Design research of an Intelligent Management System for Agricultural Machinery Based on Java

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Abstract: With the rapid development of agricultural mechanization and large-scale production, the traditional agricultural machinery management has exposed many drawbacks. Therefore, the agricultural machinery intelligent management system based on Java came into being. With Java language, Spring Boot, MySQL database and IntelliJ IDEA, the system developed. Users can easily query and manage the machinery with this system, and realize the efficient usage. At the same time, the system also supports users to statistical analysis of job data, help users to make scientific decisions, improve production efficiency. The administrator has more comprehensive management rights, including user management, mechanical information management, job record review and other functions, which can efficiently handle user requests to ensure the normal operation of the system and data security.

Keywords: Agricultural Machinery Intelligent Management System; Java; Spring Boot; MySQL

1. Introduction

With the advancement of large-scale and modernized agricultural production, traditional agricultural machinery management methods are increasingly outdated. These conventional approaches rely on manual record-keeping and paper archives, which have significant drawbacks. For instance, manual entry errors and omissions are common, especially with large machinery inventories, impacting data accuracy and subsequent production decision-making. Traditional methods struggle to meet the demands of efficient and precise management in modern agriculture. Therefore, there is an urgent need to introduce a Java-based intelligent management system for agricultural machinery, utilizing advanced technologies to optimize management processes and enhance overall production efficiency and effectiveness. This system plays a crucial role in modern agriculture and has significant practical importance. For example, Jiangsu Province's agricultural machinery company developed an "Intelligent Agricultural Machinery Management Platform" that uses IoT technology for real-time monitoring and data analysis. The system also simplifies reimbursement applications and user feedback processes, improving service efficiency and user experience, thus increasing farmer and manager satisfaction. As data accumulation and analysis capabilities improve, this intelligent management system can further support the future development of smart agriculture. [1-5]

2. Overall Design of the Java-Based Intelligent Management System for Agricultural Machinery

2.1 System Architecture Design

The design of the Java-based intelligent management system for agricultural machinery should be straightforward, meeting essential functional requirements with a user-friendly interface and smooth layout to ensure a seamless user experience in line with user habits. [6]

2.2 Functional Module Design

The system's functional module design is rational and efficient, covering the core needs of both users and administrators. For users, the system offers functionalities such as registration, login, personal center, machinery information management, machinery allocation management, operation management, statistical analysis, and reimbursement application management. This ensures users can easily access and manage personal information, execute tasks, and stay informed about machinery status. Administrators have access to a comprehensive range of functions, including login, personal center, user

management, machinery information management, machinery allocation management, operation management, statistical analysis, and reimbursement application management. The modular design ensures functional independence and scalability, allowing users and administrators to operate efficiently according to their needs and facilitating easy system upgrades and expansions. This design not only enhances operational efficiency but also improves system flexibility and maintainability. The functional module diagram of the system is shown in **Figure 1**. [7-8]

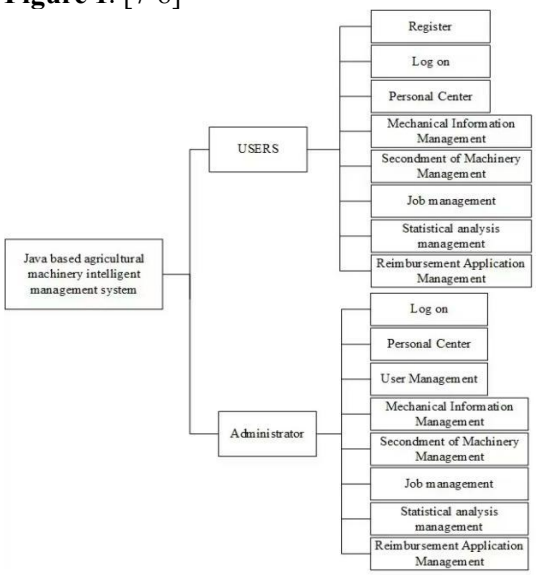

Figure 1. System Functional Module Diagram

2.3 System Functional Flow Design

(1) User Registration and Login Flow:

New users fill in basic information to create an account. The system verifies the information to complete the registration. Users log in using their username and password. After credential verification, users access the main interface. This flow ensures account security and convenient access.

