Velocity detection Application of HDNS2000 in Robot Soccer

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***Abstract*: The soccer Robot match is a competitive and complicated activity, in which the accuracy of the system strategy is heavily depended on the motion performance of Robot. To prevent the condition that the wheel of the Robot skids when starts up, this paper presents a new velocity detection method. By using of the HDNS-2000 to detect the actual motion state of the Robot which is used as the velocity feedback signal, the method can achieve the precision control of the Robot.**

Index Terms: Robot Soccer, Optical sensor, Velocity detection

I. INTRODUCTION

It is more and more competitive in Soccer Robot. When the Robot starts up quickly, the wheels of the Robot skid, especially on smooth ground. So the optical sensor chips are used to detect the velocity in the start-up of the Robot, which is used as the feedback source of the system. But under common conditions, the velocity of the Robot surpasses the maximum motion velocity the optical sensor chips can detect, so the feedback signal of servo motor using encoder is used to detect the velocity. By doing this, the start-up velocity of the Robot has been greatly increased, so it can reach the velocity of the upper unit as soon as possible and the superiorities of the Robot are displayed in the match.

The HDNS-2000 is a low-cost reflective optical sensor that provides a non-mechanical tracking engine for implementing a standard mouse. The chip has two channels, quadrature mode, and four output state. We use it on the Robot because it is more convenient to detect the state of the Robot.

The HDNS-2000 is comprised of three major functional blocks: an Image Acquisition System (IAS), Digital Signal Processor (DSP), and PS/2 or quadrature output converter. The IAS acquires microscopic surface images via the lens and illumination system continuously. These images are further processed by the DSP to determine direction and distance of motion. The DSP generates a stream of Dx and Dy relative displacement values that are then communicated to the output converter. This converter provides a PS/2 2 or 3-Button output, replacing existing mouse microcontrollers, or two-channel quadrature output, for direct interface to mouse microcontrollers [1][2].

II. Theory of operation

The Image Acquisition System can capture 1500 sheet images each second. It can accurately detect the maximum velocity of 30.48cm/s.Its resolution is 400cpi.The pins diagram is shown in Fig1.

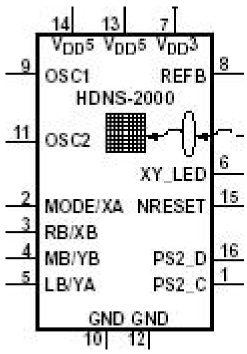

Fig1.Pins diagram of HDNS-2000

It has two state machines inside of HDNS-2000 which point to X direction and Y direction respectively. Each state machine has four solid state.Fig2 shows the states machines. State 0 is entered after a power up reset. When it detects the object moves in positive direction or negative direction by one unit, it transfers to the next state. So the motion direction and the velocity of the object can be calculated if the continuous transformation of the state is detected.

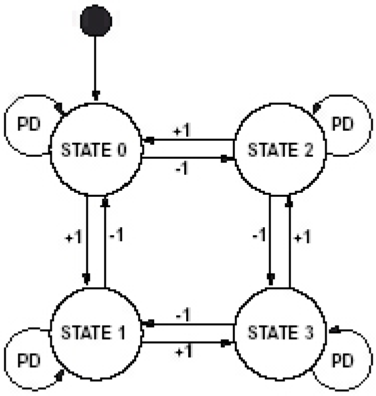

Fig2 Quadrature state machine.

Fig2 shows the output signal of the state separately. A corresponding logical calculus of the output impulse signal can help to decide the direction and the distances between the current state and the previous state. It is very convenient to decide the direction and the velocity of the Robot by using circuit. Base on the above theory, the software and the hardware of Robot system can be designed.

III. SYSTEM DESIGN

The main function of Soccer Robot is to receive the information from upper unit (it contains the number, left wheel velocity, right wheel velocity of the Robot).Then the information are used to calculate. Finally, the motor are controlled by pulse width modulation in order to satisfy the request of the upper unit.

The testing system feed back current velocity; the Single Chip Micyoco compares the current velocity and the given velocity of the upper unit, then Proportional, Integral and Derivative (PID) is used to calculate the wheel velocity of the next time slice and rectification of the two wheel velocity is made.

