Design of Intelligent Scheduling System for Wine Grape Agricultural Equipment Based on User Requirement

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Abstract. User requirement analysis and agricultural machinery scheduling are of great significance to promote the mechanized development of wine grape industry. In order to improve the field intelligent scheduling efficiency of wine grape agricultural equipment, reduce the manual scheduling cost and waste of farm machinery resources, this paper analyses the requirements through literature analysis and field investigation, and then designs the business process and divides the functional structure based on the requirements. The intelligent scheduling system of agricultural equipment for wine grape is designed and implemented based on the user's demand. According to the operation requirements of different farmers for different agricultural equipment, the order execution order is arranged as a whole, and a scheduling scheme of agricultural equipment is generated. After confirmation by the administrator, agricultural operators and farmers, scheduling starts, and the scheme is evaluated and fed back after scheduling. It can promote the informatization development of wine grape industry in Ningxia.

Keywords. Wine Grape; Agricultural Equipment Scheduling; Management Information System

1. Introduction

38 degrees north latitude is recognized as the "golden zone" of grape planting in the world, and there are world-famous wine producing areas, among which Ningxia wine grape planting area in China is located. At present, the planting area of wine grapes in Ningxia is 570,000 mu, with an annual output of nearly 100,000 tons of wine and a comprehensive output value of 26.1 billion yuan. The eastern foot of Helan Mountain has become the largest concentrated contiguous planting area and winery wine producing area in China, and it is also one of the best wine producing areas in China and internationally renowned.

Ningxia government has attached great importance to the development of wine grape industry in recent years, and issued a series of normative documents to support and guide its development. In 2018, the total power of agricultural machinery in Ningxia reached 6.219 million kilowatts, 9.4 times higher than the 663,000 kilowatts in 1978. There are 211,000 tractors of various types, up 12.4 times from 17,000 in 1978; Among

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them, the number of large and medium-sized tractors reached 39,000, an increase of 8.3 times. Not only has the number of agricultural equipment increased substantially, but the corresponding supporting agricultural machinery service organizations are also increasing, and the mechanization and scale construction of grape industry in Ningxia Autonomous Region has a good material foundation and guarantee. In this context, the demand for information management of wine grape planting will become an essential part.

Although the whole process of wine grape production has been assisted by a variety of mechanical operations and the degree of mechanization has been significantly improved, there are still problems of small quantity and uneven distribution of agricultural equipment. In addition, the planting time of wine grapes in different regions of the winery is different, and the operation requirements of agricultural equipment in each grape field are often different from field to field. Most mechanized operations of agricultural equipment are arranged by agricultural machinery cooperatives, and the scheduling process is still mainly based on telephone contact. Besides, whether the scheduling equipment meets the individual needs of farmers and whether the scheduling operation is timely or not are subjectively influenced by the dispatcher, which easily affects the normal operation of wine grape production.

Therefore, in the whole process of wine grape production, the following scheduling problems often occur:

First of all, manual scheduling takes a long time, which seriously affects the standardized production of wine grapes. Due to the untimely manual scheduling, the production cycle of wine grape is often further prolonged. It has become a serious obstacle to the scale development of grape industry and the improvement of economic benefits.

Secondly, manual scheduling is subjective and empirical, and it is difficult to meet the individual needs of farmers. The traditional scheduling of agricultural equipment is over-dependent on manual experience and lack of technical support, which leads to the unreasonable scheduling scheme of agricultural equipment. Incorrect path distribution may even cause damage to vines.

Finally, due to the limitation of special planting environment and insufficient mechanization, the management cost of grape planting process is high. Because the mechanization degree of grape planting management is low, the management cost is increased by at least 15000 yuan /hm2. In addition, Due to the narrow row spacing of grape fields in some wineries, fertilization and dosing of grapes are more dependent on manual labour, lacking the application of corresponding small and medium-sized agricultural equipment.

To sum up, based on the survey data of farmers' needs and field environment, the design and implementation of intelligent scheduling system for wine grape agricultural equipment, guided by users' orders, can effectively change the current situation of shortage of agricultural equipment in wine grape producing areas in Ningxia. The platform will manage information and data of farmers, farm operators, farm machinery and equipment in an integrated way, and make use of a unified data platform to facilitate data sharing and exchange; The scheduling scheme adopts the method of combining the tripartite confirmation of the scheme with the feedback of post-scheduling evaluation, simultaneously meets the tripartite needs of farmers, agricultural operators and administrators, and ensures the quality of scheduling operations. The intelligent scheduling system of grape-making agricultural machinery equipment can effectively reduce the cost of field scheduling, improve the efficiency of manpower, material

resources and financial resources, and enhance the economic benefits of grape-making industry.

