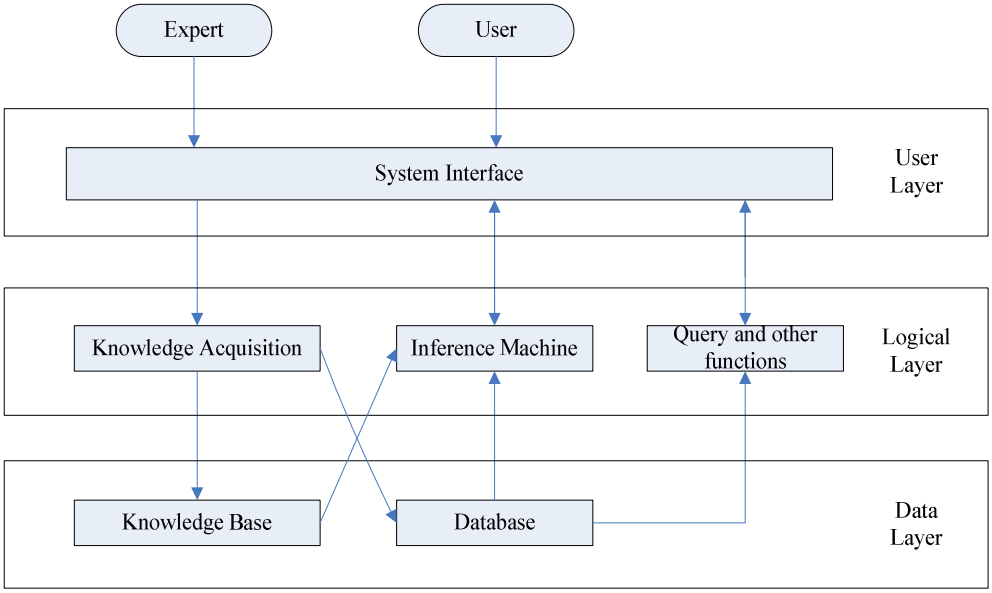

Figure 3:Logical structure

RESULTS AND DISCUSSION

The difficulty of the expert system is the obtaining and representation of knowledge, namely, how to create basic database and knowledge base logically. Obtaining knowledgeis the prerequisite of the construction of the expert system, whereas the representation is the important part [13]. The database we use consists of five tables, and their relations are discussed above in details. The knowledge base consists of information table of pests anddiseases and their relations.

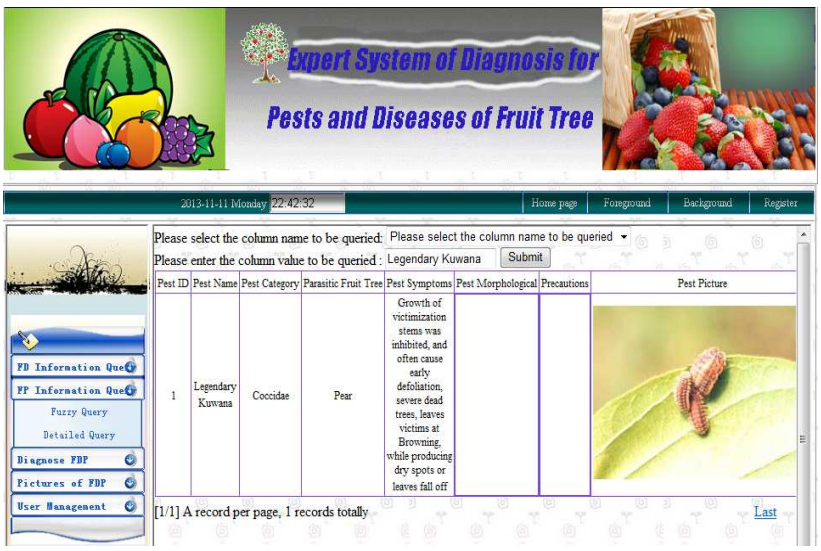

Figure 4: Results page of pest information query

This paper usesproduction rules to express the domain knowledge as the form “IF fact THEN result”. After comprehensively collecting the knowledge about orchard pests and diseases, we store them into the database. Then based on “IF fact THEN result”, the system obtains the knowledge in depth and completes the building of the knowledge. Finally, all the knowledge will be stored into the knowledge base, and the obtaining process is

completed.

