Design and implementation of a selenium-rich grape disease diagnosis expert system

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Abstract: In order to solve the problem of disease in the process of grape growing in facilities, a web-based expert system for diagnosis of selenium-rich grape disease was designed. The system took the common grape diseases as the research object, and the traditional experience and the expert knowledge transformation was used as the diagnosis rules. It provided remote support and services to the grape farmers through the Internet by using the ADO technology as the object-oriented interface, the ASP.NET for web design and the HTML language for the system development. This study adopted the method of artificial acquisition to collect and collate the knowledge and adopted the method of combining forward and reverse reasoning to solve the problem that may be a conflict in the process of disease and symptoms matching. By adding, modifying, deleting and querying the data in the knowledge base, the grape disease diagnosis was achieved. The system has the features of safe, simple and practical.

Keywords: selenium-rich grape, disease diagnosis, expert system

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1 Introduction

With the improvement of living standards, people also have higher demand for daily intake of nutrients in food. The selenium-rich grapes have achieved a lot of attention in recent years because it is rich in selenium elements and a variety of other nutrient elements as well, which can be a supplement to the daily needs of people (Chen et al., 2013). Therefore, it will have broad market prospects to vigorously develop the facility selenium-rich grape cultivation and improve its production.

The selenium-enriched grape facilities are based on the full use of natural environmental conditions, including the greenhouse, plastic sheds and shelters and other protection facilities, to improve or control the environmental factors within the facilities and provide appropriate environmental conditions for the growth and development of selenium-rich grapes (Li et al., 2010; Yan et al., 2013; Wang et al., 2009). As the temperature and humidity in the facilities are obviously higher than those in the open field, the plant growth is relatively dense and young. The occurrence of the disease to the selenium-enriched grapes in the facilities is often earlier and sudden, even more complex, which brings some difficulties in identification, prevention and control of the disease (Li et al., 2015; Zhao et al., 2014). Therefore, it is of great practical significance to understand the characteristics of the selenium-rich grape diseases in the facilities and to diagnose them in time to minimize the damage.

In recent years, with the rapid development of computer technology, agricultural expert system has also made great progress, and is widely used in many aspects of agricultural production management with huge economic and social benefits.

The study of agricultural expert systems originated in the late 1970s, with the earliest in the United States (Ge et al., 2008; Wu et al., 2008). China's agricultural expert system research began in the 1980s. Zhejiang University

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and the Institute of Sericulture of the Chinese Academy of Agricultural Sciences cooperated to study the expert system of silkworm breeding in 1980. The Institute of Intelligent Machinery of the Chinese Academy of Sciences and the Soil and Fertilizer Institute of Anhui Academy of Agricultural Sciences worked together to develop a mortar black soil wheat fertilization expert system, which had a large scale of application in more than ten counties in the city of Huaibei, and Anhui Province in 1983 (Ma et al., 2005; Yu et al., 2015). Li et al. (2002) developed a web-based diagnosis system for fish disease in 2002. The system used 300 rules, 400 images and charts to construct a web-based expert system to identify fish disorders, which could identify 126 diseases of 9 species of freshwater fish. Duan et al. (2003) had further developed a web-based remote diagnosis system for fish diseases, including synchronous and asynchronous diagnostic systems in 2003. Xu et al. (2006) designed and developed a web-based citrus production expert system, using the forward reasoning on the citrus' diagnosis of 183 kinds of nutrient and pests and diseases, and putting forward corresponding preventive measures and methods in 2006. Chen et al. (2006) designed and developed a web-based tobacco expert system to collect and compile 121 kinds of tobacco nutrition diagnosis and pest diseases with more than 1,000 pictures and video clips. Then the tobacco experts summarized out more than 100 kinds of tobacco pests and weeds, and the relationships the concepts were described in a regular form (Chen et al., 2006). Jin et al. (2009) designed and developed an expert system of grape disease diagnosis based on artificial neural network, and analyzed the symptoms in five infestation sites including grape roots, dendrites, leaves, inflorescence and ears, which could diagnose 18 diseases of grapes. Liu et al. (2011) studied and designed an artificial neural network based diagnosis system for apple disease in 2011. Pertot et al. (2012) designed a web-based plant disease identification system. Sun et al. (2013) used a three-layered B/S architecture to design a crop pest diagnosis system, which was queryable, diagnosable and consultable in 2013. Tan et al. (2014) used computer vision technology combined with BP Artificial Neural Network (ANN) to identify the soybeans with gray leaf spot, mothy soybeans, moldy soybeans and damaged soybeans in 2014. Xu et al. (2014) focused on the three common diseases in sunflower leaves including bacterial leaf spot, black spot and downy mildew disease and developed a sunflower leaf disease diagnosis system based on image recognition in 2014. Xue et al. (2015) designed and developed an Android-based identification of new potato pest's diagnostic system in 2015. Liu et al. (2016) designed a WebGIS-based tobacco pest diagnosis and prediction system in 2016.

At present, it is no longer a vision for the computers entering into the rural areas for the majority of farmers to provide a variety of advisory services. Therefore, it is a feasible and meaningful thing to study how to effectively use the computer to spread the knowledge of agricultural experts to millions of households and to guide farmers to perform scientific diagnosis. This paper mainly includes two parts. Firstly, in the process of system construction, knowledge of a wide range of selenium-rich grape in facilities was collected from a large number of channels for the construction of a database. Secondly, a web-based selenium-rich grape disease diagnosis system was established to provide remote support and services for the grape growers through the internet, helping them to get accurate and objective disease diagnosis results.