(2) Viewing Machinery Information:

This feature allows users to access machinery details within the system, providing real-time information on machinery specifics.

(3) User Management:

Upon administrator login, they can access user accounts and manage them comprehensively, including adding new accounts, modifying user information, and deleting outdated profiles. These operations ensure that user information is accurate and up-to-date.

(4) Machinery Information Management:

Administrators access the machinery information management interface to add, delete, modify, and query machinery information. The system updates the database upon confirmation, completing the machinery information management process.

2.4 Database Design

(1) Database Conceptual Model Design:

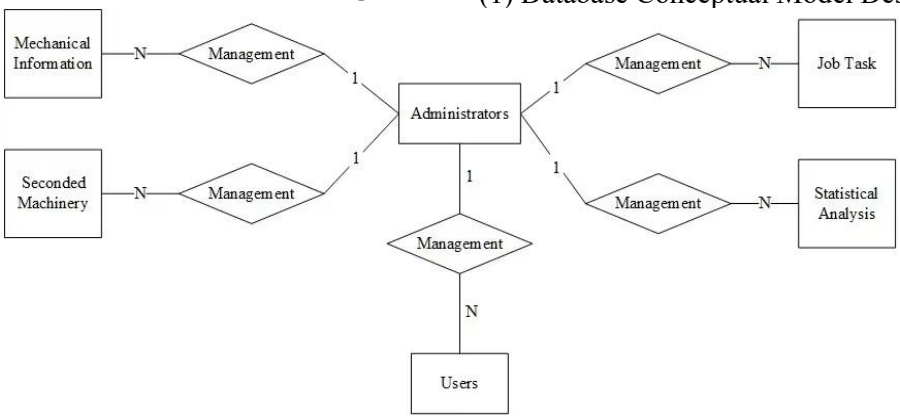

Figure 2. Database E-R Diagram

The conceptual model design provides a high-level abstract description of the data structures and relationships within the database system. [9] It uses an Entity-Relationship (ER) diagram to graphically represent data entities, attributes, and their interrelationships, aiding in defining the logical structure of the database. Key focus areas include identifying essential entities and attributes and establishing relationships to ensure data integrity and consistency, laying the groundwork for subsequent physical model design. The system's E-R diagram is shown in **Figure 2**.

(2) Database Logical Model Design

① Machinery Information Table:

The machinery information table is a specific table within the database system designed to store various data related to machinery information. The structure of the machinery information table is illustrated in **Table 1**.

Table 1. Mechanical Information Sheet

Column names	Data type	Length	Primary key or not	Field Description
id	bigint	20	Yes	Primary key
addtime	timestamp	-	Not	Create time
jixiemingcheng	varchar	200	Not	Name of the machine
cheliangleixing	varchar	200	Not	Mechanical type
zhaopian	longtext	-	Not	Photos
shengchanchangjia	varchar	200	Not	Manufacturer
jixiezhuangtai	varchar	200	Not	Mechanical condition
jixiexiangqing	longtext	-	Not	Mechanical details

② Administrator Table:

The administrator table is a specific table within the database system used to store various data related to administrators. The structure of the administrator table is presented in **Table 2**.

Table 2. Admin Table

Column names	Data type	Length	Primary key or not	Field Description
adminid	bigint	20	Yes	Administrator No.
adminname	varchar	10	Not	Username
adminpwd	varchar	10	Not	Password
role	varchar	10	Not	Characters
headimg	varchar	30	Not	Profile picture
admincreatetime	longtext	-	Not	Create time
islock	varchar	11	Not	User status

③ Task Table:

The task table is a specific table within the database system designed to store various data related to tasks. The structure of the task table is shown in **Table 3**.

Table 3. Job Sheet

Column names	Data type	Length	Primary key or not	Field Description
id	bigint	20	Yes	Primary key
addtime	timestamp	-	Not	Create time
zuoyemingcheng	varchar	200	Not	Assignment name
zuoyeleixing	varchar	200	Not	Type of assignment
diaodushijian	datetime	-	Not	Scheduling time
diaodubeizhu	longtext	-	Not	Scheduling Notes
yonghuzhanghao	varchar	200	Not	User accounts
chufadi	varchar	200	Not	Departure location
mudedi	varchar	200	Not	Destination

④ User Table:

The user table is a specific table within the database system used to store various data related to users. The structure of the user table is presented in **Table 4**.

