Design of Ship Intelligent Monitoring System Based on Embedded System

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Abstract: With the penetration of science and technology into various industries, more and more new cutting-edge technologies have been widely used in the field of ships, and the ship monitoring system, as an important part of the entire ship, is also increasingly tending to the development direction of intelligence and modularity. Among them, embedded technology has a very good development prospect in the field of ship monitoring. This paper mainly studies the design of ship intelligent monitoring system based on embedded system. This paper uses embedded technology, data acquisition technology and wireless communication technology to design and implement a ship information acquisition and transmission system based on embedded technology. The system collects the acceleration, angular velocity, angle, magnetic field, longitude and latitude, satellite positioning, horizontal and vertical position information of each ship in the fleet by means of hardware and software combination. According to the experimental results, 100 abnormal ship position data can be identified in a certain period of time when the number of abnormal ship position is greater than or equal to the threshold value. When the number of abnormal position of a ship is less than or equal to the threshold, the system will not identify it as an abnormal position of the ship.

Keywords: Embedded Technology, Ship Monitoring, Monitoring System, Can Communication

1. Introduction

Modern information technology, big data technology and artificial intelligence and other technologies have infiltrated many fields, taking land transportation as an example, the application of modern technical means makes the transportation industry such as vehicles and logistics more efficient, environmentally friendly, safe and reliable. For the shipbuilding industry, the application of modern information technology and network technology will certainly change the working mode of traditional ship navigation, management, search and rescue, scheduling, etc., and

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develop in a safer and more intelligent direction. International organizations such as the International Maritime Organization and the International Organization for Standardization have listed smart ships as an important topic for future research [1]. The "E-navigation" strategic plan proposed by the International Maritime Organization also needs to be supported by ship intelligence, and the relevant regulations, technical rules and standards of intelligent ships are also being improved day by day. Various foreign shipbuilding countries are competing to study the technical problems related to intelligent ships and industrial equipment, and the process of intelligent ships is rapidly advancing. According to the "Guidance on the Development of Intelligent Shipping" issued by seven national departments including the Ministry of Transport and the Central Cyberspace Administration in 2019, the state has planned the development goals of intelligent shipping in the next 30 years, emphasizing the importance of autonomous navigation, energy efficiency monitoring and optimization control, cargo status monitoring, hull and equipment life cycle status monitoring and management, and the construction of a safe navigation support system [2]. Whether from the international or domestic point of view, the development of intelligent ships has been the general trend. In maritime management, Vessel Traffic Service (VTS) plays an important role in maintaining traffic order, ensuring ship safety, combating traffic hit-and-run and guiding maritime emergency affairs [3].

For a long time, foreign countries have always been in the leading position in the field of ship monitoring system, the system they developed has the advantages of stable performance, high degree of automation, easy to expand and so on. Foreign representative enterprises include: Germany's Siemens, Sweden's ABB Group, Norway's Norkon company, etc. [4]. "Ship automation" was first proposed around the middle of the 20th century. After more than half a century of continuous development, the ship engine room monitoring system has undergone four major breakthroughs in general, and the step by step improvement has made the system more reasonable in structure, more complete in function and higher in reliability [5]. In the mid-1980s, fieldbus as a new type of network communication technology began to develop in various fields. Fieldbus distribution system actually uses fieldbus to connect sensor modules, controller modules and actuators together to achieve the characteristics of digital communication [6]. In the 1990s, the field of ship also began to use the fieldbus fully distributed control system, and the development momentum was rapid, representing the development direction of the field of ship automation for a long period of time in the future [7]. With the development of semiconductor technology, the development of embedded technology is becoming more and more perfect,ARM7, ARM11, Cortex and other models of the development board in the field of industrial design is increasingly widely used. Embedded system is a kind of integrated computer system with both software and hardware functions, but it is different from traditional computer systems in the past. Embedded system focuses more on application, in order to achieve functions, on the basis of computer technology, complete the corresponding cutting, customization, operation and so on. It has outstanding advantages in terms of instruction execution speed and addressing mode [8]. The Marine environment is complex, and uncertain factors such as weather, wind and waves have a great impact on the course and speed of the hull. The high reliability of embedded devices can better meet the requirements of the accuracy and stability of ship data acquisition [9].