2. Literature Review

2.1. Related Research on Intelligent Management Platform of Agricultural Equipment

The agricultural machinery management and control platform can manage agricultural machinery with low cost and scientificalness, match agricultural machinery and operations with high efficiency, and play a positive role in promoting agricultural mechanization and decision-making management of agricultural operations.

Fengjie Sun et al. (2020) [1] designed the UAV as agricultural machinery equipment to realize the scheduling functions of pesticide spraying, flying and charging. Haotian Yang(2020) [2] is based on the Web, which converts the collected data into graphs by using bipartite adjacency matrix representation, and optimizes the electric vehicle scheduling by edge colouring technology of graphs.

2.2. Related Research on Agricultural Equipment Scheduling Problem

Farm Machinery Scheduling Problem (FMSP), which has strong connection and certain similarity with vehicle scheduling problem, is an extension of vehicle scheduling problem in the field of agricultural machinery scheduling.

Bochtis D D et al. (2010) [3]used VRP to solve the scheduling management problem of agricultural transport vehicles, and planned and controlled the job tasks and agricultural machinery scheduling routes; Baio F H R et al. [4]established a mathematical model with the lowest operating cost according to the agricultural production process, and automatically gave the optimal planning scheme by linear programming using the network platform; Zhu X M et al. (2017) [5]aimed at the low efficiency of agricultural machinery scheduling, an improved immune tabu search algorithm (ITSA) based on immune optimization algorithm is proposed. By improving the immune tabu search to generate neighbourhoods solutions, the convergence speed of the algorithm is accelerated, and a good optimal solution search rate is obtained.

3. Field Research and User Requirement Analysis

At present, the degree of mechanization in the grape producing areas in Ningxia is high, and the comprehensive mechanization of the main crops has reached 63%. Most wine grape production operations can be assisted by some agricultural equipment. At present, the whole process of mechanized production of wine grapes has been realized, including tillage and land preparation, fertilization, pesticide application, weeding, pruning, and vine burying. Among them, the main types of agricultural machinery are: vine-lifting machine, pruning machine, weeding machine, pesticide-applying machine and vine-burying machine, which basically cover the whole process of four wine grape planting operations: seed and product transportation, vine-lifting and vine-burying operation, weeding and pruning operation and plant protection operation.

With the continuous improvement of agricultural mechanization level and the growing area of common wine-making in Ningxia, the importance of information management of wine grapes is increasing. The realization and application of intelligent scheduling system of grape farm machinery equipment can further improve the informatization level of wine grape planting wineries in Ningxia. Promoting the information exchange and resource allocation among the demand provider (farmers), the operator (agricultural equipment operators) and the winery manager (administrators), and rationally distributing the scheduling orders can not only realize the income of agricultural machinery service organizations, but also solve the scheduling problems of agricultural equipment with low cost and high efficiency. Through the demand collection of farmers, farm operators and winery managers, we get the functional demand domain of the intelligent scheduling system of grape wine farm machinery equipment, and the mapping relationship is shown in figure 1 below.
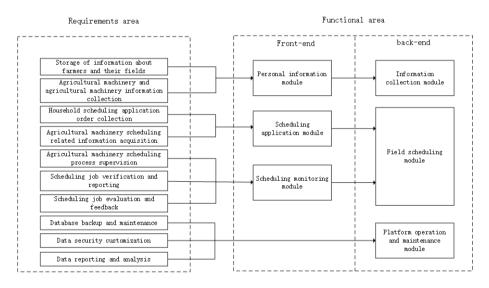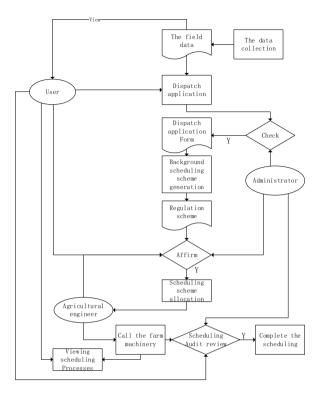

Figure 1. Mapping relationship between user requirements and system functions

4. Design of Intelligent Dispatching System for Wine Grape Agricultural Equipment

4.1. Business Process Analysis

Through the field investigation of wine grapes in Ningxia, combined with the demand analysis of applications, the current business process of scheduling agricultural equipment for wine grapes has been reorganized, and the front and back business processes are shown in the following figures 2 and 3.