Table 4. User Table

Column names	Data type	Length	Primary key or not	Field Description
id	bigint	20	Yes	Primary key
addtime	timestamp	-	Not	Create time
yognhuzhanghao	varchar	200	Not	User accounts
mima	varchar	200	Not	Password
yonghuxingming	varchar	200	Not	User name
xingbie	varchar	200	Not	Gender
nianling	int	-	Not	Age
lianxifangshi	varchar	200	Not	Contact information
touxiang	longtext	-	Not	Profile picture

3. Testing of the Java-Based Intelligent Agricultural Machinery Management System

3.1 Testing Objectives

The objective of system testing is to ensure the quality and reliability of the software system, verifying whether it meets the expected functional and performance requirements. System testing helps identify and fix defects and issues, ensuring stability and compatibility across different environments. Specifically, it aims to verify the correct interaction of system modules and components, assess performance under high load and abnormal conditions, and evaluate security and data integrity. Additionally, it identifies potential user experience issues, ensuring a user-friendly and intuitive interface. Comprehensive testing increases user satisfaction, reduces post-deployment maintenance costs and risks, and ensures the system meets desired quality standards before official release. [10-11]

3.2 Testing Methods

In testing the Java-based intelligent agricultural machinery management system, black-box testing is used to verify whether the system's functions and performance meet requirements and specifications. This method does not focus on the system's internal structure and code but rather on observing outputs and behaviors through various input data to check functional correctness. Specific tests include functionality, interface, performance, boundary, and error handling tests. Functional testing ensures correct operation of registration, login, user information management, and machinery management features; interface testing checks the layout and usability; performance testing simulates high user load; boundary testing validates time constraints on reservations; error handling tests ensure appropriate responses to invalid data. Black-box testing comprehensively evaluates the system's functionality and performance, ensuring it meets user needs and operates stably across scenarios. [12-13]

3.3 Testing Content

(1) User Login Test

Login test cases are designed to verify whether users can successfully log into the system. The user login test cases are detailed in **Table 5.**

Table 5. Table of User Login Test Cases

Test modules	Test items	Expected results	Actual results	Passed or not
User logged in	Log in with the correct username and password	The user successfully logged in and entered the system home page	Successfully logged in, jump to the main page	Yes
User login	Log in with wrong username and correct password	The system displays a "Wrong username or password" prompt	Displays an "Incorrect username or password" prompt	Yes
User login	Log in with the correct username and incorrect password	The system displays a "Wrong username or password" prompt	Displays an "Incorrect username or password" prompt	Yes
User login	Log in with an empty username and correct password	The system displays a "username cannot be empty" prompt	Display the "Username cannot be empty" prompt	Yes
User login	Log in with the correct username and empty password	The system displays "password cannot be empty" prompt	Displays the "Password Cannot be empty" prompt	Yes
User login	The empty user name and password to log in	The system displays a "username and password cannot be empty" prompt	Display the "Username and password cannot be empty" prompt	Yes

(2) User Management Test

User management test cases ensure the system performs as expected when handling various user management operations and can effectively process both valid and invalid data inputs. The user management test cases are detailed in **Table 6.**

Table 6. Table of User Management Test Cases

Test module	Test items	Expected results	Actual results	Passed or not
User management	Add users (valid data, the user name "user001" and password "Pass123")	User successfully added that "users to add successful" prompt	User successfully added that "users to add successful" prompt	Yes
User Management	Add user (username "user002", password is empty)	The system displays "password cannot be empty" prompt	Displays the "Password Cannot be empty" prompt	Yes
User management	Delete user (username "user001" and user exists)	The user was successfully deleted and the "User Deleted successfully" prompt is displayed	The user was successfully deleted, and the "User deleted successfully" prompt is displayed	Yes
User Management	Delete user (username "nonexistent" and user does not exist)	System displays "the user does not exist"	Displays a "user does not exist" prompt	Yes
User Management	Modify the user information (valid data, change the username	User information updated successfully, according to the "user	The user information has been updated successfully, and the "User updated	Yes

	"user002" to "user003")	updated" prompt	successfully" prompt will be displayed	
User Management	Modify user information (empty username)	The system displays "user name cannot be empty" prompt	According to the user name cannot be empty	Yes
User Management	Query user information (username "user003")	The system correctly displays the user information for "user003"	Display correctly "user003" user information	Yes
User Management	Query the user information (user called "nonexistent")	The system displays a "user does not exist" prompt	According to "the user does not exist"	Yes

(3) Machinery Information Management Test

Machinery information management test cases ensure the system performs as expected during various machinery information management operations and effectively processes both valid and invalid data inputs. The machinery information management test cases are detailed in **Table 7**.

