Research on mobile robot navigation based on gyro

Shi-guang LI, Hong-wei ZHANG, Zheng-zhong GAO, Xiang-bin LIN, Fan-xue KONG

(*Shandong university of science and technology,qingdao 266510, China*)

***Abstract*—A kind of mobile robot navigation system based on Silicon gyro was designed in this paper. First, full-field emplacement theory was discussed. Second, using TMS320F2812 DSP and CRS03 sensor, useful signal was extracted by signal conditioning circuit. Finally, the location of mobile robot was confirmed through digital filtering and gyro date processing.**

Keywords—navigation; silicon gyro; data acquisition; digital filte

Manuscript Number: 1674-8042(2010)supp.-0066-03
dio: 10.3969/j.issn1674-8042.2010.supp..17

1 Introduction

According to their autonomy mobile robot can be divided into manual control and automatic control, and automatic control mobile robot can be understood as independent movement robot. In robot competition automatic control mobile is often asked to identify moving path ，reach intended target and complete corresponding action[1].The robots used line patrol methods to identify route, which through comparing the record of the white line and the original location to locate position. In order to make sure automatic robot can do arbitrary path moving to realize game plan., not only confined to line patrol moving. Automatic robot needs to locate full field position and accurately positioning the direction at different time to get the two-dimensional coordinate of automatic robot in playing field. In recent years, due to the rapid development of microelectron-mechanical gyroscope, research on mobile robot navigation based on gyroscope get more and more and technology get more mature. This article is research on mobile robot navigation system based on Silicon gyro.

2 Full-field location principle [2]

If the path of robot is straight line, the coordinate of the robot in playing field can be calculated by the geometrical knowledge using lope and the length of the linear. The path of automatic robot in the game is not only straight line. Sometimes the robot needs move arbitrarily, such as arc or irregular curve. So straight line can not solve all location problems, we use calculus idea that divide arc into many tiny straight line, then according to calculation method of straight line to work out the coordinates of the robot which moving arbitrarily.

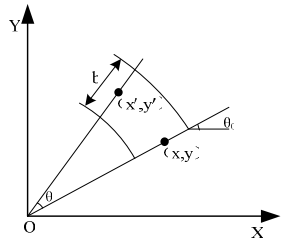

Fig. 1 Robot moving position chart

As shown in figure 1, (x, y) and (x', y') are the midpoints of two robot wheels. The length of inner arc is n_1 which called arc 1，and the length of external act is n_2 which is called arc 2. The distance between the two front wheels is b, the included angle between lift horizontal axis and the straight line which decided by initial position of two wheels. Suppose t as the moving time between two points and θ as the running angle of two wheels. Because the moving time is very short，arc 1 and arc 2 can be considered as two circular arcs. The distance can be worked out by the number of pluses during period t. It is known by geometrical knowledge:

$$\frac{a}{a+b}=\frac{l_1}{l_2}=\frac{2\pi r n_1 t}{2\pi r n_2 t}=\frac{n_1}{n_2}$$

$$a=\frac{n_1 b}{n_2-n_1}$$

The running angle: $$\theta=\frac{l_1}{a}=\frac{2\pi r n_1 t}{n_1 b}\bullet(n_2-n_1)$$

$$=\frac{2\pi r}{b}\bullet\frac{n_2-n_1}{n_1}\bullet t$$

Supposing the coordinate of the circle centre is $O_0(x_0, y_0)$，

$$x=x_0+(b+a)\bullet\cos\theta_0$$
$$y=y_0+(b+a)\bullet\sin\theta_0$$
$$((x-(b+a)\bullet\cos\theta_0),(y-(b+a)\bullet\sin\theta_0))$$

Received: 2010-5-25
Corresponding author: Hongwei Zhang (hongwei.qd@163.com)

The coordinate of robot after moving time t is

$$x' = x_0 + (b+a) \bullet \cos(\theta + \theta_0)$$

$$y' = y_0 + (b+a) \bullet \sin(\theta + \theta_0)$$

After calculating the coordinate of the robot，the whole movement can be regarded as many periods of t. The position of the automatic robot on full field can be calculated by accumulating time t. It is shown in the chart bellow.

