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# WEB-based Intelligent Diagnosis System for Cotton Diseases Control

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**Abstract.** Diseases control is always an issue in cotton production, the timely detection and effective control of diseases depend on, in most cases, an effective diagnosis system. Based on the distribution of cotton diseases in the main yielding areas of China in recent years, the main species and characters of cotton diseases were listed classified in the study and a database was established for this purpose. BP neural network as a decision-making system was used to establish an intelligent diagnosis model. Based on the model, a WEB-based Intelligent Diagnosis System for Cotton Diseases Control was developed. An experiment scheme was designed for the system test, in which 80 samples, including 8 main species of diseases, 10 samples in each sort were included. The result showed the rate of correctness that system could identify the symptom was 89.5% in average, and the average running time for a diagnosis was 900ms.

**Key words:** Cotton, Diseases, Intelligent Diagnosis System

## 1. Introduction

Cotton is playing a crucial role in the national agricultural economy of China. Cotton diseases and insects are the two main causes of damage on both quantity and quality of the cotton production. A timely detection of the pests and feasible controlling measures are cure to the effective cotton protection.

The researches concerning disease diagnosis systems for agricultural products started from the late seventies of the last century. The first disease diagnosis system, the soybean disease diagnosis expert system (Plandds), was developed by the University of Illinois (1978). Some additional work, the integrated expertise system for soybean pest control (SOYBUG) <sup>[6]</sup>, the expertise system for orchard management and pest control (POMME) were developed in the state of Florida. Japan has also conducted a lot of researches on disease diagnosis <sup>[3-5]</sup>. Comax-Cossym (Cotton Production Management System) developed by the Crop Simulation Center from Agricultural Research Service in the United States Department of Agriculture (USDA) is the most successful agricultural expertise system in the world, which improved the U.S. cotton production management <sup>[9-10]</sup> significantly.

The related researches in China are developing rapidly since last eighties. The Cotton Pests Management Expertise Decision Support system (COPMEDS) developed by the Institute of Zoology at Chinese Academy of Science was in the leading place <sup>[11]</sup>. Liang and Shi (1997) developed a cotton pest diagnostic system based on the BP neural network, which enhanced the running speed of the

system by simplifying the neural network model <sup>[13]</sup>. Jiang et al. (1998) developed the Prototype of rule-based cotton pest management expert system by utilizing the expertise system development tool KA3 <sup>[14]</sup>. Zhang et al. (2005) designed the knowledge-model-based decision support system for cotton management. This system used system analysis and mathematical modeling to solve the issue of the overly-spread information in a huge knowledge data base, enabling decision-making processes to be more rapidly and simplified <sup>[15]</sup>. Wang et al. (2008) designed a cotton fertilization expertise system based on Geographical Information System (GIS) in XinJiang. The system presented extensive research and discussion on the application of GIS technology to cotton fertilization expertise system <sup>[16]</sup>. Liu, etc. (2009) designed a Web-GIS-based expertise system to forecast agricultural diseases and pests <sup>[17]</sup>.

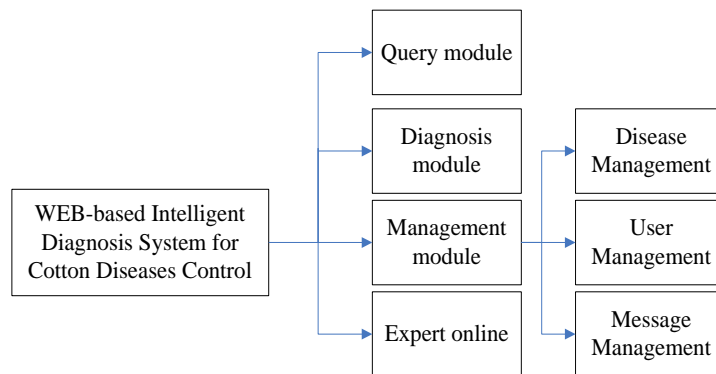
The work presented in this paper is based on the description of the pattern of the cotton diseases, and the identification of the type and characteristic of the major disease problems during the recent years in China. A Cotton Disease Intelligent Diagnosis and Decision Model was established, and a WEB-based Intelligent Diagnosis System for Cotton Diseases Control was developed with the BP neural network as the decision support system.

## **2. System Overview**

The yield and the quality of cotton are affected significantly by the disease, which means farmers' great financial loss. As the lack of basic knowledge of cotton diseases detection and protection, the cotton farmers are longing for the guidance from experts since the occurrence of new and large variety of diseases. However, such experts are not always available for the emergencies. A diagnosis system is therefore considered effective in helping cotton farmers.