When PID is used, the feedback wheel velocity is a parameter used to calculate. The way wheel velocity feeds back and the accuracy directly affect the rectification accuracy of the wheel velocity of the next time slice. Most of the Robots use encoder having 128 buses to achieve the feedback of the wheel velocity. During the match, while Robot receives commands from the upper unit continuously; the motor starts and closes alternatively, the motion process is also not all skidding process. It can not satisfy the accuracy if we use motor encoder. The wheel velocity detected by HDNS-2000 is used as the feedback to enhance the control precision and let the strategy made by upper unit achieve better.

According to the request of the match rules, the theory diagram of the designed Robot control system is shown in Fig3.

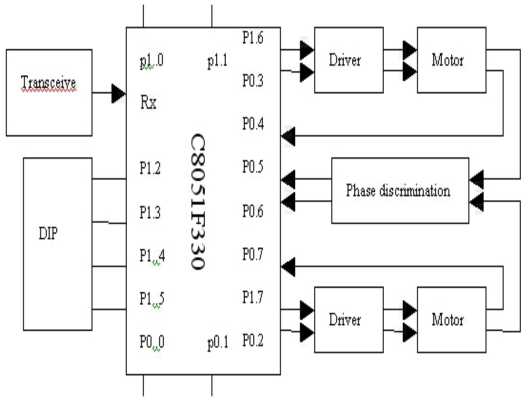

Fig3.Hardware System Design

The processor used by the Robot is C8051F330 made by the CYGNAL Company. Its high speed, pipeling architecture, compatible with the MCS-51TM instruction set, On-Chip Debug Circuitry Facilitates Full Speed and Non-Intrusive In-System Debug interface, sustenance of 16bits PWM output and so on, all make program, debug, and precision control easily. The driver module uses L298 in order to achieve pulse width modulation output and control the motor more precisionly. The sending module uses the low power, high frequency data sending and receiving module, produced by Radiometrix Company in Britain. Its type is BIM-418-F and BIM-433-F and its frequency of carrier wave is 418MHZ and 433MHZ.It is used to achieve the communication between the upper unit and the lower unit. The velocity detection and the phase detection module use subsection design. When the wheel velocity bellows 250mm/s (10inch/s), the optical sensor chip is used. Encoder is used in other conditions. The motor uses 250021 motor produced by Maxthon Company. In addition to the data MR encoder, feedback of wheel velocity and motion direction of the wheel can be obtained by the Single Chip Micyoco.

IV. DESIGN OF VELOCITY DIRECTION DECTION USING OPTICAL SENSOR CHIP

A. Hardware design of velocity and phase detection

The capture velocity of optical sensor chip is 1500 frame per second. As the time of each frame is 667 μs and the minimum state time is 133 μs, up to four states can exist in each frame. The maximum motion distance of the optical sensor chip is 12inch/s under the condition that no frame is lost. So the linear distance between a state and the consecutive state is as follows:

$$X = \frac{p \times 25.4}{k \times n} = \frac{12 \times 25.4}{1500 \times 4} = 0.0508(mm)$$

p is the maximum motion distance between two consecutive states.

k is the number of frames captured each second.

n is the time of states changes

The above equation is used as the basis of the detection of velocity. The theory diagram of the system is shown in Fig 4.

