TPPADS: an expert system based on multi-branch structure for Tianjin planting pest assistant diagnosis

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Abstract: At present, green plants exist in all aspects of our lives. And statistics shows that the pest species of green plants is very large. Thus accurate and rapid diagnosis is regarded as an essential component of green plant protection. Moreover, we couldn't find relevant information easily. That is why pest diagnosis is difficult and inefficient for technicians and farmers. In view of the above, the expert systems have been widely used in pest identification. However, most of traditional expert systems for assistant diagnosis of green plant pests are based on dichotomous structure. They are not flexible enough and only equal the electronic dichotomous keys. Compared with dichotomous structure, the system based on multi-branch structure has more advantages for accurate and rapid diagnosis. This paper describes the design and development of a web-based green plant pest expert system as part of Tianjin science and technology cooperation project. Based on user needs, Tianjin Planting Pest Assistant Diagnosis System (TPPADS) was developed with ASP.NET, C# and Microsoft SQL server 2008 database. It can show many features simultaneously. Meanwhile, data maintaining is also very easy and simple as same as the Microsoft Windows Explorer. The system included about more than 300 species of green plant pests. Diagnosis knowledge was obtained from Tianjin Institute of Plant Protection. TPPADS can be used as a diagnosis tool and information database both for plant protection professionals and farmers. We believe its application prospect should be well.
Key words: green plant, expert system, multi-branch structure, pest diagnosis

1. INTRODUCTION

At present, green plants exist in all aspects of our lives. And statistics shows that the

pest species of green plants is very large. There are about 500 kinds of pests, who can harm green plants in Tianjin, which is one of the supper cities in China. Identification of pests is very difficult for farmers and technicians. Not only pests' information is not enough to meet the needs of farmers and technicians, but also the expert resources of green plant pest are very scarce. Usually, human experts are needed to provide the diagnostic knowledge, however, in some areas, pest management experts are not readily available to carry out disease diagnosis or insect identification [1]. Meanwhile, Lack of database or expert system is one of the reasons for this situation. They find information difficulty, such as biological characteristics, control method, pest images, etc.

Expert systems (ES) are a branch of applied artificial intelligence (AI), and were developed by the AI community in the mid-1960s. The basic idea behind ES is simply that expertise, which is the vast body of task-specific knowledge, is transferred from a human to a computer [2]. The essence of an expert system is to mimic expertise and distribute expert knowledge into non-experts' hands. This can be enhanced significantly by using the Internet. ES solutions are based on reasoning by using problem domain knowledge and heuristics. Hence, ES approach is the most suitable methodology for simulating human experts. Most of the ESs for ship design is aimed at development of assistance to deal with the complex characteristics of design problem[3].

Expert systems have been applied in agriculture from 1980s [4-20]. Most of them are developed for crop production and pest management[21-26], animal husbandry and aquaculture[27-30]. At the same time, ESs are also widely used in forestry, medicine, industry etc[31-33]. Some are stand-alone early [34-37], many of them are web-based at present[38-41]. Some ESs also began to integrate mobile communication systems, GIS technology etc[42-44].

This paper discusses our experience in developing and evaluating a web-based expert system for identification of green plant pests, named as TPPADS (Tianjin Planting Pest Assistant Diagnosis System). The system included about more than 300 species of green plant pests. It has been developed by China Agricultural University and Tianjin Institute of Plant Protection. TPPADS could be used as a diagnosis tool and information database both for plant protection technicians and farmers.

2. USERS' NEEDS and KNOWLEDGE ACQUISITION

2.1 Users' needs

Efficient identification work is a vital to help to make a decision about the pest control measures. When applying an expert system for technicians and farmers, it is necessary to investigate both their attitudes toward that the system. Essentially, understanding their perceptions toward the tool is a crucial issue for enhancing effect of green plant protection. In order to meet the requirements of Tianjin Institute of Plant Protection work, we had several meetings to discuss the system requirements, and careful analysis. The needs analysis report shows that:

- Need of basic information in a large number of pests. Technicians and farmers couldn't find relevant information easily.
- Need of assistant diagnosis system. Accurate and rapid diagnosis is regarded as an essential component of green plant protection. That is why pest diagnosis is difficult and inefficient for technicians and farmers.
- Friendly interface and easy operation. One of the most important design considerations behind the system was that a system should be as user friendly as possible. Understanding of the user's cognitive structure and the users' task is a critical component in the development of user-centered interface design. A good interface will enhance user/expert system interaction and task performance [45]. Simple operation allows users to easily use the system.
- Interactive Consulting. Users can get experts' answer about some problems through interactive consulting on-line.

2.2 Knowledge acquisition and information collection

Knowledge acquisition (KA) is the process of transferring knowledge from the knowledge source to knowledge engineer (or expert system builder). To acquire the required knowledge, we followed the KA procedure discussed in Morpurgo[46] (Morpurgo et al., 2001) and Wada etc [47].The knowledge, symptom descriptions and the rules from domain experts, i.e. entomologist and psychopathologists.