A Web-based Intelligent Diagnosis System for Cotton Diseases Control could realize the querying, diagnosing and online consulting of the main diseases during the whole growing process. Multiple users could access the system simultaneously. The system also could facilitate experts to input, update, modify and search data, information and rules associated with cotton intelligent diagnosis system knowledge and database.

Web-based Intelligent Diagnosis System for Cotton Diseases Control was consisted of four separate modules: Query module, Diagnosis module, Management module, and Expert online. The scheme of the system is shown as figure 1.



**Fig. 1.** Scheme of the system function

Where:

1. Query module: information could be queried from the cotton disease database by the keywords imputed in the query interface by users.
2. Diagnosis module: inference engine of the system provided diagnosis results and corresponding control methods by the disease factors chosen by users in the diagnosis interface.
3. Management module: serviced for the system back-stage management, which was divided into three parts: disease management, message management and user management.
4. Expert online: the communication bridge between experts and users.

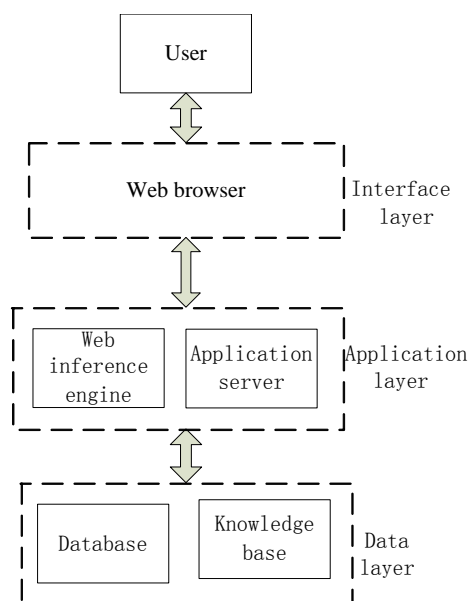
### 3. System Design

The system was a three-layer model with "data layer / application layer / interface layer". Where: Data layer was the bottom layer of the system, which was used for the storage of information needed by the system, and was consisted of database and knowledge base. Database was used to store the basic facts of cotton disease, description of problems, intermediate and final results during the diagnostic process, etc. Knowledge base was used to store knowledge and experience of cotton disease experts.

Application layer which included Web inference engine and application server could realize the inference and explanation functions of the system diagnosis. The BP neural network technology was used to execute the knowledge inference and diseases diagnosis based on the symptoms supplied by users.

Interface layer enabled the interaction of users and system. There were two types of users, ordinary and administrator, in the system. Ordinary users could query disease and input the required information by selecting disease factors, and the disease diagnosis and appropriate control methods were given to users in the form of interface. Administrator users managed the knowledge base and database.

The structure of cotton intelligent diagnosis system is shown in figure 2.



**Fig. 2.** Structure of cotton intelligent diagnosis system

### 3.1. Cotton Disease Database

The database designed in this paper included the disease table, disease picture table, user table and message table, which has played an important role in the development of Intelligent Diagnosis System for Cotton Diseases Control.

The structure of diseases table is as follows:

**Table 1 .** Structure of disease table

| List       | Data Type     | Non-empty | Notes              |
|------------|---------------|-----------|--------------------|
| dis_id     | Int           | Yes       | Keyword            |
| name       | Varchar(20)   | Yes       | Name               |
| region     | Varchar(80)   | No        | Geographical place |
| Pathogen   | Varchar(160)  | No        | Pathogen           |
| law        | Varchar(1000) | No        | Occurrence         |
| prevention | Varchar(1000) | No        | Control methods    |
| germ       | Varchar(300)  | No        | Germ               |

### 3.2 Knowledge Base of cotton diseases

Knowledge base was used to store basic knowledge and practical experience of cotton disease experts. Based on the investigation of the occurrence and the distribution of cotton diseases in recent years, there were more than 20 kinds of main cotton diseases in the main yielding areas of China. 8 kinds of diseases as the major disease of cotton were identified, such as, Cotton anthracnose, Cotton

damping-off, Cotton Red rot disease and Cotton wilt, etc. Based on the analysis and summary of cotton disease symptoms, 5 categories and 32 symptoms were summarized, and which were numbered, so that each symptom of each category corresponded to a number.