2 Knowledge acquisition and presentation

2.1 knowledge acquisition

Knowledge acquisition is a very important part in the process of building a selenium-rich grape disease diagnosis expert system. The basic task of knowledge acquisition is to acquire knowledge for the expert system and establish a sound, perfect and effective knowledge base to meet the needs of solving the problems in the field. In the construction process of the system, knowledge of a wide range of selenium-rich grape in facilities was collected from a large number of channels for the construction of a database. Knowledge was collected and acquired from the knowledge sources, basically in the following three ways:

• Manual acquisition. That is, the knowledge engineers discuss with the domain experts to collect, organize and summarize the relevant knowledge, and

build up a knowledge base after reorganizing the knowledge in a manual way.

• Semi-automatic access. The computer deals with the experts through an intelligent editor tool, organizes and arranges the knowledge base in accordance with the requirements of human-computer interaction.

• Automatic access. The computer directly obtains the knowledge from the experts, books, examples and data, and continuously improves the performance of the knowledge in the acquisition process, for example, using the machine learning.

As the basic information of disease diagnosis mainly comes from the field of knowledge and expert experience, this study has taken the way of artificial acquisition of knowledge collection and finishing in order to ensure the accuracy and applicability of knowledge expression. And in the system operation, the administrator can continuously add, delete and modify knowledge through the management Interface. As the diseases features and prevention approaches of the selenium-rich grape in facilities are different from that of the common grapes cultivated in open field, in order to ensure the accuracy and applicability of the expert system and to facilitate the practical application and operation of the grassroots users, this study has collected nine of the most common grape diseases in facilities.

2.2 Knowledge representation

Because of the empirical and causal characteristics of the knowledge of the selenium-rich grape disease, this study applied the most widely used productive method to express the knowledge of the grape disease diagnosis. The term "productive" was first proposed by American mathematician E. Post in 1943, and its basic form is:

IF <condition 1>, <condition 2>, ..., <condition N> THEN <expression>

Where <condition 1>, <condition 2>, ..., <condition N> are the prerequisites for indicating whether the production is available, and each condition is a compound condition connected with "and" or "or", and the <expression> is a set of conclusions or operations that indicate the conclusions that should be drawn or the operations that should be performed when the prerequisites are met. The meaning of the whole production is that if the premise is satisfied, the action specified by the expression <expression> or the execution of <expression> can be introduced.

The disease knowledge base system has got nine common grape diseases in facilities. The diagnosis and control of diseases in the process of grape growing should be on the basis of the known information such as the site of the diseases and the symptoms to determine the types of diseases in order to make the right disease prevention or treatment decisions and control the development of the disease. The grape growth evidence obtained here uses "I" to represent a record in the disease signature, that is, a primary characteristic attribute that determines the disease. Then it can be expressed as follows.

IF I1 (disease site) AND I2 (disease symptom) $\in \alpha$, THEN D (disease name),

Where, α is the disease knowledge base, D is the disease name based on the above conditions. Some diseases have symptoms in the incidence of multiple parts such as leaves, fruits and others, which need to meet multiple symptoms at the same time to diagnose the disease results. Some typical disease diagnosis method is relatively simple, just a symptom to determine the disease name.

For example, in the grape disease diagnosis rule base, there is a production type:

IF onset site = flower AND symptoms = large amount of rot

THEN disease name = gray mold

3 System design

3.1 Design goals

The expert system tries to combine the knowledge of the planters, experts and the computer technology to establish a web-based selenium-rich in-facility grape disease diagnosis system. This system will provide remote support and services to the grape farmers, so that the experts' knowledge, experience and problem-solving methods can be promoted and inherited, so as to help grape growers to have accurate and objective diagnosis of the diseases.

3.2 Structure and function design

The functional modules of the system include: the

overview module of selenium-rich grapes in the facilities, the prevention and control modules of the selenium-enriched grape diseases, and the diagnosis and system management module of the selenium-rich grape disease. Each functional module is composed of several sub-modules as shown in Figure 1.

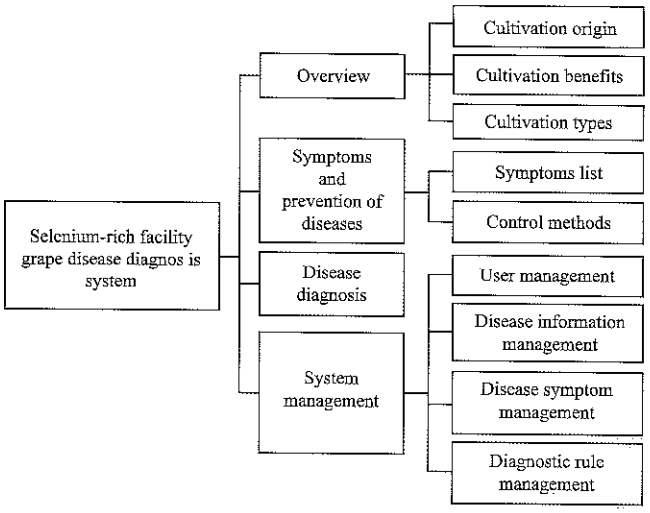


Figure 1 System function module structure diagram

The main functions of the system modules are as follows:

- In-facility grapes overview module. It introduces the basic information of the origin, cultivation benefit and cultivation type of the grapes in facilities.
- Grape disease symptoms and prevention module. It introduces the common symptoms of typical grape diseases, and the control methods of several typical grape diseases in facilities.
- Grape disease diagnosis module. It selects the disease symptoms in the fruit, leaves, flowers and spike, etc., and thus determines the type of grape diseases.
- System management module. It mainly takes management of the grape disease information database, disease symptom database, diagnostic rule base and user information database, including data addition, modification, deletion and etc.

