Data Acquisition of Wave Heave Based on LabVIEW

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Abstract

The six-degree-of-freedom swinging platform with servo motor + electric cylinder as the actuator was introduced in the laboratory, and the swinging platform was used for sinusoidal excitation to simulate the heave motion posture of the sea vessel. Inertial navigation system (INS) is used as the acquisition system to study the serial communication of INS. The output data of INS is configured according to the protocol of INS. The disassembly algorithm of data package is studied, and the acceleration information of heaving platform acquired by INS is obtained. The filtering and integration of acceleration signal are studied to acquire the displacement information of the platform is. Using the LabVIEW software development platform, the host computer software for data acquisition was written.

Keywords

6-DOF swing platform, Inertial navigation system, Protocol analysis, LabVIEW, data acquisition.

1. Introduction

For the exploitation of marine resources, the development of offshore equipment is crucial. Mining on the sea is different from land. Under the influence of wind and waves, the mining vessels on the sea will be swayed, swayed, heave, roll, pitch, and shake in six directions [1]. Then, secondary excitation will be given to underwater hoisting equipment, resulting in large random offset, which will not be able to complete normal operations in serious cases. It will make the tension of the flexible connection too large and break, thus causing serious accidents such as the loss of equipment and instruments.

Because the vertical movement of the ship changes the stress inside the wire rope continuously, when the fatigue strength exceeds the wire rope, the wire rope will break, resulting in the loss of working equipment under the sea, causing economic losses and stagnation of production operations. For such drilling operations on the surface of the sea, or other fluctuating water surface operations, if the device with wave compensation function is not added, the force of the bit will change continuously during the operation. In severe cases, the bit will be Damaged [2, 3]. Therefore, accurate collection of wave data is particularly important.

2. Experimental Platform for Heave Compensation

The laboratory has introduced Dalian Ruixin Science and Technology's six-degree-of-freedom swing platform. The platform system consists of the following six parts:

Mechanical system: Platform for the installation of loads and specimens, and driving loads and specimens to achieve the required movement; upper and lower joints; embedded parts.

Hardware of servo control system: monitoring unit, in order to ensure that the platform works smoothly, the unit will monitor the displacement of platform in real time. For the control command sent by the experimenter, the unit should be executed according to the command. servo control unit, which should be able to start the servo motor, motion servo motor and stop the servo motor at any time. In addition, to return to the motor operation state, it has the ability to deal with motor faults and protect the motor. Signal processing unit, which is to convert acceleration, displacement and other signals, also includes the conversion of analog signal and digital signal and the control of motor braking device.

Driving system: electric cylinder; servo motor, driver and position detection equipment.

Software of servo control system: system management and monitoring software; Servo control application software.

The six-degree-of-freedom swing table (RX/YBT-6-100) includes control cabinet and experimental platform, as shown in figs. 1 and 2. The actuator of the platform is replaced by servo electric cylinder, which can accurately simulate position and attitude, sine wave, single-degree-of-freedom motion, multi-freedom superposition motion, and complex non-linear motion can be realized according to a certain format of displacement data.

Fig. 1 Control cabinet Fig. 2 Experimental platform

3. Inertial Navigation System

Hardware of inertial navigation include 3DM-GX4-25 inertial sensor, serial communication cable (RS232), power supply with international plug adapter. As shown in Figure 3.

Fig.3 Hardware of inertial navigation system

Sensors in Inertial Navigation System (INS) are called Inertial Measurement Unit (IMU) for measuring navigation and positioning. These sensors are mounted on three spindles (x, y and z) to sense angular velocity, acceleration and local magnetic field. Accelerometer can measure both linear acceleration and gravity. Magnetometers can sense the Earth's magnetic field and local magnetic lines. All measurements are temperature compensated and mathematically aligned with orthogonal coordinates. Three-axis accelerometer measured data, low-pass filter filtered data, A/D conversion module converted analog signal to digital signal, then the mean filter processed digital signal, after temperature compensation, unitization. The data is filtered by Kalman filter and sent to the host through serial communication for storage. The monitoring software can configure the collected physical quantity and sampling frequency to display and store the collected data. The monitoring software can configure the collected physical quantity and sampling frequency, and display and store the collected data. Fig. 4 is a schematic diagram of the internal data measurement and processing flow of the sensor.

