Design and Implementation of Super-station Measurement and Control Software

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Abstract: Measurement and control software of super-station is the core part of super-station and it is also the important part of realizing super-station function. Aiming at the functional characteristics of the super-station, this paper designs the measurement and control software of the super-station and implements it by programming, focusing on the three aspects of the design requirements of the super-station. The interface connection between the measurement and control software and each unit of the super-station is solved in the design. In the aspect of the realization of measurement and control function, the design scheme and flow chart are defined, and the control instruction analysis and interface design are carried out. In the database module, by transplanting FATFS file system, the operation of adding, deleting, modifying and checking measurement data can be realized in the form of files. Finally, we summarize the main work and shortcomings of the design.

1. Introduction

1.1. Background and significance
The super-station is a device that integrates many kinds of measurement devices which are composed of angle measuring unit, infrared ranging unit, laser ranging unit, Beidou positioning unit and measurement and control unit and it can realize the measurement functions of angle measuring, ranging and positioning, control the orientation function of gyroscope[1], geodesic calculation function and user interaction function, and data communication function.

1.2. Research content
Geodesy consists of super-station, gyroscope, auxiliary equipment such as towing mark, tripod and portable power supply[2]. Geodetic software is composed of embedded software of each unit and its component unit. The composition of the geodesy is shown in the following figure (Fig.1).
2. Composition of geodesy

The software of super-station measurement and control needs the functions of measurement control, geodesic subject calculation, database management, data communication and bottom control. The paper will study and solve three aspects: The first is to solve the interface connection between the super-station measuring and controlling unit, the angle measuring unit, the infrared ranging unit, the laser ranging unit, the Beidou positioning unit and the gyroscope unit. The second is to control each unit of the super-station measurement and control unit, realizing the functions of controlling the angle measurement unit to acquire angle measurement data and ranging unit to acquire distance measurement data, gyroscope monomer orientation and so on. The third is compiling database to manage the acquired data and establishing file system to realize the functions of adding, deleting, modifying and searching data.

2. Material and Methods

2.1. Configure interface

The configuration of communication interface[4] mainly solves the interface connection between the super-station measurement and control software and the super-station units and gyroscope units. Determining the identification name of each interface and defining the communication protocol of each interface is needed.

2.1.1. Connect interface

The external interface of the super-station measurement and control software is the interface of the super-station unit, the embedded software of the gyroscope unit and the upper computer. The interface is shown in the figure (Fig.2).
Figure 2. Configuration of interface

As is shown in the figure, Infrared ranging unit, laser ranging unit, temperature and pressure sensor connect with super-station measurement and control software through \( I^2C \) bus. The gyroscope is connected with the superstation measurement and control software through RS485 interface. Angle measuring unit is connected through RS232A interface. Beidou positioning unit is connected through RS232B interface and upper computer software is connected through RS232C interface.

2.1.2. Identification and Use

The external interfaces of measurement and control software mainly include RS485, IIC and RS232. The interface identification and use of these interfaces are shown in the table (Table 1) below.

| Interface name | Interface identifier | Sender/Receiver | Interface use |
|----------------|----------------------|-----------------|---------------|
| RS485          | JK_485               | Measurement and Control Software/Gyroscope Software | Sending Gyroscopic Control Command |
|                |                      | Gyroscope Software/Measurement and Control Software | Feedback gyroscope orientation data and instrument status |
| RS232A         | JK_232A              | Measurement and Control Software/Angle Measuring Unit Software | Send commands of angle measurement and state acquisition, software upgrade data |
|                |                      | Angle Measuring Unit Software/Measuring and Controlling Software | Feedback Angle Measuring Unit Angle Measuring Data and State |
| RS232B         | JK_232B              | Measurement and Control Software/Beidou Positioning Software | Send Beidou positioning data control commands, data and status acquisition commands, and PRM annotation data. |
|                |                      | Beidou positioning software/measurement and control software | Feedback Data and State of Beidou Positioning Unit |
| RS232C         | JK_232C              | Measurement and Control Software/PC Software | Sending data of geodesic results |
|                |                      | Upper Computer Software/Measurement and Control Software | Embedded Software Upgrade of Receiving Angle Measuring Unit, Infrared Ranging Unit and PRM Filling Data of Beidou Positioning Unit |
| I2C            | JK_IIC               | Measurement and Control Software | Send infrared ranging control commands, collect data |
Interface name | Interface identifier | Sender/Receiver | Interface use
---|---|---|---
| | | | software/Infrared Ranging Software
| | | or status commands, software upgrade data
| | | Infrared Ranging Software/Measuring and Controlling Software
| | | Feedback Infrared Ranging Data and Equipment Status
| | | Measurement and Control Software/Laser Ranging Software
| | | Sending Laser Ranging Control Command, Collecting Data or State Command
| | | Laser Ranging Software/Measurement and Control Software
| | | Feedback of Laser Ranging Data and Equipment Status

2.2. **Design and Implementation**

In view of the functions of geodesic measurement and control, the software of super-station measurement and control needs to design control and measurement functions[3]. In the aspect of control, it is necessary to use each interface to send control instructions to operate angle measuring unit, range measuring unit and gyroscope unit. At the same time, the measurement data of angle measurement unit and distance measurement unit are acquired.

2.2.1. **Realization of Control Function**

The configuration of communication interface between measurement and control unit and each unit of super-station has been solved. Next, this section will solve the realization of the control function of the super-station and how to use each interface to send control instructions to operate the angle measuring unit, ranging unit and gyroscope unit. How the angle measurement unit can acquire the angle measurement data. How the distance measurement unit acquire the distance measurement data and how the temperature and pressure sensor data be received.