3.3 Database and knowledge base construction

The selenium-rich grape disease diagnosis expert system is using SQL server 2000 to build the system database, and the main contents of the database include:

- The selenium-rich grape disease symptoms table

This table stores the symptoms of grape diseases, as shown in Table 1, and the symptoms set is shown in Table 2.

Table 1 Disease symptom

Field name	Data type	Length	Field description
id	int	4	Automatic identification
symptom	varchar	200	Symptom description
part	varchar	10	Disease part
image	varchar	50	Symptom image file name

Table 2 Symptoms set

id	Symptom	Part	Image
1	Rotten a lot	flower	pic1.jpg
2	White powder	fruit	pic2.jpg
3	Water-stained brown spots with expansion of depression	fruit	pic3.jpg
4	Small black spot on the lesion	fruit	pic4.jpg
5	Rust red conidia	fruit	pic5.jpg
6	Round dark brown spot with diameter of 2 mm on the surface of young fruit epidermis. As the fruit is constantly expanding, the lesion has scab-like surface. When the fruit grows into medium size, the scab falls off.	fruit	pic6.jpg
7	Black coal-like small particles	fruit	pic7.jpg
8	Hardened flesh	fruit	pic8.jpg
9	Cracked fruit	fruit	pic9.jpg
10	Stop growing	fruit	pic10.jpg
11	Mouse gray mold	fruit	pic11.jpg
12	Light brown rounded small spot	fruit	pic12.jpg
13	The middle of the spots gradually become white, depression, with the reddish-brown edge, like "bird" shape	fruit	pic13.jpg
14	Black lesions, hardening cracks	fruit	pic14.jpg
15	Brown spot	leave	pic15.jpg
16	Sporadic small yellow spots appear on the leaves, surrounded by water-like shape	leave	pic16.jpg
17	Translucent, water-like small spots with the edge not clear	leave	pic17.jpg
18	Withered	leave	pic18.jpg
19	Early fall off	leave	pic19.jpg
20	The lesion is dry and may form perforations.	leave	pic20.jpg
21	The veins are rhombic or fusiform.	leave	pic21.jpg
22	Yellow round spot with dark brown margin and light brown or gray center.	leave	pic22.jpg
23	Pale yellow lesions	leave	pic23.jpg
24	Yellow brown spot	leave	pic24.jpg
25	Yellow-green lesions	leave	pic25.jpg
26	White powder	leave	pic26.jpg
27	The back of the lesion produces white mold.	leave	pic27.jpg
28	A large number of orange-yellow powdery spores cover the leaves.	leave	pic28.jpg
29	The back of the diseased leaves has orange summer spores heap, gradually expanded along the veins.	leave	pic29.jpg
30	Crisp spike ear	fringe	pic30.jpg
31	Ear deformed, withered	fringe	pic31.jpg
32	The ear branches of the young ear produce brown water-like small spots, and quickly spread to the surroundings. The entire branch of the spike is dead in serious situation.	fringe	pic32.jpg
33	The surface has black mold and the ear has atrophy and falls off.	fringe	pic33.jpg

• Selenium-rich grape disease basic information table

This table stores the basic information of the grape disease, details the symptoms of each disease and the prevention and treatment methods, and the number of features corresponding to each disease varies. For example, there are three symptoms for the disease of gray mold. See Table 3 and Table 4 for details.

Table 3 Grape disease basic information data

Field name	Date type	Length	Field description
id	int	4	Automatic identification
Disease name	varchar	20	Disease name
symptoms	varchar	50	Basic symptom
prevention	text	16	Prevention method