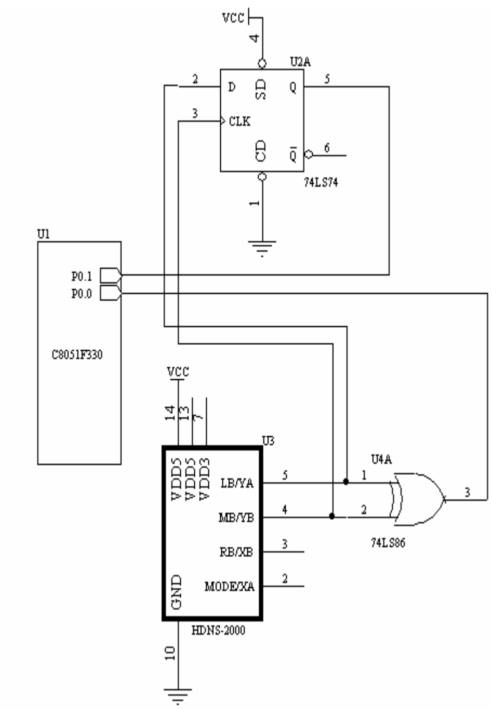

Fig4.velocity and phase detection system in single side of Robot

After the procession of information collected by optical sensor chip, two pulse signals have been outputted form YA and YB, as is shown in Fig3. It is easy to find that the phase of YA and YB is discrepant by 90 degrees. By use of the condition that YA is connected to D end of D trigger and YB is used as the input signal of clock, the current move direction of the Robot can be obtained. If 1 can be obtained from Q end, it is shown that the robot is moving in the negative direction, otherwise 0; the robot is moving in the positive direction. The velocity detection can be realized by inquiring about the changing times and calculating the moving distance of the robot in some time. The logical XOR is operated between signal from YA and signal from YB, the number of logical 1 is half of the changing times of the state, in this case, the velocity detection can be solved. In the design of the system, two kinds of signal from YA, YB are connected to the two inputting ends of the logical XOR gate, and the outputting ends are connected to P0.0 and P1.0 of the single chip. Impulse is countered by the counter, which is convenient to get the changing times of the state. So the current velocity can be calculated according to the moving distance of the robot during the process of countering.

B. Software design of velocity and phase detection

In the system program design, the timer/counter 0 and 1 are set as two counters, which work in overload mode. The timer/counter 3 is also set in overload mode, and works in 16bit mode to generate interruption. In the interruption service subsystem, the count recorded by timer/counter 0 and 1 is transferred to the according variable. So the wheel linear velocity of the Robot can be got. After the initialization of the timer 3, the program can return to the main program to calculate other things.

The motion direction of the Robot can be decided by the hardware. Single Chip Micyoco can query the output values of the D trigger to decide the current direction of the Robot. As is shown in Fig 5.The output pin of the D trigger is connected with P0.1 and P0.2 of Single Chip Micyoco.The current direction of the Robot can be known by reading the input voltage of the two pins. If the number is high voltage (logical “1”), the Robot moves forward, otherwise if the number is low voltage, it moves backwards.

V. SYSTEM PROGRAM DESIGN

The system software of Robot must satisfy the function that it receives wheel velocities of the upper unit, and control the motor to let the Robot reaches a certain speed and position precision. In the end the strategy is fully achived. The flow chart of this system is shown in Fig 5.

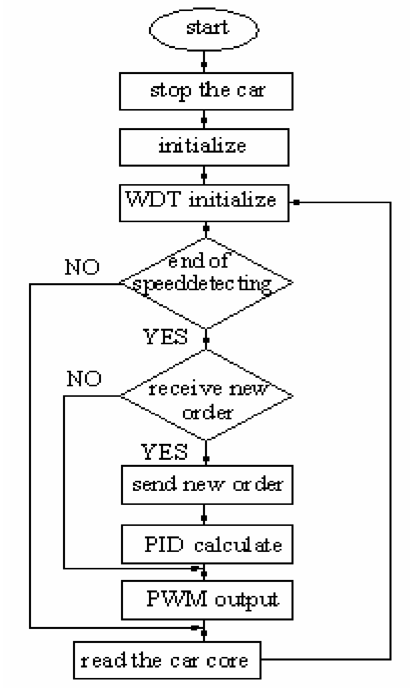

Fig 5 Flow chart of system software

In the beginning of the program, the velocity of the wheel and its direction must be queried first, the two wheels halt (The duty ratio is 0 percent).Then the initialization of system clock, counter, timer, switches, watchdog are made in order to let the Single Chip Micyoco has a definite work state.

The use of watchdog is an important way of disturbance resistance. So it needs to be reset after the main program has been run each time. If the program has not function well and the watchdog timer has not been reset after the given time period, the watchdog overflows, then reset source is produced. The program will run over again to resist disturbance.

After the calculation of PID, Single Chip Micyoco obtains the duty ratio in the next time. The PWM has been outputted. The signal is magnified, and the motor is driven to make the wheels run at the given speed. The precision control of the wheel velocity is achieved.

VI. CONCLUSION

The optical sensor chip HDNS-2000 has been applied in Soccer Robot. The current motion direction of the Robot and the actual linear velocity of both sides of Robot can be detected easily with certain precision. It is very useful in enhancing the velocity control precision of the Robot and run in the given track. The system design of the Robot is a little easier; the request that the upper unit needs can be satisfied. It is based on the Single Chip Micyoco C8051, it can wholly reach the guide line match environment needs. The performance of the Robot has been improved from different aspects by using HDNS-2000 and C8051 both.

REFERENCE

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