Design of parallel Computing based on Web Technology in Soil Moisture and Thermal process Simulation system

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Abstract. Most of the traditional simulation software of soil water, soil and crops are based on the C-paw S model, and the efficiency of the simulation and calculation is relatively underground, and the organization and management of the data is slightly inferior, most of them are more powerful on the model. From the point of view of the early organization and management of the data, the simulation and optimization of the medium-term data, the visualization of the late platform and the efficiency of calculation, this project completes a new simulation platform with the help of the classical WHCNS model. At the same time, the innovation is to simulate and optimize the data with the help of big data technology, multi-thread technology, Web technology and the classical WHCNS soil-crop management model, so that the system has become an important experimental means of pilot-scale experiment, which can solve the problems of long experimental period, high cost and regional differences in the pilot-scale experiment of soil organic reconstruction. The simulation platform of the pilot test is constructed, and the relevant mechanism models and research models involved in the experimental research are coupled and integrated into the platform system to form a simulation process of data input-model simulation-calculation output and visual display. Used to assist the pilot test.

Keywords: Web, Parallel computing, Parallel computing, Soil Moisture.

1. Introduction

Food security, efficient utilization of resources and ecological environment protection are major problems facing agricultural production in China at present. Improving the quality and yield of cultivated land is the core of these problems. In order to solve these problems, it is necessary to quantify the processes of farmland soil-crop from the perspective of ecology and solve these problems with the help of models. There has been relatively mature research on this in foreign countries, and
many models have been developed and designed for simulation, but our country has started relatively late in this area, with few such systems, and the application of foreign products is too expensive and inefficient. It cannot well meet the characteristics of China's highly intensive agricultural production, so there is an urgent need to build a simulation platform for pilot-scale experiments of land regulation projects. The relevant mechanism models and research models involved in the experimental research are coupled and integrated into the platform system to solve the problems encountered in the pilot-scale experiments of land engineering, such as long period, high cost, regional differences and so on.

For the traditional soil water, heat and other simulation software, most of the simulation software is C_picket S mode, that is, the simulation of relevant parameters is carried out in stand-alone mode, the calculation efficiency is relatively low, the ability of multi-person synchronous work is not strong, and the ability of asynchronous task execution is weak, and the ability of data organization, management and storage is slightly inferior, and most of them are only relatively powerful in the function of the model. The starting point of this project is to solve the early organization and management ability of the simulation data, to optimize the computing power and parallel ability of the data simulation, as well as the visualization ability of the final calculation result and the optimized parameter adjustment platform. Therefore, it is imperative to develop a more efficient and optimized soil water and thermal simulation system.

2. Research contents and methods

2.1. Research goal
The existing data and related test data are used to complete the data test of WHCNS model and the parameter optimization based on PEST. Complete the development of soil-crop simulation system based on Web, and the development of multi-process simultaneous computing platform using multi-thread technology.

This project relies on the land engineering big data platform. In terms of hardware equipment, the cluster platform with multiple servers and multiple storage devices has great support. At the same time, the land engineering big data platform has a relatively complete data acquisition mechanism and accumulated data results for the simulation and testing of the new system. The WHCNS model is also a mature model for soil-crop management, which has high quality references and materials and many similar software designs for reference. In the technical field of multi-thread computing, many application systems in various industries have had relatively mature examples, which can also play a good support for the solution of the technical solutions involved in this project.

2.2. Research content
This project is to want to take based on B/S (browser and server) mode of web platform, with the help of a large data multithreaded computing ability of data acquisition and computer to replace the traditional C/S (client and server) desktop stand-alone calculation, optimization from the computational efficiency, can be multiple threads at the same time for large, long-term data for simulation and optimization, so as to solve single calculation under the condition of strict, and low computational efficiency.

In terms of data acquisition, how to use big data technology to obtain more comprehensive and detailed data information of elements involved in soil-crop management, including water, soil and air, to assist model simulation. The platform is based on Web, and how to better and more efficiently call the modules under the C/S terminal to carry out multi-threading calculation under B/S, and whether different programming mechanisms can be well integrated, including:

1. Use big data technology to obtain the data of water, soil and air in soil-crop field management.
2. The WHCNS model is used to simulate the basis and implementation of soil-crop and field management.
(3) Using JAVA based multi-thread computing technology, fully utilize the computing power of the processor, parallel and synchronous completion of large quantities of data simulation, improve the optimization efficiency of reverse parameters.