Front-end scheduling platform

Figure 2. System front-end business flow chart

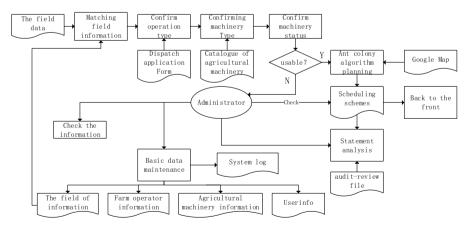background scheduling platform

Figure 3. System background business flow chart

Front-end business process: according to the data collected by terminal sensors in the field, farmers put forward personalized scheduling requests in combination with the actual situation. After receiving the request, the administrator fills in the specific

scheduling scheme table, submits it to the background intelligent algorithm to generate the scheduling scheme, and notifies the farmers and agricultural operators of the scheme. After the consent of the three parties, the final scheduling scheme is generated and submitted to the agricultural operators for execution. After the agricultural machinery completes the scheduling by hand, the photo uploading system will feed back the scheduling situation to the farmers and administrators in real time, and then the farmers will evaluate the scheduling according to the scheduling situation and the field operation situation.

Back-end business process: farmers apply for scheduling, and the platform matches the idle agricultural machinery data in the corresponding time period by obtaining the farmland data in the scheduling application, taking the individualized demand of farmers' orders as the main scheduling target, obtaining the best scheduling scheme according to the intelligent algorithm, and submitting the scheme to farmers, agricultural operators and administrators at the same time. If yes, the administrator will finally confirm the release of the scheduling plan, and inform the relevant agricultural operators of the operation to implement the operation according to the plan. Finally, the user can complete the scheduling by obtaining the actual implementation of the scheduling scheme and passing the acceptance.

4.2. Division of System Functional Structure

According to the business process analysis of the platform, the functional structure of the platform is divided into front-end function and background function, consisting of 6 modules and 23 sub-modules, as shown in figure 4 below.

The front-end function of the system is mainly aimed at farmers' information collection and feedback of scheduling situation, which is composed of three main parts: personal information module, scheduling application module and job monitoring module.

(1) Personal information module: the personal information modification function allows farmers and agricultural operators to modify their own information such as user password, contact telephone number and other basic information; Farmers can use the field information to modify the current location and variety of wine grapes. The information uploading function of the equipment is used by agricultural operators, which can be used to change whether the equipment is available or not. And the current geographical location of the equipment.

(2) Scheduling application module: it includes the scheduling scheme application function that users actively apply for scheduling; After the application is issued, farmers also need to manually apply for confirmation here; Farmers can also track their own scheduling application here to understand the application process.

(3) Scheduling monitoring module: the Scheduling scheme display function is to query the specific content of the scheduled job; Job tracking allows farmers to grasp the completion status of scheduling orders in real time; After the scheduling is completed, farmers should re-examine the completed pictures of the scheduling job by using the job result review page, and finally use the job result evaluation button to evaluate the quality of the scheduling job.
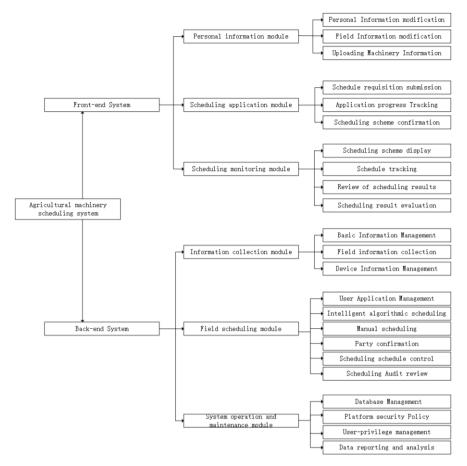
Figure 4. System functional structure diagram

Back-end system functions include intelligent generation of scheduling scheme and operation and maintenance of information by administrators, which are three main parts: information collection module, field scheduling module and system operation and maintenance module.

(1) Information collection module: including basic information management functions such as user, field size, field location, etc. The field information collection function of field location, humidity, temperature, number of weeds, grape planting status, etc. Management function of equipment information such as type, location and working status of agricultural machinery.