Table 4 Collection of disease information

id	Disease name	Symptoms	Prevention
1	Powdery mildew	2|10|15|18|26|30|31|	Completely clear the garden. The cut diseased branches and residual leaves should be completely burned each winter. Five-degree stone sulfur mixture is spayed on the plant before germination for the eradication of winter disease. The 800 times 70% methyl thiophanate or 1500 times 15% pink rust wet powder or 400 times sulfur suspension, should be applied in the early onset of the disease and again half a month later so as to guarantee a good control effect.
2	Gray mold	1|11|15|	It is necessary to strengthen the cultivation management in the facilities and reasonably regulate water, fertilizer, temperature and water conditions, to prevent sharp steep branches, and pay attention to timely topping, fixing so as to improve the ventilation and light conditions in the facilities. Drugs should be timely applied before and after flowering. The commonly used drugs include 800 times 40% Exhale leaching agent, 50% Sumilex 200 times liquid and 1000 times 50% iprodione wettable powder. The soil moisture and air humidity within the facility should be reasonably controlled, so as to control high humidity and prevent disease induced conditions.
3	Blackpox disease	9|12|13|14|20|21|22|	Carefully clear the garden. The cut branches, leaves and weeds should be completely burned and removed in winter to reduce the source of infection in the coming year. In the two or three leaves stage, 800 times 70% carbendazim solution or 600 times 78% Kobo WP or 200 times cuproxat, etc. should be sprayed once. And then 200 times Bordeaux with half amount of lime should be applied every 15 days to effectively prevent disease. It is necessary to strengthen the cultivation and management within the facilities, increase application of phosphorus, potash fertilizer, and timely prune the tied vine so as to improve the ventilation and light conditions within the facility and promote the robust branches. Pay attention to the disinfection of seedlings, and apply 10% ferrous sulfate solution plus 1% crude sulfuric acid, or the Bome 3 degrees stone sulfur mixture to dip the seedlings for 1-2 seconds or fully spray, and then dry for planting or cutting.
4	Downy mildew	15|17|19|20|23|24|27|	The diseased branches and fallen leaves should be completely burned and removed before and after pruning in autumn to reduce the source of infection in coming winter. The five-degree stone sulfur mixture should be sprayed on the grape dendrites before germination to kill the winter pathogens. From the beginning of two or three leaves stage, the following drugs should be applied once every 7-10 days including 240 times half amount Bordeaux or 600 times 78% Kobo liquid. At the beginning of the incident, the drugs should be immediately sprayed including 300 times 40% phosphorus aluminum, 2000 times 69% enoylmorpholine or 800 times 72% Klu, 1000 times 58% Biomedium manganese zinc, etc., once every 15 days.
5	anthrax	3|4|5|	Carefully clear the garden. The diseased branches and residual branches should be thoroughly removed. The eradication agent like stone sulfur mixture should be spayed on the mother branch with fruits before sprouting. In the two or three leaves stage, full and careful spraying of 600 times 78% Kobo or 500 times 50% anthrax Ami should be done to prevent the invasion of bacteria. In the fruit coloring or early onset stage, 2000-3000 times 45% amide cream should be applied rapidly. The ear bagging should be implemented in the facilities.
6	Rust	16|18|19|25|28|29|	It is necessary to do a good clearing and overwintering control. The 3-5 degrees Be stone sulfur mixture should be sprayed before sprouting. The management with enough fertilizer to maintain a good growth potential should be strengthened, and the diseased leaves should be timely removed. The drugs should be immediately sprayed in the onset of disease, laying the emphasis on the leaves and leaves back in lower part of the plant. The main reagent includes 0.2-0.3 degrees Be stone sulfur mixture, or 15% rust wet powder 1500 times spray, or the polysulfide suspension 300-500 times, once every 15-20 days.
7	Roots of leaf b light	6|32|33|	In the inflorescence interval and one week after flowering, the following drugs should be applied once including 600 times 50% carbendazim WP or 50% thalidomide wettable powder 1000 times solution, or 800 times 50% methyl thiophanate solution.

• Selenium-rich grape disease diagnosis rules

The rules used in the diagnosis of the grape disease are stored in the table. The diagnostic rules are created and maintained by dynamically adding and deleting columns in the symptom table.

The words that add columns to the symptoms table are as follows:

alter table symptoms add 'powdery mildew 3' bit

This statement indicates that a column named "Powdery mildew 3" is added, that is, the third diagnostic rule for powdery mildew, with the data type bit.

The words that delete columns from the symptoms table are as follows:

alter table symptoms drop column 'Powdery mildew 2'

This statement means that the column named "Powdery mildew 2" is deleted, that is, the second diagnostic rule for powdery mildew removed.

Part of the collection of diagnostic rules are as shown in Table 5, with the columns of symptom, part and image

omitted. As shown in the table, when the id is 2 and 6, the value of powdery mildew 2 is TRUE and the rest is FALSE. This means that the second rule of powdery mildew is for that the disease type of the grape can be judged as powdery mildew when the symptoms of the grapes in the facility are with the id of 2 and 6.

Table 5 Part of the set of diagnostic rules

id	Powdery mildew 1	Gray mold 1	Blackpox disease 1	Downy mildew 1	Downy mildew 2	Anthrax 1	Rust 1	Rust 2	Root 1
1	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
2	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
3	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
4	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
5	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
6	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
7	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
9	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
10	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

3.4 Reasoning machine design

3.4.1 Selenium-rich grape disease diagnosis reasoning process

The reasoning process shown in Figure 2 is used in the process of grapefruit disease diagnosis according to the human thinking of disease diagnosis, combined with the experience of experts in the fields.

