Smart Stick for Blind Man

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Abstract

Smart stick for blind man is a machine that can follow a path. The path can be visible like a black line on a white surface (or vice-versa) or it can be invisible like a magnetic field. Sensing a line and manoeuvring the robot to stay on course, while constantly correcting wrong moves using feedback mechanism forms a simple yet effective closed loop system. As a programmer you get an opportunity to 'teach' the robot how to follow the line thus giving it a human-like property of responding to stimuli.

Keywords*: IR sensors, magnetic field, Ultrasonic Sensor.

1. Introduction

Robots have been fascinating us from year to now. They are the part of our life in field like research, development, medicine, defence or even novels and movies. Robots have simplified our job to extent. They have provided efficient, reliable and safe mode of working hand to human beings. Due to robotic only men is now able to perform distant operations. Mars Rover is one the example of distant operation being carried out by men.

Smart stick for blind man is one of the self operating robot that follows a line that drawn on the floor. Capture line position with optical sensor mounted at front end of the robot. Most are using several number of photo-reflector, and some leading contestants are using as image sensor for image processing. The line sensing process requires high resolution and high robustness.

Steer robot to track the line with any steering mechanism. This is just a servo operation; any phase compensation will be required to stabilize tracking motion by applying digital PID filter or any other servo algorithm. Control speed according to lane condition. Running speed is limited during passing a curve due to friction of the tire and the floor.

Smart stick for blind man is a machine that can follow a path. The path can be visible like a backline on a white surface (or vice-versa) or it can be invisible like a magnetic field.

Sensing a line and manoeuvring the robot to stay on course, while constantly correcting wrong moves using feedback mechanism forms a simple yet effective closed loop system. As a programmer you get an opportunity to 'teach' the robot how to follow the line thus giving it a human-like property of responding to stimuli. Practical applications of a line follower: Automated cars running on roads with embedded magnets guidance system for industrial robots moving on shop floor etc.

2. Background

We started with building a parallel port based robot which could be controlled manually by a keyboard. On the robot side was an arrangement of relays connected to parallel port pins via op to-couplers

The next version was a true computer controlled line follower. It had sensors connected to the status pins of the parallel port. A program running on the computer polled the status register of the parallel port hundreds of times every second and sent control signals accordingly through the data pins.

The drawbacks of using a personal computer were soon clear

It's difficult to control speed of motors

As cable length increases signal strength decreases and latency increases. A long multi core cable for parallel data transfer is expensive. The robot is not portable if you use a desktop PC. The obvious next step was to build an onboard control circuit; the options – a hardwired logic circuit or a microcontroller.

"Atmel's AVR® microcontrollers have a RISC core running single cycle instructions and a well-defined I/O structure that limits the need for external components. Internal oscillators, timers, UART, SPI, pull-up resistors, pulse width modulation, ADC, analogy comparator and watch-dog timers are some of the features you will find in AVR devices.

Apart from this almost all AVRs support In System Programming (ISP) i.e. you can reprogram it without removing it from the circuit. This comes very handy when prototyping a design or upgrading a built-up system. Also the programmer used for ISP is easier to build compared to the parallel programmer required for many old microcontrollers. Most AVR chips also support Boot Loaders which take the idea of In System Programming to a new level. Features like I2C bus interface make adding external devices a cakewalk. While most popular microcontrollers require at least a few external components like crystal, caps and pull-up resistors, with AVR the number can be as low as zero!

Tools and Resources: Atmega8 has been around from many years now, consequently there are more tools available for working with it. Being a part of many engineering courses, there is a huge community of people that can help you out with Atmega8; same with books and online resources. In spite of being new the AVR has a neat tool chain (See 'References and Resources'). Availability of online resources and books is fast increasing.
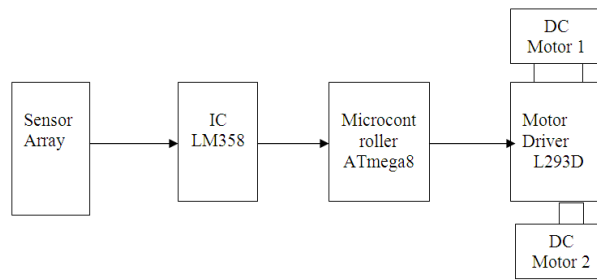
Here, Atmega8> AVR = PIC

Fig. 1: Block Diagram

The robot uses IR sensors to sense the line; an array of 8 IR LEDs (Tx) and sensors (Rx), facing the ground has been used in this setup. The output of the sensors is an analogy signal which depends on the amount of light reflected back, this analogy signal is given to the comparator to produce 0s and 1s which are then fed to the microcontroller.