Pest information (e.g. species' morphological characteristics, biology, geographic distribution, etc.) were acquired from experts interviews and literature such as

textbooks, primary and secondary literature, papers, etc. We also collected a large number of pictures by photographing. it's about 300 species of green plant pests in Tianjin.

3. System DESIGN AND DEVELOPMENT

3.1 Software and Database

TPPADS was designed to run on the internet. Its development was based on the use of internet techniques and SQL programming languages. It was developed with ASP.NET and C#. The server database played a very important role in developing TPPADS. It was used to sort all the information and knowledge which was needed to actualize every function of the expert system. In TPPADS, there are 5 databases including a user information database, basic information database and identification knowledge database etc. They were all designed using MS SQL Server 2008 Database.

3.2 Inference process

Amongst the different methods for representing the knowledge[48], production rules are the most frequently used for diagnostic expert systems[14,17]. A rule is composed of a list of IF conditions and a list of THEN and ELSE statements about the appropriate solution to the problem. A disadvantage of a rule-based system is that the knowledge is not organized in a real structure[49]. Most of traditional expert systems for assistant diagnosis of green plant pests are based on dichotomous structure which is rule-based. They are not flexible enough and only equal the electronic dichotomous keys. However, hierarchical structure provides a natural structure for the knowledge and allows the building of expert systems that can be easily modified and adapted. In hierarchical structure, knowledge is organized in a decision tree, with nodes at different levels. The knowledge is distributed among many nodes[50]. Compared with dichotomous structure, TPPADS based on multi-branch structure or is another form of hierarchical structure has more advantages for accurate and rapid diagnosis (Fig. 1).
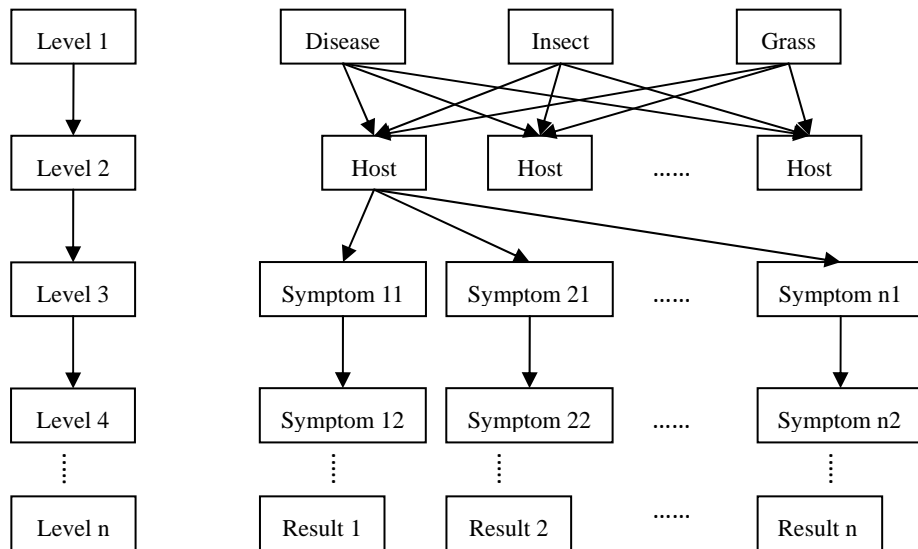
Fig.1:   The Inference diagram of multi-branch structure of TPPADS

3.3 Users interface

User interface is the direct media between users and computers. To best meet the different users' need, designers should insist on friendly principle. In another word, they should consider all users' knowledge level and ensure the interface complete, compact and easy (Fig.2). Meanwhile, data maintaining is also very easy and simple as same as the Microsoft Windows Explorer.

Fig.2: **The diagnosis page of TPPADS**

4. Discussion

Although ESs may respond faster and be more available than a human expert, are steady, unemotional, and give complete response at all times, they also do have the following disadvantages[51]:

- Some applications are difficult to use by another person who has not generated the knowledge-base.
- Some systems are very slow when compared to the human expert.
- The knowledge systems' ability tends to end abruptly.
- Sometimes, it is difficult to extract knowledge from an expert and to put it into a format that the ES can deal with and the size of the ES domain must be limited.
- The inability of ESs to exhibit common sense limits the effectiveness of present ES applications.

For expert systems, effective organization of expert knowledge has a great influence on the functions of the expert system. If it use rule-based structure, then adjusting of knowledge base becomes very difficult and the system's adaptive

capacity be reduced greatly. TPPADS adopts the multi-branch structure design, which is more suitable for various needs and the flexible adjusting to changing demands. Thereby, it may save the cost of software development and reduce maintenance difficulty.

Further work includes that increasing of pest species involved, expanding the scope of application. Secondly, we should train technicians and farmers for using of the system. However, conceptually expert systems should not be considered absolutely valid or absolutely invalid, as the overall system evaluation is a continuous process and an ongoing endeavor helping to ensure maximum usage of the developed expert system[22]. So we must publicize the system as possible as more people can know and use it. The system included about more than 300 species of green plant pests. Diagnosis knowledge was obtained from Tianjin Institute of Plant Protection. TPPADS can be used as a diagnosis tool and information database both for plant protection professionals and farmers. We believe its application prospect should be well.

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