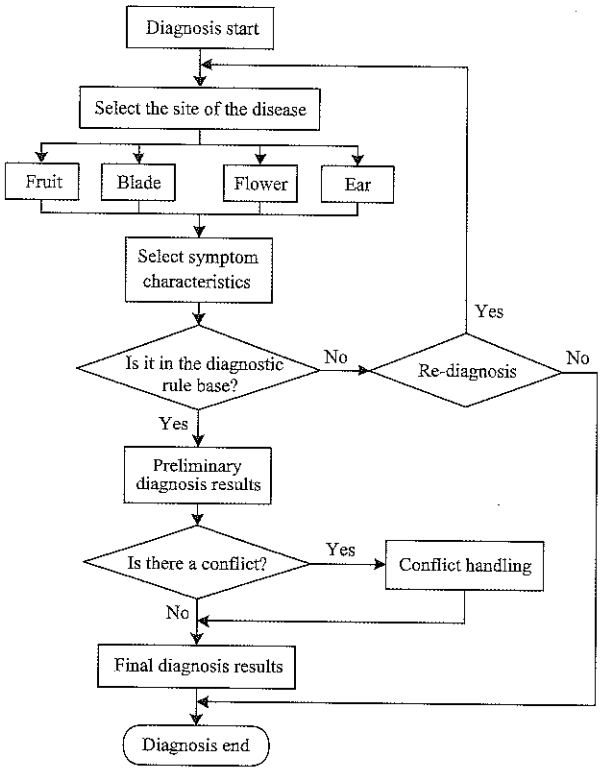


Figure 2 Reasoning process

In this study, both of the positive and negative reasoning methods are adopted according to the traditional production rules system, in which from the beginning of diagnosis to determine the possible occurrence of the disease stage, and from the onset of disease symptoms to determine the specific type of disease, it is a positive reasoning process. Using the following reasoning process to achieve positive reasoning, the rule sets are defined as follows:

Rule 1: IF P1 THEN P2

Rule 2: IF P2 THEN P3

Rule 3: IF P3 THEN q3

Where P1, P2, P3, q3 in the rules are predicate formulas. Suppose the total database has the fact P1, then these three rules are applied for forward reasoning, which is the process that is derived from P1 to infer q3. The forward reasoning link process diagram is shown in Figure 3.

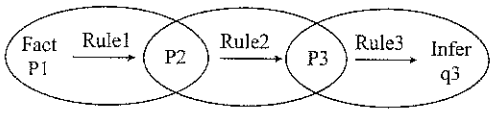


Figure 3 Forward reasoning link process

It is the reverse reasoning process that from the control of possible diseases to the selection of typical symptoms, disease period, the site of the test process, and from the disease name to the disease symptoms, with the detailed symptoms of the disease compared with the user input disease symptoms. Taking the above-mentioned three rules for example, the reverse reasoning method is applied, starting from P1 to infer q3, it is shown in Figure 4.

Firstly, it is assumed that the target q3 is true. With the rule 3 (P3→q3), it is necessary to verify that P3 is true. However, the total database does not have the fact

P3, so the sub-target P3 is assumed to be established. Then with the rule 2 (P3→P3), the P2 should be verified. Similarly, since there is no fact P2 in the database, it is assumed that the sub-target P2 is true. With the rule 1 (P1→P2) to verify P2 is true, P1 should be verified first. Because there is a fact P1 in the database, the assumed target P2 is true, and thus P3 is true, and finally the conclusion q3 is true.

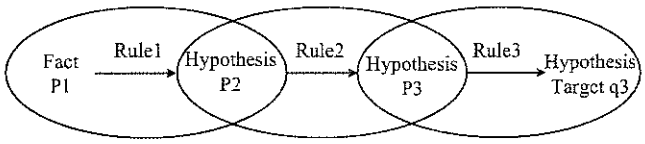


Figure 4 Reverse reasoning link process

Only after the combination of positive and negative reasoning does the final diagnosis results seem more realistic, and the effectiveness and practicality of the expert system can be increased.

3.4.2 Conflict resolution

The so-called conflict refers that in the current input of the disease information, the system infers more than one disease name, causing the phenomenon of conflict. When the user's input is complete, the system has no conflict because each disease is different from the other diseases with different symptoms. However, when the information entered by the user is the common characteristics of several diseases, the conflict may occur, so the process of the conflict is the inevitable phenomenon when the user is using the system. In the case of reasoning, this must be dealt with to ensure the effectiveness of the diagnostic results.

The system firstly uses automatic determination when it tries to resolve the conflict, and then resolves the conflict through the conflict resolution method, and finally outputs the diagnostic results. The conflict resolution rules can be expressed as:

IF <Condition> THEN <Resolution method>

where, <Condition> is the summary of the conflict, and <Resolution method> is the corresponding conflict resolution strategy, which the domain experts often used in the long-term practice and is proved to be effective conflict resolution method. The algorithm is described as follows:

Repeat

Select a conflict resolution rule R from the rule set;

Match R;

If conflict type matches successfully

Then implement the rules to resolve the conflict

Else continues

If the conflict is resolved

Then stop rule-based reasoning

Else continues to expand the rules used

If there is no rule available

Then stop rule-based reasoning

Until there is no matching conflict resolution rule

If the conflict has not been revolved at this time, the system will judge the conflict based on the information in the new rules database of the grape disease diagnosis and the information in the historical records.

If there is no relevant record in the new rules database, or if the information still fails to eliminate the conflict, the system will prompt the user to attach additional disease features as a basis for further reasoning. At this time, relying on human-computer interaction, the conflict can get a reasonable solution.

4 System implementations

The system is developed by using Visual Studio 2005 and SQL server 2000 as the development tools, ADO as the interface of the database, ASP.NET for web design, and HTML as system development language. The main interface of the system is as follows (Figures 5 to 9).