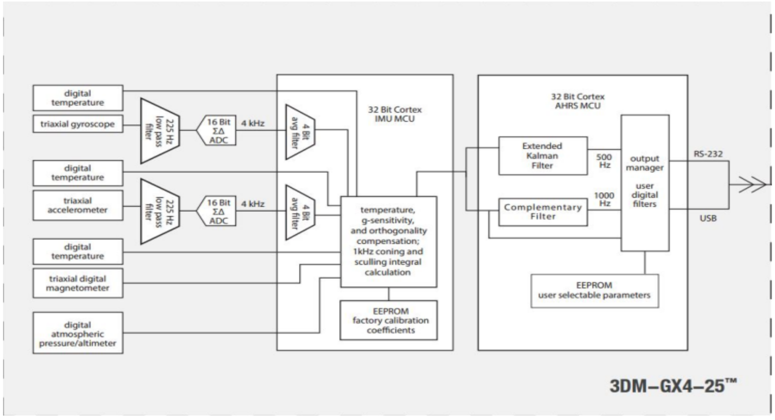

Fig. 4 Internal data flow of INS

The INS data is connected to the host via a communication cable. The INS protocol states that all commands, replies, and data are sent and received as fields in the message packet. A packet has a descriptor type field based on its content, so it is easy to identify whether a packet contains commands, replies, or IMU data. As shown in Figure 5

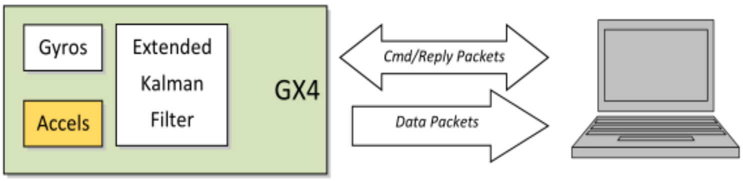

Fig. 5 Data transmission of INS

4. Compilation of Upper Computer Acquisition Program

LabVIEW is a programming environment developed by NI, similar to C and BASIC. However, LabVIEW programming language is quite different from other computer languages: LabVIEW language is not a traditional text command, but a modular and graphical programming language.The commands needed to be implemented only need to be manually dragged to the program block diagram. LabVIEW software is a good choice for engineers to implement test system or control system.

4.1 Communication between LabVIEW and INS

Usually, according to the process of configuring serial port, setting send/transfer buffer, VISA writing or VISA reading and closing serial port, combined with program structure such as event, cycle, condition, sequence and specific data operation processing, serial communication program can be written to meet user's intention. When configuring the serial port, the baud rate, data bits and parity check of the sender and the receiver should be set to the same value, that is, the transmission rate and frame format of both sides should be set in the same way. The output of "serial byte number" is connected to the terminal of "serial read" byte total number, that is, reading data according to the number of received bytes.

It should be noted that the inertial navigation device has been uploading data regardless of whether it is executed or closed in LabVIEW. At this point, if the serial port is opened directly to receive data, an error will occur. The reason for the error is that the port may not be configured when it receives the first character, so it reads invalid buffer information. The solution is to put a delay after the serial port configuration, so that the serial port has enough time to complete the settings. By using VISA to clear the I/O buffer function, the incorrect data in the receiving buffer can be cleared. The INS communication program is shown in Figure 6.

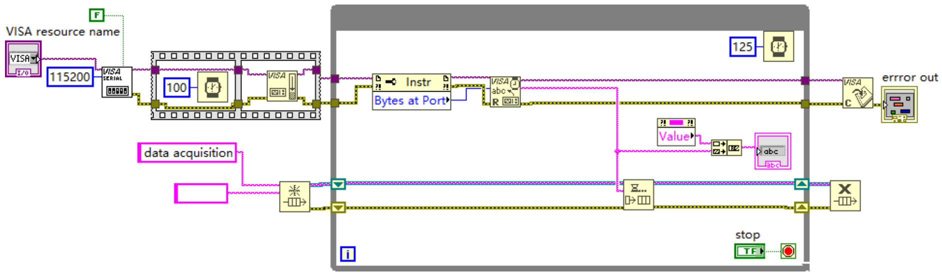

Fig. 6 Communication program

4.2 Filter processing

It can be seen from the acceleration signal that although the selected inertial navigation sensor has high precision and strong anti-interference, it is found in the experiment that the acquisition process is affected by the on-site environmental noise and temperature, and the acceleration signal contains noise interference signals. In the heave compensation experiment, it is very important to obtain the platform displacement information by acceleration. Therefore, the original acceleration signal needs to be filtered to facilitate further calculation of the displacement signal [4].