This paper designs and completes an embedded ship information acquisition and transmission system. Based on the existing sensor technology and transmission mode, it combines embedded hardware equipment in a specific development environment to complete the programming of many modules and realize the real-time acquisition and transmission of ship information. The flexibility of the receiver makes the many-to-one transmission mode more convenient and practical for offshore areas Both the internal ship management and the internal information exchange of the ocean-going fleet have certain application value.

2. Hardware Design of Embedded Intelligent Monitoring System

The ship information acquisition and transmission system designed in this paper is composed of four parts: data acquisition module, data processing module, data transmission module and data receiving module. The hardware of the data acquisition module is composed of JY901 attitude sensor,NEO-6M-V23GPS module and STM32F103 MCU. The hardware of data processing module adopts ARM7LPC2132 development board; the data transmission module adopts JZX878 wireless data transmission station; the data receiving module adopts CortexA9OK4418C development board, equipped with embedded Linux operating system.

The main control chip in the data acquisition module is STM32F103C8T6 series, the main frequency is 72MHz, the size is 51.5mm*40mm*11.5mm, and the operating temperature is in the range of -40℃~80℃ to adapt to the temperature difference at sea level.

The main system consists of four driver units, ICode bus, DCode bus, system bus, universal DMA and four passive units,SRAM, Flashmemory, FSMC, AHB to APB bridge, through a multi-level AHB bus connection.

ICode stands for instruction. After completing the writing of program functions and compiling the program, the program will become one instruction,FLITF is a FLASH interface, through which FLASH memory can receive instructions and store. When the kernel wants to run a program to implement a function, it obtains instructions from the FLASH memory through the ICode bus.

DCode stands for Data bus. When writing programs involving data types, the data should be defined according to whether it is a constant or a variable. Constants are usually expressed as const and stored in FLASH memory. If the data is a variable, either global or local, it is stored in SRAM. At this time, when DCode and DMA both want to get data, there will be access conflict, so before getting data, DCode and DMA must pass through a bus matrix, and the bus matrix determines whether DCode or DMA bus gets data at this time.

FSMC is a special external device in the STM32F103x series of microcontroller, the main function is to flexibly expand the static memory. From AHB system bus to APB1,APB2 bus is connected in a bridge mode, on APB1 and APB2, mount a large number of different peripherals, such as serial port, SPI, etc. When using STM32 microcontroller for development, it is largely necessary to drive these external devices to achieve the required functions.

The GPS sensor is ATK-NEO-6M-V23. The positioning accuracy is 2.5mCEP(SBAS:2.0mCEP), the maximum update rate is 5Hz, the default communication protocol is NMEA-0183, and the serial port communication baud rates are 4800, 9600, 19200, 38400, 57600, 115200, and 230400. Its operating temperature is in the range of -40℃~85℃, and provides fast positioning. Even when used at sea, the surrounding environment is changeable, and it has good stability. GPS sensors have one or two UART ports that can be used to transmit GPS measurements, monitor status information, and configure receivers. The serial port consists of RX and TX lines, both operating in asynchronous mode. Different baud rates can be set for each serial port, but it is not supported to set different baud rates for the receiving and sending ends or to follow different protocols on the same port. The pin functions are shown in Table 1.

Table 1. GPS sensor pin table

Lead	Name	Feature
1	RXD	Module Serial Reception (TTL)
2	TXD	Module Serial Transmission (TTL)
3	GND	Land
4	VCC	Power supply (3.3V~5.0V)

The data processing module is developed by ARM7LPC2132 chip. LPC2132 is a powerful and low-cost chip that integrates simulation and embedded tracking. In the process of running the code, the size of the code can be effectively controlled, and the function loss is small. Its serial communication interface and on-chip SRAM reserve large storage space for the development board. ARM7 development board with this chip, in practical applications for data storage, buffering, running efficiency and other aspects have great advantages. As shown in Table 2, it is the LPC2132 pin table.