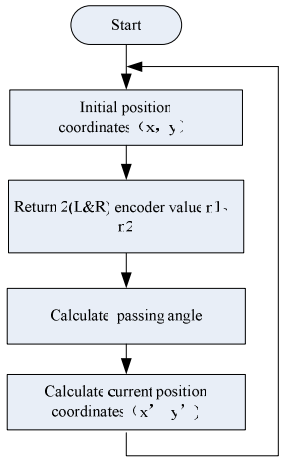

Fig. 2 Robot moving position calculation chart

3 Hardware design

The hardware functional block of gyroscope navigation system module is shown in chart 3.This module mainly includes four parts: silicon gyro, signal circuit, power supply circuit, F2812 DSP. Output voltage signal of gyroscope enter ADC of F2812DSP after signal circuit. DSP reads and processes the data. Automatic robot uses the result of angle to locate position.

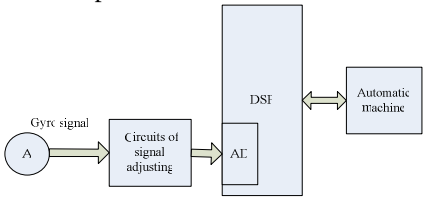

Fig. 3 Functional block of gyroscope navigation module

3.1 Gyroscope

CRS03 series microelectron-mechanical gyroscope which is made by SILICON SENSING company is chosen in this research. It uses SILICON MEMS technology and shows good performance in bad environment, such as strong vibration, impact and dramatic changes in temperature. CRS03 series microelectron-mechanical gyroscope mainly used in automatic stable driving, GPS assistant location, antenna stabile platform, sea autonomous navigation, inertial system integration, bipedal robot and remote information communication etc. The gyroscope applies Corioli effect and silicon ultra precision annulus sensing design which output high-precision voltage.

3.2 Signal circuit

MEMS gyro chips have internal signal conversion and amplifying circuit. Chip output signal voltage is between 0 and 5V. Signal disposal circuit completes two functions: isolation cushion and confusing filtering. Because of the ADC of TMS320F2812 digital signal processor input voltage range is between 0 and 3V, the output voltage of gyroscope filtered should be divided before input TMS320F2812 digital signal processor. Considering the matching problem of resistance, the gyro analog voltage output signal firstly is put into isolation cushion, then after voltage dividing inter RC circuit. Finally the result signal enter the ADC of DSP after entering isolation cushion.

3.3 Isolated buffer

Isolation buffer is constituted by high-performance emitter follower used MAX4254 made by MAXIM company. For the deep negative feedback effect of circuit, the emitter follower has many outstanding advantages such as working stable、wide frequency, high input resistance and low output resistance, which is used to impedance matching. Between the output and the input circuit of the signal add the isolated buffer，which can reduce the influence of output and input circuit.

Isolation buffer in this research is between sensor and filter circuit. For the high input resistance and low output resistance of emitter follower, which can weaken or eliminate the impact of resistance circuit in front. Voltage gain is almost 1，which can not effect the gain of entire circuit. The voltage of isolated buffer power supply is 5 V. Input signal is voltage signal of MEMS gyro. Output signal of gyro is sent to low-pass filter circuits.

3.4 RC Filter circuits

Anti-alias filter is used before signal sampler, which limit signal bandwidth and make sure it corresponds to sampling theory. Due to Shannon-Nyquist sampling theorem, sampling rate must be more than two times the signal bandwidth rather than the maximum signal frequency. For signal whose bandwidth is limited but frequency center is not zero, band-pass filter is needed as anti-alias filter. The uses of low-pass filter are removing unnecessary high frequency signal，lowering sampling frequency，avoiding frequency confusion and removing high frequency interference. Before gyroscope signal

entering TMS320F2812 DSP, RC low-pass filter is used as anti-alias filter. The frequency range of useful output signal of gyroscope is between 10-40Hz. The cutoff frequency of filter is 150Hz and sampling frequency is 400Hz.