(4) Integration and development of soil-crop simulation and optimization system platform based on B/S mode of Web end.

2.3. Research methods

(1) Regional survey, fixed-point measurement and data collection

The research method is mainly aimed at the early stage of the simulated data sources, using the regional survey of them with the aid of land engineering for the project area or experimental plot of field reconnaissance and accumulation of data, like soil index data, climate, meteorology, hydrology and water quality data, field management of data, such as document data.

(2) Analysis of each module of WHCNS model

The research method for WHCNS model itself simulation mechanism and mode, the analysis model of each important modules, including meteorological module, the soil water hot nitrogen combined transport module, crop growth module, organic matter module, root water absorption nitrogen, inorganic nitrogen absorption module and field management and so on seven modules is how to obtain the quantitative data of simulation.

(3) The integration of JAVA based multithreading technology and Web platform

This research method is aimed at the analysis of Java multithreading technology and how it is actually applied in different systems, how can model programming C#, multithreading computing Java, Web platform development of JavaScript and other different functional languages combined to design a more interactive, more friendly simulation system, to find a reasonable solution.

3. System design

3.1. System overview

The soil-crop simulation module is mainly divided into seven parts, which are: soil-crop simulation project management, parameter input and modification, optimal configuration, start-up simulation, start-up optimization, simulation results, and optimization effect. Each part provides users with convenient operation through friendly operation interface. The soil-crop simulation project management interface provides users with the soil-crop simulation project overview, increase, query function convenient management and search module. Input and modification of parameters as the input interface of soil-crop simulation parameters, users can input, view and modify the corresponding parameters; Optimal configuration realized the use of the existing measured values to optimize the selected parameters, through the PEST algorithm calculation, which undoubtedly greatly improved the ease-of-use and accuracy of soil-crop simulation; Start simulation is the start button to control the remote computer for simulation calculation. Start optimization is the start button which controls the remote machine to optimize the parameters. Simulation results for users in a variety of ways to present simulation results, the data visualization; The optimization effect shows the deviation degree between the measured value and the optimized value, and the accuracy of optimization can be intuitively interpreted.

3.2. System architecture

This system adopts B/S mode, three-tier classical architecture, distributed nodes in the data layer, Spark, MapReduce logic calculation layer, and Web application of soil water and heat simulation based on JS, Java, Python, C# and other technologies. (as shown in Figure 1), seven main function modules of simulated soil-crop simulation management module, soil module, meteorological module, crop module, field management module, organic carbon module, and soil-crop simulation calculation module constitute the simulation operation process.
3.3. System hardware and software environment

Browser: Chrome, Firefox3.0 or above is recommended. Display resolution: more than 1280*1024 recommended.

Table 1. The system software and hardware configuration

| Type                      | Specific Description                                                                 |
|---------------------------|--------------------------------------------------------------------------------------|
| The hardware system       | Intel Core i3 processor (dual-core 3.70GHz), 8 gigabytes of RAM                      |
| The operating system      | Windows7 Ultimate Edition 64bit                                                      |
| Development platform      | MyEclipse, WebStorm, Dreamweaver                                                     |
| The database              | MySQL5.5                                                                              |
| The Web server            | Struts2, Hibernate3.5, Spring4.0, Tomcat8                                            |
| The GIS server            | Tiandi map online API services                                                       |
| The client                | Echart, jQuery, Ajax, Weather Awareness API                                           |
| UI                        | Photoshop, JQuery, Yasyui Plug-in                                                   |

3.4. Detailed database design

The database design idea of land Engineering big data platform is based on the real-time business data and is implemented based on the typical three-tier database architecture pattern, namely "physical layer", "logical layer" and "expression layer". Physical layer is the concept layer in the database design, including the composition of the overall business database, because the data based on the system is relational data, so it has also been based on the relational database, to achieve the construction of structured database, unstructured database, spatial database. The logical layer is mainly aimed at the design of the main table, schedule and connection relationship of specific data table. Based on the database design paradigm, the logical relationship between each table is constructed, and the data structure and attribute fields of each table are composed. The expression layer is through the database add (Insert), Delete (Delete), Update (Select), data front and background interaction, and in a certain form in the front-end expression.

