Multi-sensors data acquisition and information fusion for manned submersible vehicle*

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Abstract A way of navigation sensors data acquisition and information fusion for manned submersible vehicle is introduced in this paper. Firstly, navigation control computer acquires the sensors data via Ethernet-based inter-communication system. And then the computer fuses those data and information in Kalman filter so as to improve the data precision and control system performance. At last the fusion data are sent to monitor computer to display the information of manned submersible vehicle.

Key words manned submersible vehicle multi-sensors data acquisition and information fusion

载人潜水器多传感器数据采集与信息融合技术

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摘 要 本文介绍了一种用于载人潜水器的导航传感器的数据采集及信息融合技术。航行控制计算机通过基于工业以太网的数据通信系统对各传感器进行数据采集,采用卡尔曼滤波器完成对各传感器数据信息的融合,以便提高数据的精度和控制系统的性能,并将结果送给监控计算机,用于载人潜水器的姿态显示。

关键词 载人潜水器 多传感器 数据采集与信息融合

1 Introduction

Recent years, because the need of exploiture of sea source and environment improves the underwater robot and correlative technology's development. Shenyang Institute of Automation, Chinese Academy of Sciences and other several institutes are researching a new type underwater vehicle-manned submersible vehicle based on the remotely operated vehicle (ROV) and autonomous underwater vehicle (AUV). In order to get all kinds of pose information of MSV, many navigation sensors are installed in the MSV, these sensors can measure the pose and movement parameters of the MSV, but some of these information is redundant, which needs to be deal with to get more precise information. These information is used for sailing control and display, which makes pilot know MSV's status exactly and operate safely.

Navigation sensors include compass (COM), fiber optic gyro (FOG), inclinometer (ICL), motion reference unit (MRU), Doppler log (DPL), CTD (conductivity temperature depth) and so on. They have standard serial digital interface, which is convenient for computer to acquire and process information. Serial device networking server is used to extend serial interface, which is based on industry Ethernet, it makes sensors data easily acquired and conveniently installed.

2 Navigation Sensors in MSV

The navigation sensors are briefly introduced in this part.

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(1) Digital compass (COM)

It provides the heading of MSV, its main performance index:

Accuracy: 0.5°

Resolution: 0.1°

Interface: RS-232

(2) Fiber optic gyro (FOG)

It provides the rotation rate of the MSV's heading, which is backup data of the MRU about this parameter, its main performance index:

Input rate (max): ±100 °/s

Rate resolution: 0.014°/s

Interface: RS-232

(3) Inclinometer(ICL)

It provides the pitch and roll of the MSV, its main performance index:

Accuracy: ± 0.1°

Angular range: ± 75 °

Interface: RS-232

(4) MRU

It provides roll, pitch, and heave, as well as instantaneous data on rotation around its own axes, its main performance index:

Dynamic range: ± 500°/s

Angular resolution: 0.2 arc second

Interface: RS-422

(5) Doppler log (DPL)

It provides movement velocity of MSV relative to the bottom of sea, its main performance index:

Range: 150m

Accuracy: ±0.4%

Interface: RS-422

(6) CTD

It provides the conductivity, temperature and depth of sea, only depth is useful in the MSV, its main performance index:

Range: 0～7000m

Accuracy: ±0.01%

Interface: RS-485

3 Hardware Structure of MSV's Sensors System

According to MSV's character, panel PC-TPC650 produced by Advantech corporation is adopted as sailing control computer to acquire and process data from sensors in the MSV. Serial device networking server are chosen to extend serial ports, which are Nport5410 and Nport5430 produced by MOXA. The Nport5410 has four RS-232 serial ports and the Nport5430 has four RS-422/485 serial ports. The information from sensors in the MSV is acquired by the sailing control computer through the two serial device networking servers. The hardware structure of MSV's sensors system is shown in Fig. 1.