**Table 2 .** Cotton disease factor

| Diseases period |               | Disease location |            | Lesion shape |                           | Lesion color |                   | Lesion state |                           |
|-----------------|---------------|------------------|------------|--------------|---------------------------|--------------|-------------------|--------------|---------------------------|
| Factor          | Symptom       | Factor           | Symptom    | Factor       | Symptom                   | Factor       | Symptom           | Factor       | Symptom                   |
| a1              | Seeding stage | b1               | Cotyledons | c1           | Semi-circular or circular | d1           | Brown             | e1           | Dot                       |
| a2              | Bud stage     | b2               | Stem       | c2           | Near circle               | d2           | Dark brown        | e2           | Water stains              |
| a3              | Boll stage    | b3               | Leaf       | c3           | Irregular                 | d3           | Red-brown         | e3           | Grease-like               |
|                 |               | b4               | Boll       | c4           | Polygon                   | d4           | Tan               | e4           | Physalospora black Dots   |
|                 |               |                  |            | c5           | Spindle                   | d5           | Pink              | e5           | Slime                     |
|                 |               |                  |            |              |                           | d6           | Yellow            | e6           | Mold, Floc                |
|                 |               |                  |            |              |                           | d7           | Dark green, black | e7           | Fold Withered             |
|                 |               |                  |            |              |                           | d8           | Gray, white       | e8           | Mycelium                  |
|                 |               |                  |            |              |                           | d9           | Deep blue         | e9           | Dwarf, Withered           |
|                 |               |                  |            |              |                           | d0           | Dark red          | e0           | Color changed, Reticulate |

Based on the diseases factors listed in table 2, the factors corresponding to different diseases and the causalities of diseases were listed in the diseases table.

**Table 3.** Disease

| Name                         | Diseases<br>period | Disease<br>location | Lesion<br>shape | Lesion<br>color | Lesion<br>state |
|------------------------------|--------------------|---------------------|-----------------|-----------------|-----------------|
| Cotton anthracnose           | a1 a2 a3           | b1 b2 b3<br>b4      | c1 c2 c5        | d2 d8 d0        | e4 e5           |
| Cotton Rhizoctonia           | a1 a2              | b1 b2 b3            | c3              | d1 d4 d6        | e7 e9 e0        |
| Cotton boll rot disease      | a1 a3              | b1 b2 b4            | c1              | d1 d5           | e6 e7           |
| Cotton Hongfen disease       | a1 a3              | b1 b4               | c1              | d1 d5           | e6              |
| Cotton wilt                  | a1                 | b1                  |                 | d6              | e0              |
| Cotton phytophthora boll rot | a1 a3              | b1 b4               |                 | d7 d8           | e2 e8           |
| Cotton angular leaf spot     | a1 a2              | b1 b2 b3            | c4              | d7              | e3              |
| Cotton damping-off           | a1 a3              | b2 b4               | c1              | d1 d6 d8        | e2 e6 e7        |

### 3.3 Inference Engine of cotton diseases

The core of the cotton disease diagnosis system was the inference engine. Most of the existing reasoning models carried out the forward and backward reasoning by constructing a database of disease recognition features and using a standard query language (SQL). The process of knowledge acquisition and mimic expert reasoning for these models has grown an over-reliance on expert knowledge and experience, the practicality was poor and also with limitations.

Neural network was a massively parallel processing and self-learning, self-organizing, nonlinear dynamic system, which was particularly suited to complex non-deterministic causal reasoning, judging, identification, and classification problems. It had the self-learning function and could constantly enrich the content of the knowledge base. Therefore, BP neural network was used as the inference engine of cotton diseases in this system.

BP neural network was constructed as a disease inference engine based on the analysis and summary of cotton disease symptoms. There were 32 input nodes which were corresponding to 32 diseases in the BP neural network. According to empirical formula  $N = \sqrt{mn}$ , the number of nodes  $N$  in the hidden layer was obtained as  $N=16$ . Then by errors comparison, the optimal number of neurons in the hidden layer was determined.

There were 8 output nodes which were corresponding to 8 major diseases of cotton. The BP neural network was trained and validated by using *Matlab* in the article. The hidden layer transfer function was s-type tangent function *tansig*, the output layer transfer function was *purelin*, and the training method was *Levenberg-Marquardt* with the training function *trainlm*. Gradient descent momentum learning function *learnngdm* was used as the learning function, and the performance function was *mse*.

By experimental verification of the system with 8 kinds of diseases (each with 10 samples), the average diagnostic accuracy was 89.5% and the average diagnosis time was 900ms.

## 4. Conclusion

A web-based intelligent diagnosis system for cotton diseases control was developed in this article. Based on the research of cotton disease occurrence in recent years and on the analysis of the cotton diseases characteristics, a corresponding database was established and disease factors for the description of various diseases were obtained then. BP neural network combined with the Web technology was used as the disease inference engine in the system, so that the diagnostic accuracy and intelligence as well as the ability to solve the uncertain and ambiguous problems were enhanced. Modelling results showed that the diagnosis system was high-accuracy and high-speed. The system was effective and easy to operate with the friendly interface. It was expected to show the high feasibility to the field situation by more practical tests.

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