Table 2. .LPC2132 PIN LIST

PINSEL0	Name	Value		Feature
17:16	P0.8	0	0	GPIO P0、8
		0	1	TXD（UART1）
		1	0	PWM4
		1	1	Reserve

3. Monitoring System Software and Communication Design

3.1 Software Design

The monitoring node software of the ship engine room monitoring system needs to complete the following tasks: initialize the hardware equipment including the control module and various sensors; the sensor is used to collect all kinds of signals and complete the A/D conversion process; the control module processes and fuses the relevant data, sends it to the bus through the controller and transceiver, or receives the control information sent by the bus, and processes it; and need to diagnose and deal with related faults. The initialization of the monitoring node control module mainly includes the initialization of the following modules :GPIO port, timer/counter module, system clock module, CAN bus module and A/D conversion module. After completing the initialization of the whole system, it starts to enter the main cycle module, calls the subroutine of each function module in the cycle body, and then enters the called subroutine module for various functions such as data collection, data processing, data packaging and control [10]. If an interrupt response occurs at this time, the control module of the monitoring node will send the packaged data to the CAN bus through the CAN gateway module. On the one hand, the control module of the monitoring node will transmit the packaged data to the control module of the upper computer in the form of sending data frames, so that the upper computer can display the data, alarm the parameter timeout and diagnose and deal with related faults. On the other hand, the control module transmits the packaged data to other nodes by sending remote frames to realize data sharing; at the same time, the monitoring node will also receive commands sent by the control module of the upper computer to set device parameters or to control the device [11-12].

A/D conversion module includes selector AMUX0, amplifier PGA0, special function register and ADC. AMUX0, PGA0 and ADC can be controlled by different special function registers. In addition, if we want to ensure that other function modules can work normally, we can only first put the AD0EN position 1 in the ADC0CN special function register, which is used to control the ADC, otherwise, the whole subsystem will be shut down Fuck.

The maximum conversion rate of this A/D conversion module theory is about 0.1Msps, and the conversion mode is determined by the special function register ADC0CN, which is jointly undertaken by the AD0CM0 bit and AD0CM1 bit, and the conversion trigger source mainly uses the internal trigger mode and the external trigger mode. The main reasons for using the internal trigger mode are as follows: First, the AD0BUSY position 1 in the special function register ADC0CN, and then the timer 2 or 3 overflow. Using an external trigger is an external A/D conversion to start the trigger of CNVSTR0 [13-14].

First, the AD0BUSY position 1 in the special function register ADC0CN is started to perform A/D conversion, and after the conversion is completed, it is set back to 0, and the converted data is stored in the ADC0H register and ADC0L register. When the A/D conversion is triggered by the AD0BUSY position 1 in the special function register ADC0CN to trigger the data conversion, it is necessary to query the interrupt flag bit (AD0INT) in order to determine the end time of the specific conversion [15].

3.2 CAN Communication Design

In this system,CAN bus interface driver includes initialization program, data sending program and receiving program. In the initialization of CAN bus, the communication rate, working mode and identifier filter are mainly set. The baud rate of CAN bus communication is determined by the characteristics of bit time, and the normal bit time includes SYNC_SEG, time period 1(BSl) and time period 2(BS2), as shown in Figure 1.

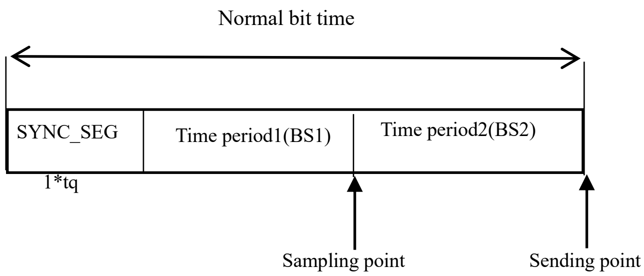

Fig 1. Bit time characteristics of CAN

t_q in Figure 1 represents a time unit:

$$t_q = L \times t_{PCLK} \tag{1}$$

In formula 1, L is the frequency division coefficient, and t_{PCLK} is the time period of the APB clock.

The bit time T_{bit} is:

$$T_{bit} = 1 \times t_q + t_{BS1} + t_{BS2} \tag{2}$$

$$t_{BS1} = M \times t_q \tag{3}$$

$$t_{BS2} = N \times t_q \tag{4}$$

From formula 2 to formula 4, M and N are the number of time end members in time period 1 and time period 2. From formula 1, we can see:

$$T_{bit} = 1 \times t_q + M \times t_q + N \times t_q = (1 + M + N) \times L \times t_{PCLK} \tag{5}$$

Therefore, the communication rate of the CAN bus is:

$$F_{bit} = 1 / T_{bit} = 1/((1 + M + N) \times L \times t_{PCLK}) \tag{6}$$

The running mode of CAN bus includes working mode and test mode. Test modes include silent mode, loopback mode, and loopback silent mode, which are not covered in detail here. Working mode includes initialization mode, normal working mode, and sleep mode. Parameters such as baud rate and mode settings are implemented in the initialization mode. During the initialization mode, packets are not received or sent. After the initialization, we can receive and send data normally. The CAN bus can work in sleep mode when idle, its purpose is to reduce power consumption, and it can be awakened by both software and hardware.