This paper uses Eclipse and SQL Server to build the system.

1. Foreground
Users can click “Foreground” in the front page to enter the user login page. After login, user enters the foreground management page for appropriate action.

(1)Results of diseases and pests query module
The query includes: orchard diseases and pests diseases, and their detailed and fuzzy queries respectively. This paper takes the detailed query of orchard diseases for example. First, users choose “FP Information Query”, then the “Detailed Query”. Next, users input the information which they want to inquiry and click the button “submit”. The result is shown in the Figure 4.

(2) Results of diseases and pests diagnostic module
The diagnosis includes orchard pests and orchard diseases diagnosis. This paper takes orchard diseases diagnosis as an example. First, click “Diagnose FDP”. Then choose “Diagnose FD”. The result is shown in the Figure 5.

Figure 5: Results page of disease information diagnosis

Via continuous choosing and submission to narrow the scope of pests and diseases, users can get an accurate diagnosis result finally.Users can get the results of fruit pests and diseases from the diagnostic details, including name of pest or disease, hazard location, clinical characteristics, prevention measures, pictures, etc. Users can make a choice about the information according to their own situation.

(3) Results of diseases and pests picture browsing module
The picture browser includes two parts: orchard pests and orchard diseases.

2. Background
Choose “Background” to login in as an administrator. Administrator can achieve the management of basic information and pictures of fruit pests and diseases. The details are not shown here.

The prevention from orchard pests and diseases plays a critical role in the life cycle and management of orchards, which means a lot to prolong the life of orchards, increase fruit harvest years, and improve the production and quality of orchards. Though expert system can provide preventioninformation in time, they are too specific to be applied widely. In terms of this disadvantage, this paper provides orchard pests and diseases information in a wide range, including 111 diseases’ information, 100 pests’ information, around 500 diseases’pictures and 400 pests’ pictures. Additionally, the system provides automatedidentification and recognition function of orchard pests and diseases name, functions ofassistant diagnosis, browse, query, learning, strategy decision and forecast etc, and visualizedmanagement tools of information dissemination, diagnosis prevention and predictions. This paper

improves thetimeliness and specific aim in the sense of controlling orchard pests and diseases, and of the security of the fruits.

In the query mode, this system provides three functions according to different levels of users: based on the names of pests and diseases, based on pictures of pests and diseases, based on selection continually. Here, users can click or type corresponding keywords to obtain the information, which simplifies the operation. In addition to the information about orchard pests and diseases in the result of query, the system also provides the prevention methods. What's more, this system will alert the users the information about prevention based on weather forecast, since it is highly related to the plants. The various methods discussed above not only implement the agricultural management scientifically with information technology, but also drive the development steadilyin the field of orchard planting, not only improve the economic efficiency of fruit industry, but also stop pests and diseases in time when they occur.

The expert system in this paper has such advantages: high-level knowledge, with massive information, practical, systematic, reliable, fast and easy. Additionally, the expert system combiningwith pictures makes it easily accessible to most people. By the virtue of software, this system promotesexperts' diagnosis and control techniquesabout orchard pests and diseases and improves scientific management through the scientific and effective system. Thus the goal of good and effectiveprevention can be achieved.Based onthe "prevention" ideas, this paper uses information technology to build preventive pestsand diseases control system, and promotes the information technology applied in the sustainable agriculture.

CONCLUSION

This paper designs an expert system of diagnosis for orchard pests and diseases based on expert system, production rule reasoning and Web technology. This system combines knowledge framework of pests and diseases diagnosis with expert system technology, making the users can diagnose the diseases and obtain related information and prevention strategy through inquiring.Our system will develop the management of orchard pests and diseases scientifically with advanced information technology, improve the overall management level of orchard pests and diseases, bring the economic, ecological and sociological benefit, and make contributions to the development of excellent, efficient and sustainable modernization of agriculture.

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