Detailed database design is to design each table structure of the basic database of land engineering big data platform, including table name, table field name, field type, primary key, foreign key, constraint and other database standards. There are many database tables designed on this platform. For the sake of the expression of this article, it is not enough to enumerate one by one. This time, meteorological data source is taken as an example, as shown in Table 2 and Table 3 below.
Table 2 Monitoring site database tables

| Data table ID number | Table name | note               |
|----------------------|------------|--------------------|
| 1                    | ZTSJ_QX    | Meteorological data source |
| 2                    | ZTSJ_SW    | Hydrologic data source  |
| 3                    | ZTSJ_TR    | Soil data source    |
| ...                  | ...        | ...                |

Table 3. Monitoring equipment detailed design table

| Field identification | Field names | null value | primary key | field type | precision |
|----------------------|-------------|------------|-------------|------------|-----------|
| ZTSJ_QX_XH           | The serial number | No         | No          | Int        | 10        |
| ZTSJ_QX_JCZMC        | Monitoring station site | No       | No          | Char       | 14        |
| ZTSJ_QX_JCZDD        | Name of monitoring station | No    | No          | Char       | 14        |
| ZTSJ_QX_ID           | longitude   | No         | No          | Char       | 14        |
| ZTSJ_QX_WD           | latitude    | No         | No          | Char       | 14        |
| ZTSJ_QX_SBXH         | precipitation | No      | No          | Char       | 20        |
| ZTSJ_QX_CSPC         | The temperature | No     | No          | Char       | 12        |
| ZTSJ_QX_DY           | The direction of the wind | No | No | Num | 8 |
| ZTSJ_QX_GNYT         | The wind speed | No | No | Char | 20 |
| ZTSJ_QX_HB           | At an altitude of | No | No | Num | 8 |

3.5. The function module design of the system

3.5.1. Simulation Management. Under the soil and crop simulation management interface is the user of all soil-crop simulation the overview of the project, can be intuitive browsing various soil and crop simulation project creation time, modify time, type, configuration, status, optimization, optimization of parameter configuration state, including new project, set up simulation project, save the simulation project, project, delete simulation cloning project, and other functions. The details are as follows:

(1) New simulation project;
(2) Set up the simulation project;
(3) Save the parameter configuration;
(4) Clone simulation project;
(5) Delete the simulation project

Figure 2 Function module diagram of the system
3.5.2. **Soil module.** Soil module is an important parameter input module for soil-crop simulation. It includes four main parameter configuration parts: soil water, soil solute transport, soil heat conduction, and numerical algorithm. It includes a large number of independent and array parameters, which help each other to complete the description of the soil module in the soil-crop simulation process.

![Logical flow of soil water simulation](image)

**Figure 3** Logical flow of soil water simulation

This module focuses on the input and transformation process of each parameter, optimizes the configuration experience through the wizard input process, and completes the linkage of multiple configurations according to the relationship between parameters, transfers the complex file configuration to the background, reduces the occurrence of configuration errors, and lowers the user's threshold of relevant industry knowledge.

1. Soil water; 2. Solute transport in soil; 3. Soil heat transfer; 4. Numerical algorithm

3.5.3. **Meteorological module.** Meteorological data is the key data affecting the results of soil-crop simulation, and its value is closely related to the climate of the geographical location of crop simulation.

The meteorological module focuses on the matching, retrieval, storage and display of meteorological data in the soil-crop simulation process.

Relying on the massive multi-source data of the big data platform and the fast retrieval ability of data, it can reduce the cost of manual data collation and improve the efficiency of soil-crop simulation.

The meteorological module is mainly used to retrieve the weather conditions in a certain region within a certain period of time, and the starting and ending dates are manually selected.

![Soil heat transfer simulation logic flow](image)

**Figure 4** Soil heat transfer simulation logic flow

There are two options for latitude and longitude. One is to input the latitude and longitude of the region directly. The other is to select the region on the map displayed by "Map Selection Point" and click, and the latitude and longitude will be automatically filled.