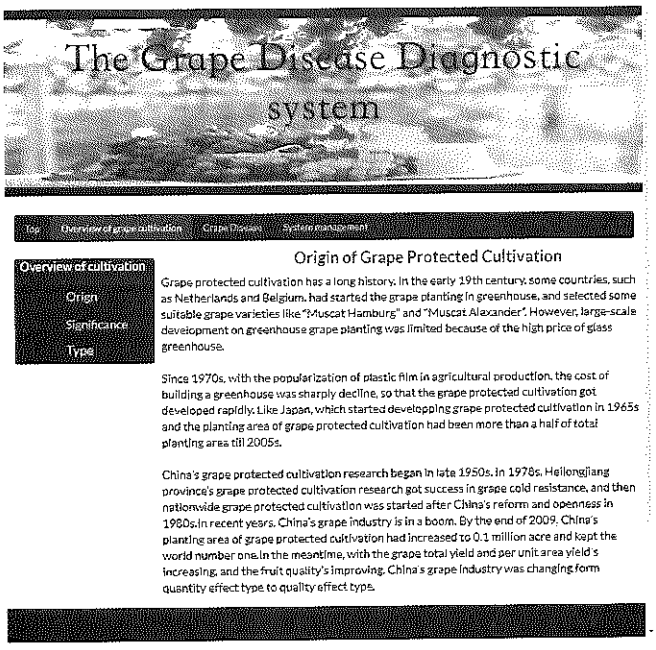


Figure 5 Grape cultivation overview interface

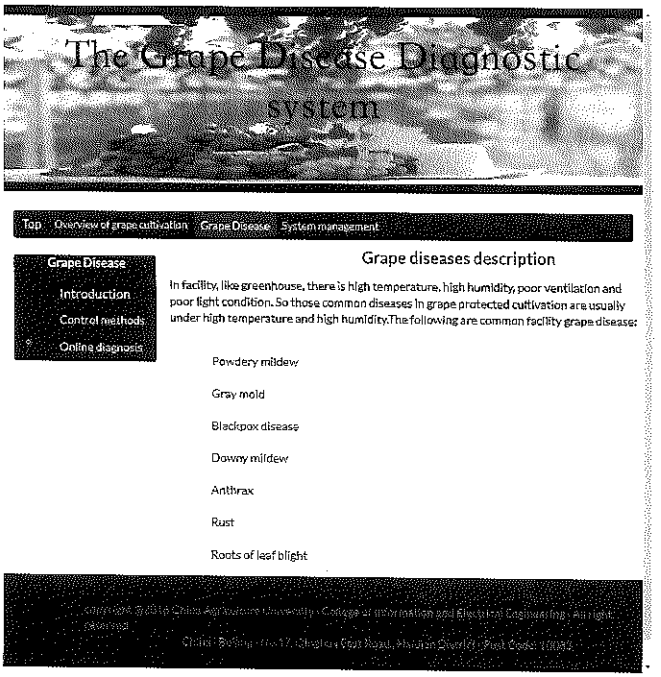


Figure 6 Grape diseases description interface

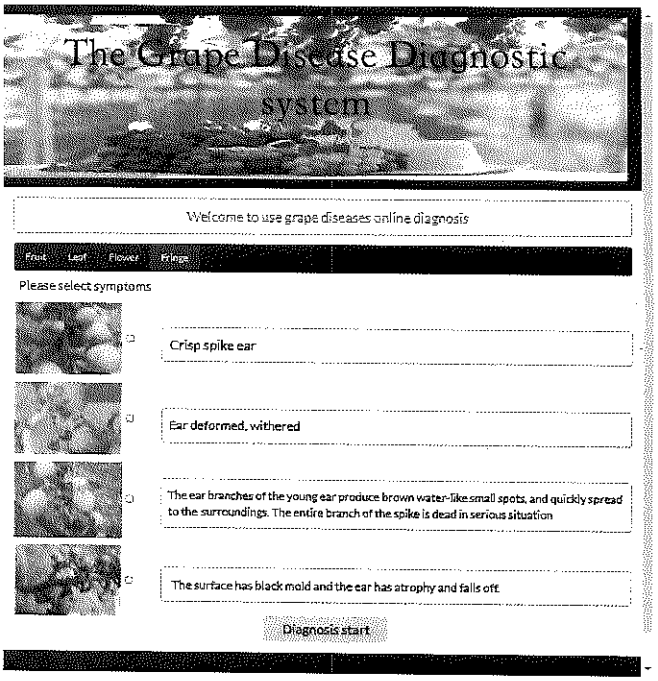
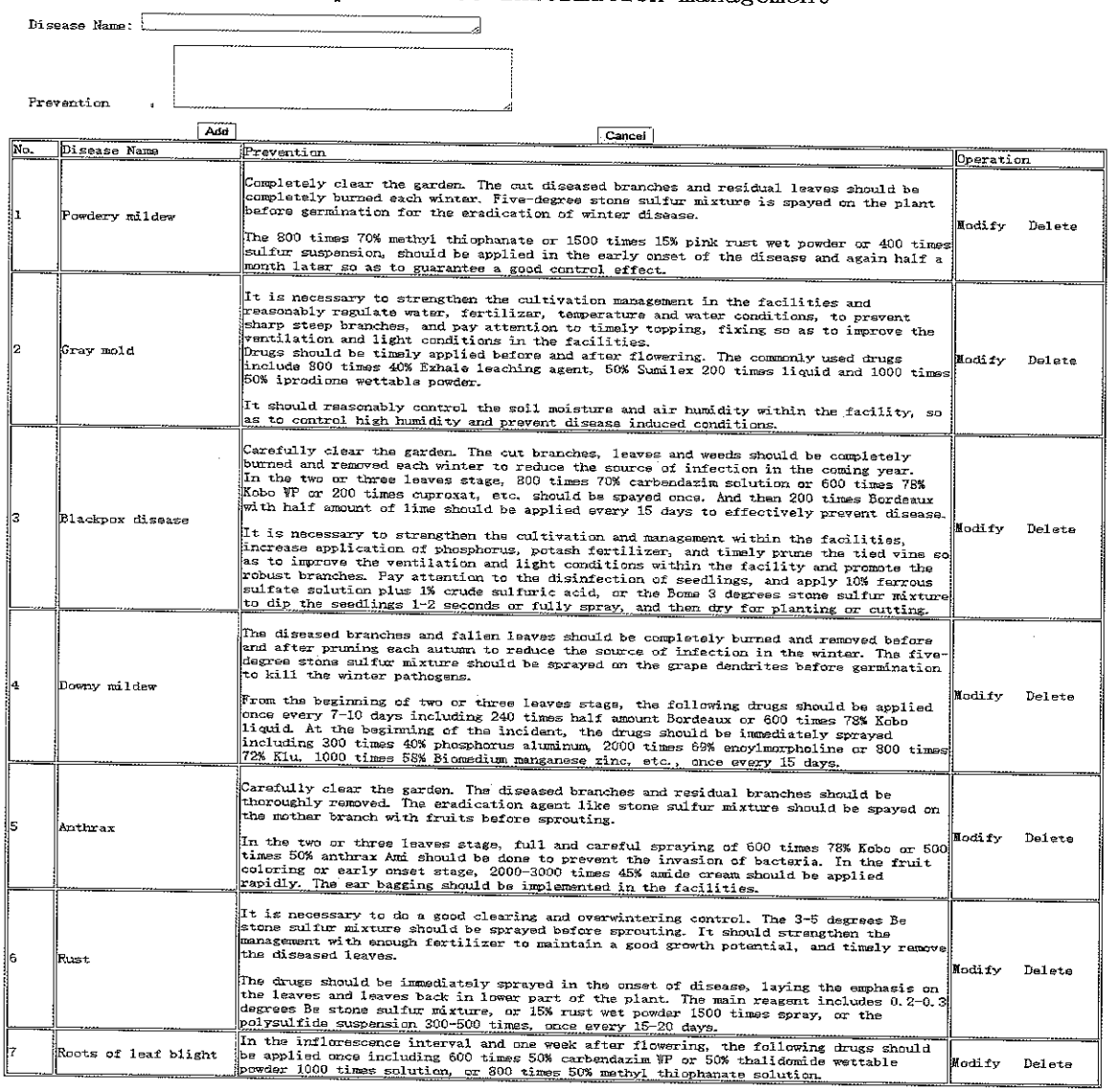


Figure 7 Grape diseases diagnostic interface



No.	Disease Name	Prevention	Operation
1	Powdery mildew	Completely clear the garden. The cut diseased branches and residual leaves should be completely burned each winter. Five-degree stone sulfur mixture is spayed on the plant before germination for the eradication of winter disease. The 800 times 70% methyl thiophanate or 1500 times 15% pink rust wet powder or 400 times sulfur suspension, should be applied in the early onset of the disease and again half a month later so as to guarantee a good control effect.	Modify Delete
2	Gray mold	It is necessary to strengthen the cultivation management in the facilities and reasonably regulate water, fertilizar, temperature and water conditions, to prevent sharp steep branches, and pay attention to timely topping, fixing so as to improve the ventilation and light conditions in the facilities. Drugs should be timely applied before and after flowering. The commonly used drugs include 800 times 40% Exhale leaching agent, 50% Sumilex 200 times liquid and 1000 times 50% iprodione wettable powder. It should reasonably control the soil moisture and air humidity within the facility, so as to control high humidity and prevent disease induced conditions.	Modify Delete
3	Blackpox disease	Carefully clear the garden. The cut branches, leaves and weeds should be completely burned and removed each winter to reduce the source of infection in the coming year. In the two or three leaves stage, 800 times 70% carbendazim solution or 600 times 75% Kobo WP or 200 times cuproxat, etc. should be spayed once. And then 200 times Bordeaux with half amount of lime should be applied every 15 days to effectively prevent disease. It is necessary to strengthen the cultivation and management within the facilities, increase application of phosphorus, potash fertilizer, and timely prune the tied vine so as to improve the ventilation and light conditions within the facility and promote the robust branches. Pay attention to the disinfection of seedlings, and apply 10% ferrous sulfate solution plus 1% crude sulfuric acid, or the Bome 3 degrees stone sulfur mixture to dip the seedlings 1-2 seconds or fully spray, and then dry for planting or cutting.	Modify Delete
