

Design of an indoor/outdoor seamless positioning and attitude detection system

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ABSTRACT

Aiming at the problems such as inaccurate positioning caused by indoor blocking of satellite positioning signals and the demand of personnel attitude detection, this paper designs a seamless positioning and attitude detection system based on GPS and inertial navigation, the system uses STM32 as the main controller, GPS and iNEMO sensors collect positioning and attitude detection data, and the processed information is sent to the upper computer through GPRS module SIM300, it realizes remote indoor and outdoor seamless positioning and attitude detection functions.

Keywords: Positioning, Attitude detection, STM32

1. INTRODUCTION

Beidou, GPS, GLONASS and Galileo are the four major satellite positioning systems at present. Outdoor positioning has wide coverage and high accuracy, but in indoor and urban complex environment, they are easily affected by signal blocking and attenuation, resulting in inaccurate positioning results or even unable to locate. In response, indoor positioning technology has gradually developed, mainly including RFID technology, WIFI technology, Bluetooth technology, ultrasonic technology, inertial navigation technology, etc. Outdoor and indoor positioning technologies are independent of each other, but seamless docking from outdoor to indoor or from indoor to outdoor cannot be realized. Seamless positioning is very important for specific personnel. It is extremely important to know the position and posture information of the firemen in real time when the firemen enter the scene of the serious fire to rescue. In order to meet this demand, this paper designs a seamless positioning and attitude detection system based on GPS and inertial navigation technology.

2. OVERALL SCHEME DESIGN

This system positioning adopts the method of combining GPS and pedestrian track estimation positioning technology, among which pedestrian track estimation positioning adopts the method of measuring walking distance based on step frequency and step length. The system merges the data of the accelerator, magnetometer and gyroscope of the inertial module iNEMO, and obtains three attitude angles of yaw, pitching and rolling. After processing the three-axis acceleration data of the waist iNEMO, the step frequency detection is realized, and the step counting function is realized. After the step counting is accurate, the yaw angle information after the fusion of the waist iNEMO is utilized, and the step size model is combined, calculate and decompose pedestrian tracks and convert them into longitude and latitude information. Receiving longitude and latitude information through GPS module, and processing the error of the output data of GPS module, when the quality of GPS signal is good, the positioning result completely adopts GPS positioning information, and use GPS positioning information to

correct the pedestrian track estimation information in real time; When the quality of GPS signal is average, combine GPS positioning information and pedestrian track estimation positioning information, and take the fused information as the final positioning result; When the quality of GPS signal is poor, the positioning result adopts pedestrian track to calculate the positioning information. The system uses two iNEMO sensors to realize attitude detection, and the two sensors are respectively installed on the legs and waist to detect the attitude angle. According to the physiological characteristics of human body movement, posture information can be obtained by analyzing the data output by iNEMO sensors in legs and waist.

The system is mainly composed of STM32 main control module, GPS module, iNEMO module, GPRS module, display module and power supply module, etc. The information collected by GPS module and inertial navigation iNEMO module is processed by STM32 main control module, and then sent to upper computer through GPRS module to complete positioning and attitude detection. The system framework is shown in Figure 1.

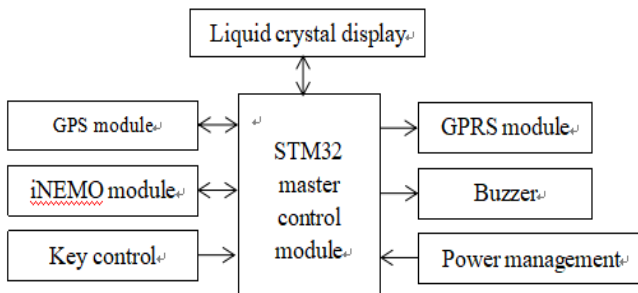


Figure 1 Overall block diagram of the system

3. HARDWARE CIRCUIT DESIGN

3.1. Master Control Module Design

The main control chip is STM32F103VCT6 of STMicroelectronics company. The design of the minimum system circuit is shown in Figure 2, including BOOT circuit, crystal oscillator circuit, reset circuit, power supply circuit, etc.