In the CAN protocol, the identifier of the packet does not indicate the node address, but is related to the packet content. The sending node broadcasts the packet to other nodes on the bus. The other nodes determine whether the packet is needed according to the value of the identifier. How to determine whether the packet is needed, it needs to set a filter group to determine.

When a node on the bus sends a message, it selects an empty sending mailbox, sets the identifier, data length, and data to be sent, and then requests to send the message. The packet is sent when the bus is idle and the priority of the mailbox to be sent is the highest. In this paper, dual CAN interface is designed. When CAN interface fails to send,CAN2 automatically switches and resends. The received messages of the node are stored in the FIFO of the level 3 mailbox depth, and the software reads the messages in the mailbox by reading the FIFO output mailbox. After a packet is read, the space is released. If three consecutive packets are not read, the space overflow occurs after the fourth packet is received.

4. Ship Intelligent Monitoring System Test

The ship location authenticity service test based on real-time location mainly tests whether the service can correctly identify the ship whose location information in a specific scene does not match the calculated location according to the last time. The authenticity judgment of the ship's position based on the real-time position needs to calculate the ship's position at the current moment according to the ship's position at the previous moment. If the calculation is abnormal for several consecutive times, the ship's position authenticity is considered abnormal. If the track is interrupted, the count will be restarted. Otherwise, the number of ship position anomalies within a period of time does not exceed a certain value, then the authenticity of the task ship position is not abnormal. Therefore, the ship trajectory data is designed to be tested under different conditions, such as the number of continuous anomalies greater than the threshold value and less than the threshold value in a certain time.

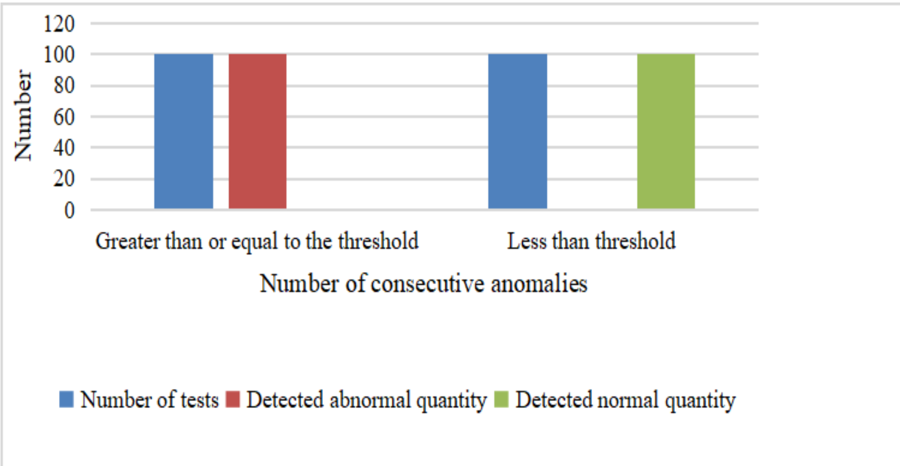

Fig 2. Based on real time ship position identification

As shown in Figure 2, it can be concluded from the test results that in a certain period of time, when the number of ship position anomalies is greater than or equal to the threshold, all abnormal ship position data can be identified based on the real-time ship position authenticity service. In a certain period of time, when the number of ship position anomalies is less than or equal to the threshold, the real-time ship position authenticity service will not identify the ship as the abnormal ship. It can be concluded that the real service based on real-time ship location can meet the requirements of the service.

5. Conclusions

The design of this system is based on embedded technology, hardware and software combination, complete a set of ship information acquisition and transmission system based on embedded. The system function realizes the real-time reception and storage of the data of the whole fleet by the shore base station in the offshore area, which is conducive to the overall monitoring of the offshore fleet by the shore control center and the subsequent analysis and processing of the information such as the sailing track, sailing speed and position of the fleet. The command ship inside the fleet is equipped with a data receiving device to complete the transmission of fleet data to the command ship, which realizes the monitoring requirements of the command ship during the voyage and facilitates the management of the fleet.

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