(2) Field scheduling module: it includes the scheduling scheme application function of collecting the scheduling applications of farmers from the front end to the background, the intelligent scheduling function of agricultural machinery to generate the scheduling path of agricultural equipment by using intelligent scheduling algorithm, the manual scheduling function of the administrator to manually select scheduling equipment and route planning, confirming the scheme by related parties. Only after the confirmation of farmers, operators and administrators at the same time can the next scheduling operation be carried out; Scheduling control function includes the monitoring of equipment scheduling path and the path supervision function of early warning when the route

deviates, positioning machines and tools through real-time monitoring, camera capture, etc. If the scheduling scheme cannot be implemented on time, the behaviours will be recorded and a reminder will be sent; The audit function scores and judges the process of scheduling jobs and the completion of jobs, so as to quantify the actual completion of the scheduling.

(3) System operation and maintenance module: the database management will maintain and update the data by using the basic database addition, deletion and query operations, and timely return the data through the database log in case of emergency; The platform security strategy uses user password encryption and monitoring abnormal data to improve the security of the platform .User rights management is to authorize users and change their operating rights on platform data; Statistics and report analysis will make statistical analysis of the past scheduling order data, and provide experience for the future scheduling.

5. System Function Module Design and Implementation

5.1. Database Design

The overall relationship diagram of the system database can be obtained according to the entities involved in the platform and their dependencies, as shown in figure 5. The entities involved in the entity relationship diagram mainly include users, fields, scheduling applications, administrators, scheduling schemes, agricultural machinery operators, agricultural machinery equipment and audit and evaluation, and the platform database is built according to these entities and their attributes, which is deployed on Alibaba cloud.
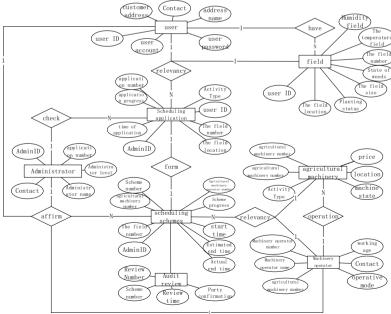

Figure 5. Overall E-R diagram of database

5.2. Design of Information Acquisition Module

As shown in figure 6, the information acquisition module is mainly responsible for the basic information management functions of the platform, which can complete user management, farmer management, agricultural equipment management, field information management, scheduling application management, scheduling scheme management, scheduling evaluation management and role authority management, and can add, modify and delete information.

Figure 6. Design of information acquisition module

5.3. Design of Scheduling Information Module

Figure 7. Design of Scheduling Information Module

In the scheduling application management interface, the dispatcher can check the locations of agricultural machinery and hangars, the number of available agricultural machinery near the fields, confirm the location of satellite map and the basic information

of scheduling, and then enter the scheduling review page, where the administrator can check the scheduling scheme generated by intelligent algorithm. And select the most efficient scheme and submit it to the dispatcher and farmers for review. As shown in figure 7, administrators can also choose to schedule manually. The system will select the work type and work organization of farm operators and the corresponding farm operators and equipment according to the application information of farmers. At the same time, the scheduling scheme can be modified before the scheme is released. As shown in figure 8, after the agreement of the farmers, dispatchers and agricultural operators, the instructions will be given to the corresponding agricultural operators, and the specific contents of the scheme will be notified to the farmers, allowing them to master the scheduling process.

Figure 8. Visualization of scheduling route

5.4. Design of System Operation and Maintenance Module

The system operation and maintenance module is mainly responsible for maintaining the daily functions of the platform, monitoring abnormal data to improve the security of the platform, and protecting the reliability of user data; The platform also analyses and summarizes the data of previous scheduling schemes, and obtains the daily scheduling frequency of different types of agricultural equipment, which helps wineries purchase agricultural equipment in a targeted manner. As shown in figure 9.
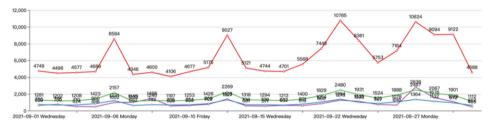

Figure 9. Design of Scheduling Information Module

6. Conclusion

Agricultural machinery management informatization is an important branch of intelligent agriculture development, and it is also an important way to improve crop production efficiency and reduce labour costs. Based on the actual situation of wine grape planting and user's needs in Ningxia, the intelligent scheduling system of wine grape agricultural equipment designed can improve the lag and low efficiency of manual scheduling. It has certain progressive significance for the development of wine grape industry in Ningxia. However, this system does not consider the situation of multiple orders and multiple decisions, and the order accumulation in busy farming period still needs more research. Aiming at the scheduling jobs with high concurrency, this system still needs further improvement.

Acknowledgments

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