Table 7. Mechanical Test Case Table Information Management

Test module	Test items	Expected results	Actual results	Passed or not
Mechanical Information Management	Add mechanical information (valid data, machine name "tractor", machine details "efficient tractor", manufacturer "Farm Machinery factory")	Mechanical information to add, according to "machine add success" prompt	Mechanical information added successfully, display "Machine added successfully" prompt	Yes
Mechanical information management	Add machinery information (machine name is empty)	System show "machine name cannot be empty	Display the "Machine name cannot be empty" prompt	Yes
Mechanical information management	Delete machinery information (machinery name is "tractor" and machinery exists)	Mechanical information was successfully deleted, and the "Mechanical deletion was successful" prompt was displayed	Mechanical information successfully deleted, display "Mechanical deletion success" prompt	Yes
Mechanical information management	Delete machinery information (machinery name is "non-existing machinery" and machinery does not exist)	System displays "machine does not exist"	Displays the "Machinery does not exist" prompt	Yes
Mechanical information management	Modify mechanical information (valid data, change the name of the machine from "tractor" to "harvester")	The mechanical information was successfully updated, and the "Mechanical Update was successful" prompt is displayed	Mechanical information updated, showing "mechanical updated" prompt	Yes
Mechanical information management	Modify mechanical information (machine name is empty)	The system displays the "Machine name cannot be empty" prompt	Display the "Machine name cannot be empty" prompt	Yes
Mechanical information management	Query machinery information (machinery name is "harvester")	The system correctly displays the mechanical information for "harvester"	Display the mechanical information of the "harvester" correctly	Yes
Mechanical information management	Mechanical information query (machine name as "not exist mechanical")	The system displays a "machine does not exist" prompt	Displays the "Machinery does not exist" prompt	Yes

3.4 Testing Conclusion

Throughout the testing process, the results for user login, user management, and machinery information management modules met expectations. The user login test validated the system's response to various input conditions, ensuring the correctness of the login function. User management tests covered scenarios such as adding, deleting, modifying, and querying users, with the system performing stably and handling both valid and invalid data. The machinery information management test confirmed the system's accuracy in processing machinery data, with all functions executed as expected. Consequently, all test cases passed, indicating strong system performance in these modules.

4. Conclusion

The Java-based Intelligent Agricultural Machinery Management System is an efficient tool enabling comprehensive management and data analysis of agricultural machinery on a centralized platform. This enhances machinery utilization, reduces resource wastage, and improves user management experience, achieving information transparency and real-time monitoring. The system employs the Spring Boot framework, simplifying development processes and boosting system performance for more efficient and flexible backend development. Additionally, it uses MySQL as a data storage solution, ensuring data security and reliability

while supporting high-concurrency query requests to meet the growing data demands of agricultural machinery management. During development, IntelliJ IDEA was used as the development tool, leveraging its powerful code intelligence and debugging features to enhance development efficiency and code quality.

Users can access features such as registration, login, personal center, machinery information management, machinery lending management, operation management, statistical analysis management, and reimbursement application management. These features are designed to facilitate the convenient management of machinery information, acquisition of operation data, and cost analysis, thereby optimizing agricultural production efficiency. Administrators have additional management privileges, including user management, machinery information CRUD operations, machinery lending approval, operation record review, and statistical analysis, ensuring smooth system operation.

The system enables efficient information sharing and communication between users and administrators. Users can query machinery status, lending records, and operation conditions in real-time, while administrators can swiftly process user requests and feedback, facilitating efficient resource allocation and management. This design not only improves work efficiency but also supports the digital transformation of modern agriculture, promoting the advancement of intelligent and information-driven agricultural production.

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