4	Downy mildew	The diseased branches and fallen leaves should be completely burned and removed before and after pruning each autumn to reduce the source of infection in the winter. The five-degree stone sulfur mixture should be sprayed on the grape dendrites before germination to kill the winter pathogens. From the beginning of two or three leaves stage, the following drugs should be applied once every 7-10 days including 240 times half amount Bordeaux or 600 times 78% Kobo liquid. At the beginning of the incident, the drugs should be immediately sprayed including 300 times 40% phosphorus aluminum, 2000 times 69% enoylmorpholine or 800 times 72% Kiu, 1000 times 58% Biomedium manganese zinc, etc., once every 15 days.	Modify Delete
5	Anthrax	Carefully clear the garden. The diseased branches and residual branches should be thoroughly removed. The eradication agent like stone sulfur mixture should be spayed on the mother branch with fruits before sprouting. In the two or three leaves stage, full and careful spraying of 600 times 78% Kobo or 500 times 50% anthrax Ami should be done to prevent the invasion of bacteria. In the fruit coloring or early onset stage, 2000-3000 times 45% amide cream should be applied rapidly. The ear bagging should be implemented in the facilities.	Modify Delete
6	Rust	It is necessary to do a good clearing and overwintering control. The 3-5 degrees Be stone sulfur mixture should be sprayed before sprouting. It should strengthen the management with enough fertilizer to maintain a good growth potential, and timely remove the diseased leaves. The drugs should be immediately sprayed in the onset of disease, laying the emphasis on the leaves and leaves back in lower part of the plant. The main reagent includes 0.2-0.3 degrees Be stone sulfur mixture, or 15% rust wet powder 1500 times spray, or the polysulfide suspension 300-500 times, once every 15-20 days.	Modify Delete
7	Roots of leaf blight	In the inflorescence interval and one week after flowering, the following drugs should be applied once including 600 times 50% carbendazim WP or 50% thalidomide wettable powder 1000 times solution, or 800 times 50% methyl thiophanate solution.	Modify Delete