L4	L3	L2	L1	R1	R2	R3	R4

Left   center   Right
Sensor Array

Starting from the center, the sensors on the left are named L1, L2, L3, L4 and those on the right are named R1, R2, R3, and R4.

Let us assume that when a sensor is on the line it reads 0 and when it is off the line it reads 1

The microcontroller decides the next move according to the algorithm given below which tries to position the

Robot such that L1 and R1 both read 0 and the rest read 1.

L4	L3	L2	L1	R1	R2	R3	R4
1	1	1	0	0	1	1	1

Left   Centre   Right

Desired State L1=R1=0, and Rest=1

3. Hardware

Microcontroller ATmega8: The Atmel®AVR® ATmega8 is a low-power CMOS 8-bit microcontroller based on the AVR RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega8 achieves throughputs approaching 1MIPS per MHz, allowing the system designed to optimize power consumption versus processing speed.

Microcontrollers are used in automatically controlled products and devices, such as automobile engine control systems, implantable medical devices, remote controls, office machines, appliances, power tools, toys and other embedded systems. By reducing the size and cost compared to a design that uses a separate microprocessor, memory, and input/output devices, microcontrollers make it economical to digitally control even more devices and processes. Mixed signal microcontrollers are common, integrating analog components needed to control non-digital electronic systems. 4KB ROM. 128 bytes internal RAM.4 register banks of 8 bytes each (R0-R7).16 bytes of bit-

addressable area.80 bytes of general purpose memory...Four 8-bit I/O ports (P0-P3).Two 16-bit timers (Timer0 & Timer1).One serial receiver-transmitter interface. Five interrupt sources (2 external & 3 internal).One oscillator (generates clock signal)
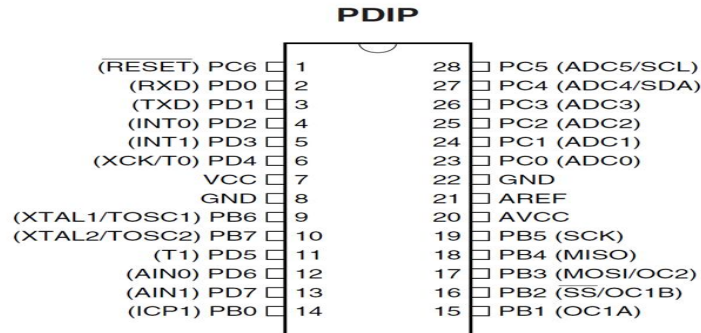
PDIP

(RESET) PC6	1		28	PC5 (ADC5/SCL)
(RXD) PD0	2		27	PC4 (ADC4/SDA)
(TXD) PD1	3		26	PC3 (ADC3)
(INT0) PD2	4		25	PC2 (ADC2)
(INT1) PD3	5		24	PC1 (ADC1)
(XCK/T0) PD4	6		23	PC0 (ADC0)
VCC	7		22	GND
GND	8		21	AREF
(XTAL1/TOSC1) PB6	9		20	AVCC
(XTAL2/TOSC2) PB7	10		19	PB5 (SCK)
(T1) PD5	11		18	PB4 (MISO)
(AIN0) PD6	12		17	PB3 (MOSI/OC2)
(AIN1) PD7	13		16	PB2 ($\overline{SS}$/OC1B)
(ICP1) PB0	14		15	PB1 (OC1A)

Fig. 2: Pin Diagram of ATmega8 [3]

4. L293D IC

This is a dual H-bridge motor driver integrated circuit (IC). Motor drivers act as current amplifiers since they take a low-current control signal and provide a higher- current signal. This higher current signal is used to drive the motor

L293D contains two inbuilt H-bridge driver circuits. In its common mode of operation, two DC motors can be driven simultaneously, both in forward and reverse direction. The motor operations of two motors can be controlled by input logic at pins 2 & 7 and 10 & 15. Input logic 00 or 11 will stop the corresponding motor. Logic 01 and 10 will rotate it in clockwise and anticlockwise directions, respectively.

Enable pins 1 and 9 (corresponding to the two motors) must be high for motors to start operating. When an enable input is high, the associated driver gets enabled. As a result, the outputs become active and work in phase with their inputs. Similarly, when the enable input is low, that driver is disabled, and their outputs are off and in the high-impedance state.