The Butterworth filter is more common in low-pass filtering, and the ship's heave motion is low-frequency motion. This paper uses Butterworth to filter [5]. The Butterworth filter is characterized in that the frequency response curve in the passband is as flat as possible, without undulations, and gradually decreases to zero in the blocking band. On the Bode plot of the logarithmic diagonal frequency of the amplitude, starting from a certain corner frequency, the amplitude gradually decreases with the increase of the angular frequency, and tends to negative infinity. In this paper, a second-order Butterworth filter with a cutoff frequency of 0.09 and an upper cutoff frequency of 0.2 is selected.

4.3 Quadratic Integration

Acceleration data are measured by inertial navigation sensors. In order to get the information of heave data, quadratic integration is needed. There are three commonly used quadratic integration methods: time domain integration, frequency domain integration and time domain-frequency domain integration [6]. Through analysis, the time domain integral satisfies the low frequency vibration, and the calculation amount is small, which is suitable for online operation. Therefore, the choice of time domain integration is more appropriate.

Suppose the acceleration signal obtained by the test is a(t), and the speed signal v(t) is obtained after one integration in the time domain:

$$v(t) = \int a(t)dt = v'(t) + v_0 \tag{1}$$

After two integrations, the displacement signal s(t) is obtained:

$$s(t) = \int v(t)dt = s'(t) + s_0 \tag{2}$$

LabVIEW provides a point-by-point integration module for real-time data collection. Point-by-point integration can flexibly calculate data of any length. It is calculated once every time the program is run once. The initial value of the current integral is the result of the previous call.

According to the above steps, the acquisition program is shown in Fig. 7.

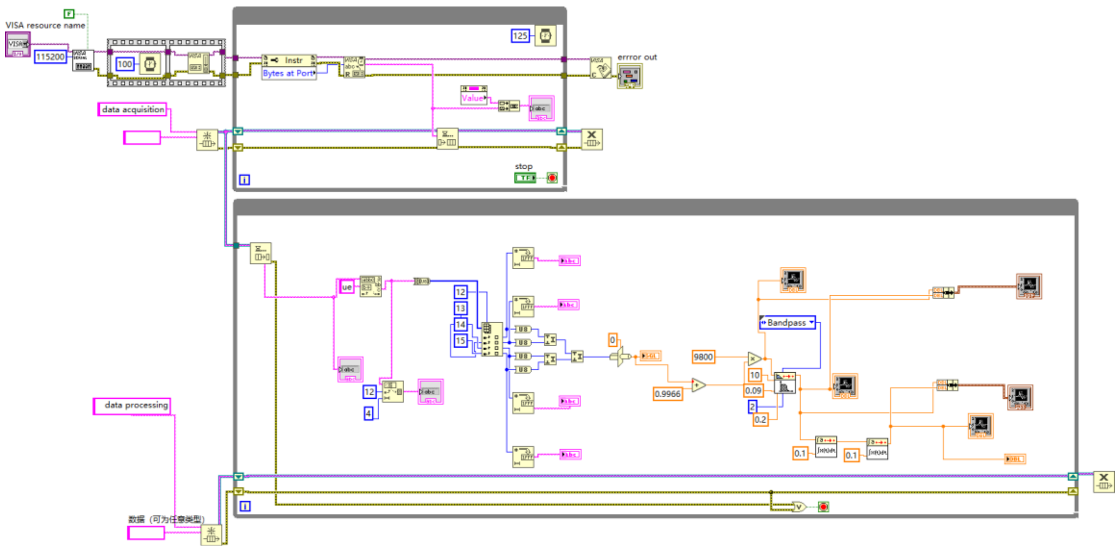

Fig. 7 Data acquisition program

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5. Conclusion

Firstly, the inertial navigation system is introduced. The inertial navigation is connected to the host computer, and the serial communication program is written by LabVIEW software. According to the internal protocol of the inertial navigation, the data packet sent to the host through the serial port is parsed, thereby obtaining the IMU signal. Then, using the inertial navigation to acquire the heave acceleration of the six-degree-of-freedom swing table, Butterworth filtering is applied to the acceleration signal, which has achieved good results. Using the point-by-point integration in LabVIEW, the second integral of the filtered acceleration signal, combined with the integrated displacement signal and theoretical analysis, the displacement signal has no time delay and the amplitude is attenuated. The upper computer program has strong reliability.

Acknowledgements

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