3.5 Voltage circuit and power circuit

The input voltage range of TMS320F2812 DSP ADC is between 0-3V, and the output voltage range of gyroscope is 0-5V. The voltage signal of gyroscope isolated can not enter ADC directly which needs take some necessary measures to divide voltage. The measure that two precise resistance in series is used to realize dividing voltage. Two precise resistance are all 1K ohm. The voltage needs high accuracy and precision which will be integrate to obtain angle value. In order to ensure the output voltage of gyro is stable, the resistance resistivity must be fixed during working. The resistance in this research is precise resistance with high stablity.

The power supplies needed in this module are 5V power supply for gyro and 5V power supply for isolated buffer. The power supply in competition is 12V. 7805 chip is used to change voltage from 12V to 5V then offer 5V to gyro and isolated buffer as power supply.

4 software design

TI company offers high-efficiency C compilers and integrated development environment. It is not only the code generation tool, but also have basic debugging facility and Real-time analysis ability, which support the whole process of software development including designing, code generation, debugging and real-time analysis.

4.1 Digital filtering

The gyro signal still has high frequency interference after the RC filter circuits. Average filtering is used in software to reduce frequency interference.

$$y[n]=\frac{1}{L}\sum_{k=0}^{L-1}x[n-k]$$

$$=\frac{1}{L}\left(x[n]+x[n-1]+\cdots+x[n-L+1]\right)$$

It can be seen from the chart 4, the burr is obvious before filtering. The signal becomes smooth and retains useful information after soft filtering.

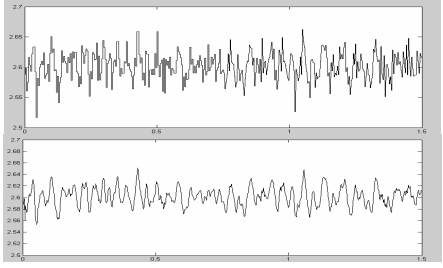

Fig. 4 Initial gyro signal and filtered signal

4.2 Data processing

The calculating of angular velocity: Conversion formulas,

$$V_0=\frac{1}{2}\times V_{dd}+\left(R_a\times SF\times\frac{V_{dd}}{5}\right)$$

Vo is the output voltage of gyro. Vdd is the voltage of power supply. Ra is angular velocity. SF is scale factor. The angle is gotten by accumulating angular velocity in different time . Program flowchart is shown in chart 5.

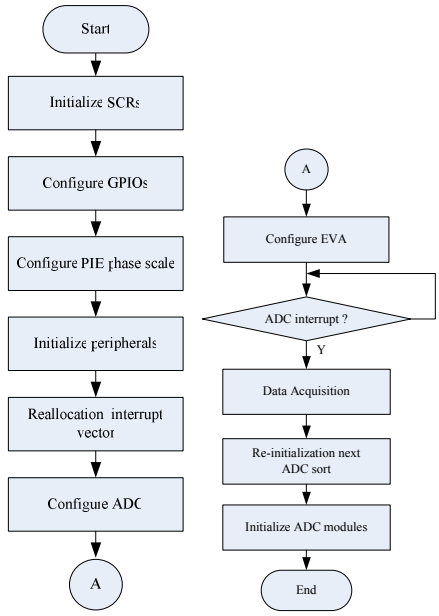

Fig. 5 Program flowchart

5 Conclusions

Hardware and software in this research have applied in actual robot competition, which proves it is possible that realizing mobile robot full-field navigation system by using silicon gyro.

References

[1] Lozano-Perea T. Spatial planning:A configuration space approach .IEEE Transaction on Computers, 1983, C-32 (2) :108-120 .

[2] Dong-Han Kim, Jong-Hwan Kim. A real-time limit-cycle navigation method for fast mobile robots and its application to robot soccer .Robotics and Autonomous Systems, 2003, (42) :17-30 .

[3] Lozano-Perea T. Automatic planning of manipulator transfer movement .IEEE Transaction on System Man and Cybernetics, 1981, SMC-11 (10) :681-698 .

[4] Waston D F. Computing the n-Dimensional Delaunay Tessellation with Application to Voronoi Polytops .The Computer Journal, 1981, 24 (2) .16-20.

[5] Jacky Baltes, and vcholas Hildreth. Adaptive path planning for highly dynamic environments .RoboCup 00. Springer Verlag, 2001.