Figure 8 Grape disease information management interface

Grape diseases diagnostic rules management

Disease Name: Powdery mildew

Add Modify

No.	Symptom Descriptions	Diseasedparts	Powdery mildew 1	Powdery mildew 2	Powdery mildew 3
2	White powder	fruit	☑	☑	☑
3	Water-stained brown spots with expansion of depression	fruit	☐	☐	☐
4	Small black spot on the lesion	fruit	☐	☐	☐
5	Rust red conidia	fruit	☐	☐	☐
6	Round dark brown spot with diameter of 2 mm on the surface of young fruit epidermis. As the fruit is constantly expanding, the lesion has scab-like surface. When the fruit grows into medium size, the scab falls off	fruit	☐	☐	☐
7	Black coal-like small particles	fruit	☐	☐	☐
8	Hardened flesh	fruit	☐	☐	☐
9	Cracked fruit	fruit	☐	☐	☐
10	Stop growing	fruit	☑	☐	☐
11	Mouse gray mold	fruit	☐	☐	☐
11	Mouse gray mold	fruit	☐	☐	☐
12	Light brown rounded small spot	fruit	☐	☐	☐
13	The middle of the spots gradually become white, depression, with the reddish-brown edge, like "bird" shape	fruit	☐	☐	☐
14	Black lesions, hardening cracks	fruit	☐	☐	☐
1	Rotten a lot	flower	☐	☐	☐
30	Crisp spike ear	fringe	☑	☐	☑
31	Ear deformed, withered	fringe	☑	☐	☑
32	The ear branches of the young ear produce brown water-like small spots, and quickly spread to the surroundings. The entire branch of the spike is dead in serious situation	fringe	☐	☐	☐
33	The surface has black mold and the ear has atrophy and falls off	fringe	☐	☐	☐
29	The back of the diseased leaves has orange summer spores heap, gradually expanded along the veins	leaf	☐	☐	☐
25	Yellow-green lesions	leaf	☐	☐	☐
26	White powder	leaf	☑	☑	☑
27	The back of the lesion produces white mold	leaf	☐	☐	☐
28	A large number of orange-yellow powdery spores cover the leaves	leaf	☐	☐	☐
17	Translucent, water-like small spots with the edge not clear	leaf	☐	☐	☐
18	Withered	leaf	☑	☑	☐
19	Early fall off	leaf	☐	☐	☐
20	The lesion is dry and may form perforations	leaf	☐	☐	☐
21	The veins are rhombic or fusiform	leaf	☐	☐	☐
22	Yellow round spot with dark brown margin and light brown or gray center	leaf	☐	☐	☐
23	Pale yellow lesions	leaf	☐	☐	☐
24	Yellow brown spot	leaf	☐	☐	☐
15	Brown spot	leaf	☑	☑	☐
16	Sporadic small yellow spots appear on the leaves, surrounded by water-like shape	leaf	☐	☐	☐

Figure 9 Grape diseases diagnostic rules management interface

5 Conclusions

In view of the most important knowledge acquisition part of the expert system of selenium-rich grape disease diagnosis system, this study adopts the method of artificial acquisition to collect and collate the knowledge, which can guarantee the accuracy and applicability of knowledge acquisition.

Since there may be conflict problems in the disease and symptoms matching search process, a special inference engine is designed by combining positive and negative reasoning methods, so as to make the final diagnostic results more realistic, thereby increasing the effectiveness and practicality of the expert system.

The system uses the Visual Studio 2005 and SQL server 2000 as the development tools. With the help of ADO technology, database technology and expert system theory, the selenium-rich grape disease diagnosis system is achieved through the operation of adding, modification, deletion and query in the knowledge database. The system has the characteristics of safety, simplicity and practicality, which reduced the conflict of disease retrieval and has a good application prospect.

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