IC LM358: LM358 is a Quad Operational Amplifier. It is used as a simple ADC (Analog to digital converter) to create a digital signal and send to control stage of the robot.

5. Features
- Short Circuited Protected Outputs
- True Differential Input Stage
- Single Supply Operation: 3.0 V to 32 V
- Low Input Bias Currents: 100 nA Maximum (LM324A)
- Four Amplifiers per Package
- Internally Compensated
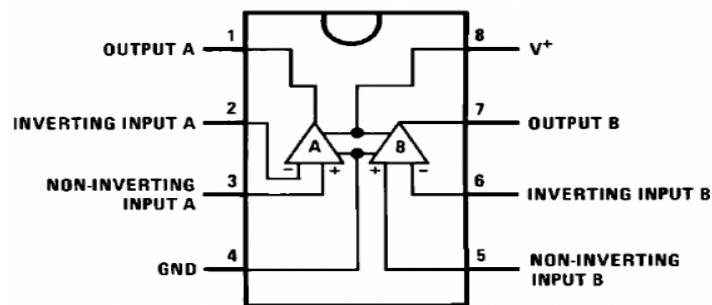- Common Mode Range Extends to Negative Supply

Fig. 4: Pin Diagram of LM358 [4]

SENSOR: Sensor (528-1994 the inertial sensor technology) is a device that receives a signal (as heat or pressure or motion or light) and responds to it in a distinctive manner. Sensor used in the robot works in the same way as the eye in the human being. The sensor used is IR sensor. It emits and detects IR.

Fig. 5: Sensor Circuit.

6. Implementation

The resistance of the sensor decreases when IR light falls on it. A good sensor will have near zero resistance in presence of light and a very large resistance in absence of light.

We have used this property of the sensor to form a potential divider. The potential at point '2' is R sensor / (R sensor + R1).

Again, a good sensor circuit should give maximum change in potential at point '2' for no-light and bright-light conditions. This is especially important if you plan to use an ADC in place of the comparator.

To get a good voltage swing, the value of R1 must be carefully chosen. If R sensor = a when no light falls on it and R sensor = b when light falls on it. The difference in the two potentials is:
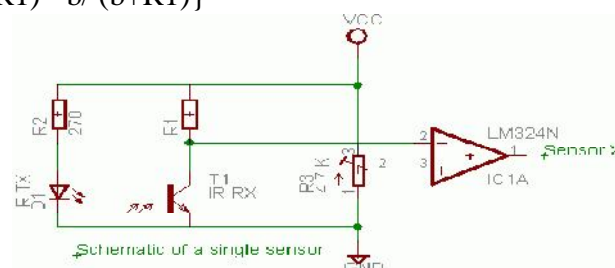
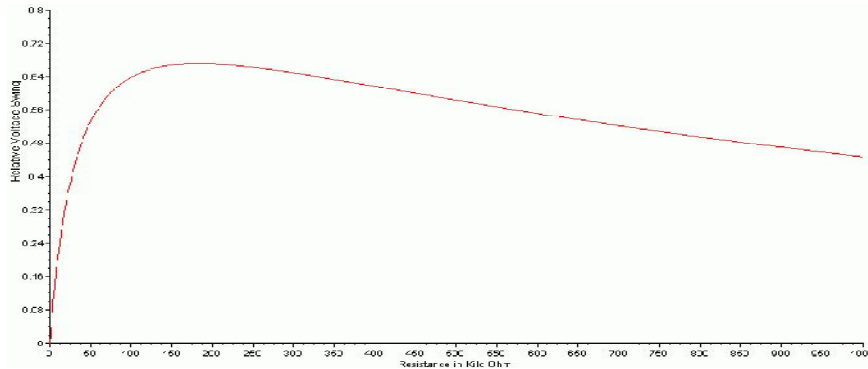$V cc * \{a/ (a+R1) - b/ (b+R1)\}$

Fig. 6: sensor circuit.

Fig. 7: voltage swing.

Relative voltage swing = Actual Voltage Swing / Vcc
                                 = Vcc * {a/ (a+R1) - b/ (b+R1)} / Vcc
                                 = a/ (a+R1) - b/ (b+R1)

The sensor I used had a = 930 K and b = 36 K. If we plot a curve of the voltage swing over a range of values of R1 we can see that the maximum swing is obtained at R1= 150 K (use calculus for an accurate value).