After time and latitude and longitude are filled in, weather retrieval can be carried out on the information filled in.
Information retrieved parameters include: latitude, altitude, year, month, day, the day is the most low temperature, the high temperature, daily average temperature, average day average relative humidity, wind speed, minimum relative humidity, sunshine hours and rainfall, irrigation amount, PREC, rainfall, rainfall or irrigation water nitrate nitrogen concentration, the concentration of ammonium nitrogen rainfall or irrigation water

3.5.4. Crop models. The crop module is responsible for the configuration of simulated soil - crop crop parameters. Multiple simulated crops can be added to crop configuration, and character parameters of different crops in different periods can be described according to different soil-crop simulation model needs.

The crop model is consistent with the selection of the project type of the new project. The crop model PS123 is taken as an example below.

Click "Add Crop" to generate a new blank line for adding new crop parameters. In the table below, the corresponding crop name and corresponding development stage and parameter input interface of each organ will also be generated.

3.5.5. Field management module. The field management module is responsible for the input of field management parameters such as seeding and fertilization in soil-crop simulation. Different seeding cycles and fertilization patterns will affect the results of simulated soil-crop simulation.

In the field management module, users can design the parameter information of each sowing and fertilization process in the process of crop growth according to the needs, so as to better improve the accuracy of simulated soil-crop simulation.

Field management includes seeding, fertilizer application, organic fertilizer application or straw return.

3.5.6. Organic carbon and nitrogen modules. Soil organic matter is the most important material basis affecting the sustainable utilization of soil, and organic carbon and nitrogen are mainly recorded in soil organic matter types and distribution. Click Add the soil layer and input the initial organic matter content, C/N ratio and the added organic matter pool AOM of a certain depth of the soil layer. The color of the rectangle in the soil layer displayed on the right side changes from deep to light according to the initial organic matter content

4. Analysis of system characteristics

Innovation: The purpose of this project is to adopt the Web platform based on the Bamp S (browser and server) mode, with the help of big data's distributed storage and distributed parallel computing capabilities and the computer's multithreaded computing technology to replace the traditional desktop stand-alone computing method based on Cmax S (client and server). The computing efficiency is optimized, and a large amount of long-term data can be simulated and optimized by multithreading at the same time. So as to solve the situation that the calculation condition of the system is harsh and the calculation efficiency is low under the condition of stand-alone operation.

Practicality: it is no longer necessary for researchers and model applications to carry out experiments in front of workstations or simulation equipment, a single person can complete multiple tasks, and multiple people can also complete a task simulation together to simplify manual data entry. Capture the changing process of scientific research practice on a more accurate time scale, provide a good technical equipment support for production and scientific research, and save money and labor costs. Improve production efficiency.

Reliability: this project has a set of big data cluster platform on the hardware equipment, and the system realizes the high concurrency simulation mode of task parallel and data parallel, multi-person and multi-task can be simulated synchronously and asynchronously, which satisfies the PEST parameter adjustment of multiple parameters at the same time, and realizes the background calculation, which improves the efficiency and accuracy of the simulation, and the error range between the
simulation and the measured value is 13%–18%. There is a new improvement for the pilot test of land regulation, which has a certain value of application and popularization.

5. Conclusion
According to the comparison between the actual soil water and heat detection results and the simulation optimization results, it can be seen that the theory of the simulation system is established, the actual simulation results are in line with the confidence interval, the results are accurate, and the simulation results can be recorded and stored, which greatly reduces the investment in scientific research. It meets the precision requirements of some indoor experiments, pilot tests and field experiments, and has a good economic effect. The system goes on the Internet and adopts the sharing mode. It can be convenient for more researchers or practitioners in this field to use, and has a certain social effect.

This system has a good simulation accuracy in the application stage, and has a great improvement in simulation efficiency compared with the traditional system. The existing problems are mainly aimed at automatically matching meteorological and climatic data according to longitude and latitude without strict cleaning and standardization. Therefore, in the future optimization and improvement, focus on this kind of objective data to establish cleaning rules, standardize data, can be better applied to the simulation and visualization of the system.

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