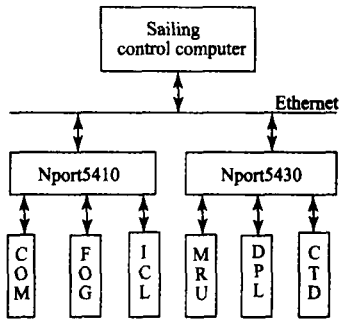

Fig. 1 the hardware structure of MSV's sensors system

4 Data Acquisition and Information Fusion

4.1 Data Acquisition

The operation system of sailing control computer is Windows CE, which has powerful ability of network communication, so it is easy for sailing control computer to access the two serial device networking servers through industry Ethernet. Every serial device networking server is allocated an IP address by programmer, which has four serial interfaces, each of them has a different Ethernet port number. According to IP address and port number, the sailing control computer may communicate with the corresponding sensor and acquire data through the socket communication function provided by Windows CE.

4.2 Multi-sensors Information Fusion

After the information from the navigation sensors is acquired by sailing control computer, the computer will deal with the information. Because the navigation information from MRU includes all sailing movement information of the MSV except the depth, it is dealt with by computer through Kalman filter to get high precision data.

The information from FOG, COM, ICL is regarded as the redundant data of the MRU. The velocity information from DPL is more precise than that from MRU, so it is preferentially used. Because the DPL can't measure the velocity when it is far to the sea bottom, the velocity information from MRU will be used. Navigation calculation (Navi Cal) will be obtained through information from sensors too. After the information is dealt with, it is sent to control computer and the monitoring computer for control and display. Multi-sensors information fusion is shown in Fig. 2.

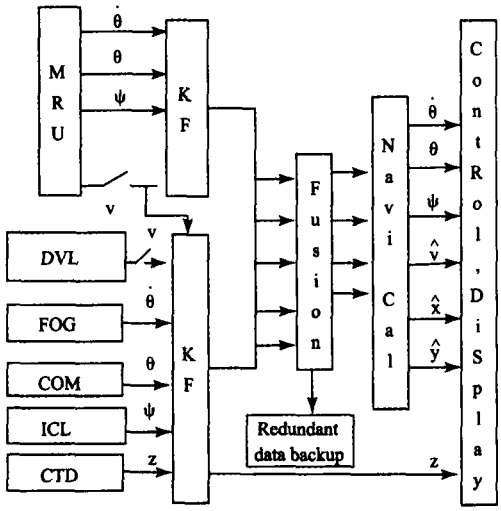

Fig. 2 multi-sensors information fusion

There are two Kalman filters in Fig. 2, which adopt the same status transfer equation (1), but the data noise matrix is different from each other, it is easy to realize data filter.

$$p(k+1)=p(k)+v(k)\cdot dt+v'(k)\cdot dt^2/2 \quad (1)$$

4.3 Asynchronous Data Filter Mode and Redundant Data Process

Because the sampling frequency is different, not all sensor data used in an iterative filter loop is up to date. To make the filter carry out normally, the data of the last time will be used, which is called asynchronous data filter mode.

Much of data in MSV is redundant, which is seen in Fig. 2, which needs to be fused to attain more precise control data after Kalman filter. It is well known that each Kalman filter has its own data estimation error's variance matrix. It is supposed that the data matrix from the two filters are $P_1(k)$, $P_2(k)$ at the kth moment, then the variance matrix of estimation error from the two filter are . The fusion data from two sensors is supposed by $Y_f(k)$, which is figured out from equation(2):

$$Y_f(k)=\frac{Y_1(k)\cdot P_2(k)+Y_2(k)\cdot P_1(k)}{P_1(k)+P_2(k)} \quad (2)$$

The more precise data is attained by this way, which is very useful for the sailing control and data display.

5 Conclution

Because the MSV works in very complicated and deep ocean environment, the accuracy and reliability of data are very important for MSV, it is necessary to make multi-sensors data fusion. A method about multi-sensor data is proposed in this paper, which is based on multi-sensors data acquisition. It is tested in our semi-physical simulation platform, the result is better.

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