1). Control Process

The flow chart is shown in the following figure (Fig 3).
2). Design Scheme

There are two main aspects in the design of angle measurement control unit. The first aspect is the command of angle measurement control, and the second aspect is the design of angle measurement interface. Angle measurement control commands are divided into acquisition of angular data commands, switch partition board lighting commands, horizontal zero-crossing selection commands.

The design of the angle measuring interface is as follows (Fig.4).
Different key values are given to different keys. The key table is shown in the table below (Table 2).

| NAME | F1 | F2 | F3 | F4 | page | right | down | up | left | esc | enter | menu |
|------|----|----|----|----|------|-------|------|----|------|-----|-------|------|
| NUM  | 1  | 2  | 3  | 4  | 5    | 6     | 7    | 8  | 9    | 10  | 11    | 25   |
| NAME | 8  | 0  | 7  | 9  | +/-  | 5     | 1    | 4  | 6    | 2   | 3     | sub  |
| NUM  | 13 | 14 | 15 | 16 | 17   | 18    | 19   | 20 | 21   | 22  | 23    | 24   |

2.2.2. Realization of Geodesic Calculation Function
The software of super-station measurement and control should have the functions of geodesic calculation, including forward calculation, inverse calculation, multi-point inverse calculation, traverse measurement, elevation measurement, astronomical azimuth determination, fragmentation measurement, calculation of aiming point division, datum direction assignment, forward intersection, three-point rear intersection, distance intersection, triangular network, triangular lock between two control points, degree-minute-second and dense conversion, etc. Taking positive operation as an example, this section introduces the input and output screen, calculation model and process of positive operation.

1) Input and Output Screen
2). Compute Model

\[
\varepsilon = \frac{\pi}{2} - G1(G2) \quad (1)
\]

\[
D_{ab} = S \times \cos \varepsilon \quad (2)
\]

\[
H_b = H_a + S \times \tan \varepsilon + iL \quad (3)
\]

\[
X_b = X_a + D_{ab} \times \cos \alpha_{ab} \quad (4)
\]

\[
Y_b = Y_a + D_{ab} \times \sin \alpha_{ab} \quad (5)
\]

3). Flow Chart

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Figure 5. Input and output screen

Figure 6. Flow chart
2.3. Design Database Model
The purpose of designing the software database of super-station measurement and control is to manage the acquired data such as angle and distance, to facilitate data storage and to meet the operational requirements of adding, deleting, modifying and checking the design process. Data is stored in SRAM. After calculation, the data is transferred to FLASH in the form of files by establishing FATFS file system[5]. The operation of data is realized by calling file read-write function.

2.3.1. Building FATFS File System
FATFS can be used to implement FAT file system on small embedded systems. It is a general file system module. FATFS has several outstanding features: fast access to multiple files, separate and buffer each file of FAT structure, support for multiple drivers and partitions, and optimization of 8/16 micro-controllers.

The first step of migration is to define the data type, match the data type with the corresponding MCU and modify integer, h. The second step of migration is to configure ff.h. We change 0 in define WORD_ACCESS 0 to 1 because 1 represents byte access. STM32 is byte access, so it is modified to 1. In addition, we also need to modify the sentence define FS TINY 0, according to the size of RAM and FLASH, the size is set to 0, the larger is set to 1; At the same time, we can modify the specific situation according to different needs. The third step of transplantation is to modify the underlying functions, which is the most critical step. We need to modify six underlying functions: DSTATUS disk_initialize、DSTATUS disk_status、DRESULT disk_read、DRESULT disk_write、DRESULT disk_ioctl、DWORD getfattime_RCT.

The flow chart is shown in the following figure (Fig 5).

Figure 7. FATFS Transplant Flow

2.3.2. Design Flow
1). General operation
Figure 8. General operational chart

Description: Enter the database interface to display all saved job name files. Select button to view or delete operation. View operations can display job name files and data while delete operations delete specified file names and data or modify file names.

2). Data file saving operation

Figure 9. Data operational flow chart
Description: First enter the name of the job to determine whether the name of the job is duplicated or not. If duplicate reminders are repeated, re-enter the name of the job. Then input the data that need to be saved to determine whether the data need to be saved, if saved, then perform the corresponding file operation and if not, enter into the calculation. Determine whether to save the result, if to save the result, perform the corresponding operation, if not, save and end the operation.

3). Database main interface

![Database Interface](image)

Figure 10. Database interface

Description: Geodetic subjects enter the database interface, and page turning can be controlled by pressing the page turning key. The first screen shows forward operation, inverse operation, elevation measurement, traverse measurement, forward intersection, rear intersection and other subjects; the second screen shows distance intersection, step-by-step measurement, azimuth estimation, astronomical azimuth determination and other subjects. Select the keys to enter different subjects.

3. Results and Conclusions

3.1. Results display
3.2. Conclusions
My main work and harvest are as follows: The problem of configuration of communication interface between super-station measurement and control unit and angle measurement unit, ranging unit, Beidou unit and gyroscope unit is solved. The name and type of interface are determined, and the functions of each interface are defined. The control function of the super-station is realized, and the design scheme and flow chart are provided. Some functions of geodesic calculation are realized, and the calculation model and flow chart are designed. By transplanting FATFS file system to read and write the measured data in the form of files, and designing the database interface, the operation functions of adding, deleting, modifying and checking data are realized through interactive functions.

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