There is a catch though, with such high resistance, the current is very small and hence susceptible to be distorted by noise. The solution is to strike a balance between sensitivity and noise immunity. I chose value of R1 as 60 K. Your choice would depend on the 'a' and 'b' values of your sensor.

If you found this part confusing, use a 10K resistor straightaway, as long as you are using a comparator it won't matter much.

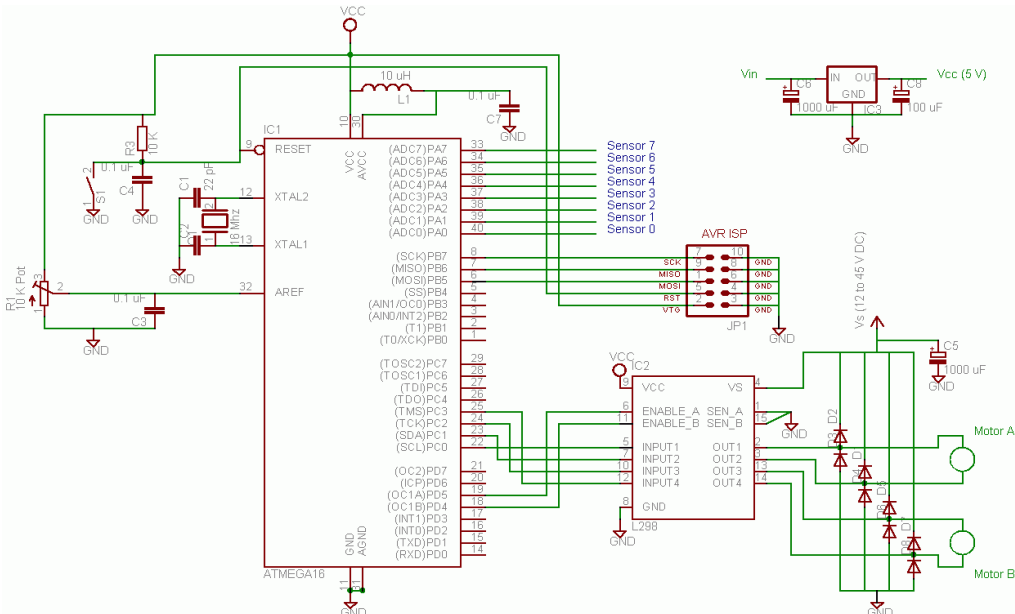## 7. Motor Interface and Control Circuit

Fig. 8: Motor Interface and Control Circuit.

The 8 sensors are connected to PORTA.

You need not connect anything to AVCC and AREF, it is required only if ADC is used.

The L293 Motor Driver has 4 inputs to control the motion of the motors and two enable inputs which are used for switching the motors on and off. To control the speed of the motors a PWM waveform with variable duty cycle is applied to the enable pins. Rapidly switching the voltage between Vs and GND gives an effective voltage between Vs and GND whose value depends on the duty cycle of PWM. 100% duty cycle corresponds to voltage equal to Vs, 50 % corresponds to 0.5Vs and so on. The 1N4004 diodes are used to prevent back EMF of the motors from disturbing the remaining circuit. Many circuits use L293D for motor control, I chose L293 as it has current capacity of 2A per channel @ 45V compared to 0.6 A @ 36 V of a L293D. L293D's package is not suitable for attaching a good heat sink; practically you can't use it above 16V without frying it. L293 on the other hand works happily at 16V without a heat sink, though it is always better to use one.

8. Conclusions

Robotics and Automation based systems and technologies are vastly advancing in the field of computer engineering. Mostly in developed countries which are exposed to modern high end technologies, many researches are carried out in this field. These kinds of systems have proved to be highly advantageous in many areas like educational, military and industrial applications.

Main target of Smart stick for blind man is to provide the basis for improvement in robotics based systems for usage in various application scenarios mentioned above.

Although this is carried out as a research project in Smart stick for blind man, results of this project will be vastly advantageous in future researches as well as industry related applications. Especially engineering undergraduates in the field of computer technology should pay more attention to this field. Sufficient support and motivation should be provided to them from the universities.

Smart stick for blind man can be used in many practical applications such as baggage carriers, shopping carts etc. This platform can be used as a learning platform for researches in traversal of robot systems. This can be considered as an important usage of this system.

9. Acknowledgement

References

Books
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Standards

[3]   Standards SA 528-1994 the inertial sensor technology
[4]   Standards SA 528-2001 the inertial sensor technology