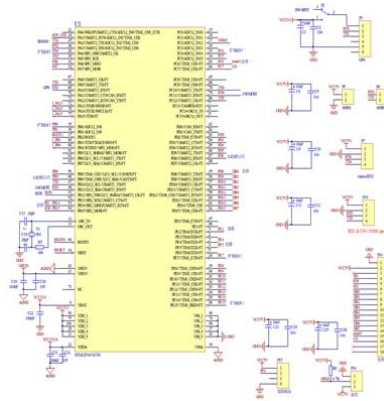


Figure 2 Minimum system diagram of STM32F103

3.2. GPS Module Design

This system adopts the GPS module GS-216m with ceramic antenna. Gs-216m is an intelligent satellite receiving module with high efficiency and low power consumption. GPS module continuously sends data to the main controller STM32 through the serial port.

3.3. GPRS Module Design

SIM300 is selected as GPRS wireless transmission module. SIM300 is designed with low power consumption, and the current consumption is only 2.5mA in sleep mode; SIM300 integrates TCP / IP protocol stack and extends TCP / IP at instruction, which makes it easy for users to develop data transmission equipment by using this module. The application circuit of SIM300 chip is shown in Figure 3.

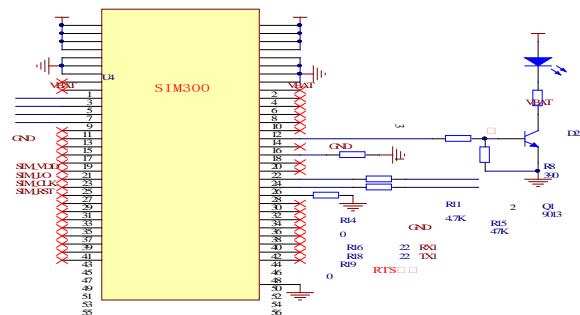


Figure 3 Circuit diagram of SIM300

The RXD and TXD pins are adopted to conduct serial communication with the SCM STM32 and receive the data and instructions sent by the STM32. The SIM card information Reading circuit is shown in figure 4.

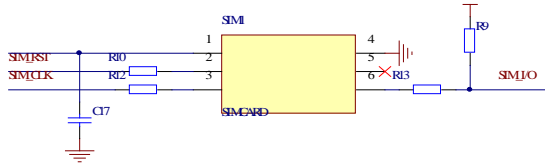


Figure 4 SIM card information Reading circuit

3.4. Serial Communication Module Design

The serial communication uses MAX3232 chip for level conversion. STM32 adopts serial communication with GPS, iNEMO and GPRS, STM32 uses serial port 2 to send instructions to GPRS through MAX3232 level conversion and receive the returned information; The main control board provides 3.3V voltage to supply GPS power, use serial port 1 to receive GPS longitude and latitude information; Power supply voltage of leg and waist inertial navigation module is 5V, leg iNEMO and waist iNEMO respectively use serial port 3 and serial port 4 to receive angle and acceleration information. The MAX3232 circuit is shown in figure 5.

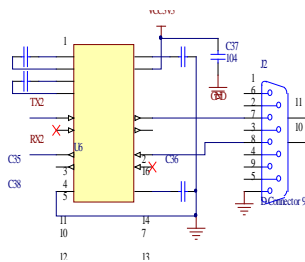


Figure 5 MAX3232 circuit

3.5. Inertial Navigation Module Design

The inertial navigation module adopts the iNEMO sensor produced by Italian semiconductor company. The iNEMO sensor can provide raw data through serial port, and also can provide pitch angle, rolling and yaw after AHRS algorithm fusion.

3.6. Display Module Design

The TFT2.4-inch color screen is selected to display the user's position, posture and other information. The TFT ILI9320 is selected as the display control part of the color screen, and the color screen interface P14 is designed. CS is the color screen selection pin, reset1 is the RESET pin, RS is the data command selection pin, and RW is the read/write selection pin. The color screen display circuit is shown in figure 6.

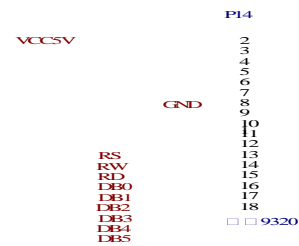


Figure 6 Color screen display circuit interface

3.7. Power Module Design

The system selects LM2940-5.0 voltage stabilizing module to output 5V DC voltage, and selects LM1117-3.3 voltage stabilizing module to output 3.3V DC voltage. The power supply circuit is shown in Figure 7.

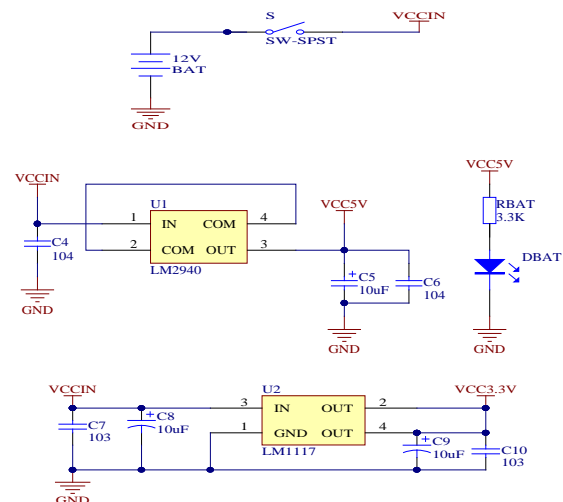


Figure 7 Power Circuit Schematic diagram

3.8. Circuit System Structure

The structure of the circuit system is shown in figure 8.

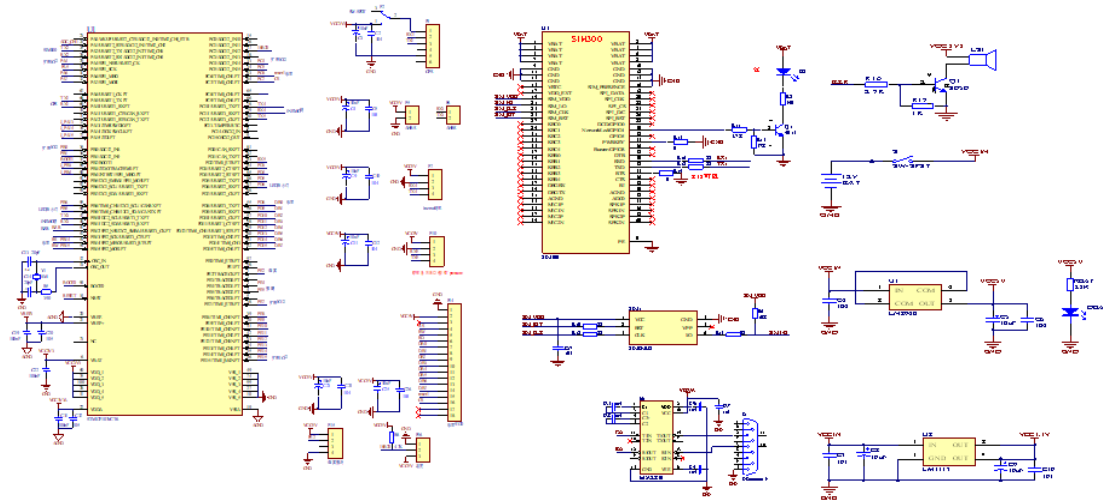


Figure 8 Circuit system structure diagram

4. SYSTEM COMMUNICATION DESIGN

The positioning and attitude detection system communicates with the upper computer through sockets and uploads information such as pitch angle, yaw angle and attitude to the upper computer. The specific communication mechanism is shown in Table 1. Among them, the upper computer starts to parse the data packets uploaded by the system through frame head recognition,

and the 2-20 bits are the location information collected by GPS. After processing, the upper computer converts it into the required format, 21-26 is the three-axis acceleration information collected by iNEMO sensor. PDR algorithm is realized by combining the yaw angle of iNEMO sensor at waist. After analyzing the pitch angle and yaw angle of iNEMO sensor at waist and leg, realize remote positioning and attitude detection.

Table 1 Upper and lower computer communication protocol

Function	0x55 0xAA	GPS	ACC	YAW	PITCH	0x66 0xBB
Byte	0-1	2-20	21-26	27-28	29-30	31-32
0-1	Frame Header					
2-20	2-11: Latitude, 11-20: longitude					
21-26	Acceleration values of X, Y, and Z axes					
27-28	Yaw angle of lumbar inertial navigation module					
29-30	Pitch angle of leg inertial navigation module					
31-32	Frame End					

5. CONCLUSION

In order to verify the positioning and attitude detection performance of the system, the positioning and attitude detection functions were tested respectively.

5.1. Positioning test

The positioning result of the test is shown in Figure 9, the red point is the starting point of positioning, and the red line represents the actual motion track. The test proves that the walking track coincides with the map display of the upper computer, and the positioning function is successfully realized.



Figure 9 Positioning test results

5.2. Attitude detection test

The test results of personnel attitude test are shown in figure 10. The test has tested a series of continuous actions such as standing, walking, standing, bending down, sitting down, lying down, standing and lying down. The test proves that, the upper computer can accurately display the Test action and realize the attitude detection function.



Figure 10 Attitude detection test results

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