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Development of a Smart Mobile Robot for Airport Passenger Luggage Conveyance

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Abstract: ***This paper presents smart mobile robot for airport passenger luggage conveyance. In airport, baggage handler is used to transport passenger luggage to a boarding unit. The airport baggage handlers are driven and controlled by airport workers during boarding period. The use of airport workers to convey passengers' luggage is not efficient in this modern technological world. Reason being that the workers can be tired, sick or absent at work. Therefore, mobile robot for luggage conveyance is required to handle such activities in the airport. This work is aimed at introducing mobile robot to the airport that would be used for such activities. The mobile robot system is made up of hardware and software. The hardware components were strictly selected for the tasks and the program codes written using embedded C language. The system was built and successfully tested in the airport.***

Keywords: mobile robot, airport premises, embedded C language, smart, luggage

1. Introduction

The advance in technology has brought rapid development in various aspect of human living. Mobile robots have gained research interest in the past year. Since the inception of microcontrollers and computers, the fields of automation and robotic technologies have been zealously utilized to create consumer products that increase life quality and standards [1]. Mobile Robots are very attractive Engineering systems, not only because of many interesting theoretical aspects concerning kinematics, intelligent behavior and autonomy, but also their applicability in many human activities [2]). A typical example is the line follower robot (LFR). The Line Follower robot Carrier is a small, wheeled robot, which would follow the user, and have a surface on which to conveniently place heavy objects. In order for an LFR to function effectively, it must demonstrate excellent line tracking control. This is achieved by having accurate and responsive control algorithms as well as high precision color sensor systems [3]).

Basically, there are two types of line follower robots: one is the black line follower which follows black lines and the second is the white line follower which follows white lines. A Line Follower Robot is a machine which follows a line, which can either be a black line or a white line. The Line follower Robot simply senses a line and runs over it [4].

The Follower robot Carrier can be applied to solve many common issues; one example is the carrying of heavy items like luggage in airports. There are many problems associated with carrying heavy items, ranging from health concerns (either based on age, or ailment), and the stress incurred in conveying the luggage. Line follower robots can be used as load carriers, thereby alleviating the pains passengers went through to board aircraft [5].

2. Related Research Works

Saddam *et al* [6] designed line follower wheeled mobile robot that follows a line drawn on a floor accurately. Adnan *et al* [7] designed a line following robot that carry products from one manufacturing plant to another in a separate block. Saleh *et al* [8] designed a car-like robot equipped with a system called HANS, which was able to navigate in an autonomous and safe manner, performing trajectories similar to the ones carried out by human drivers.

3. Methodology

The mobile robot system is designed using top-down approach by splitting the entire system into different sections. The captured sections are sensor, control and actuation/driver, display and power supply as shown in figure 1.

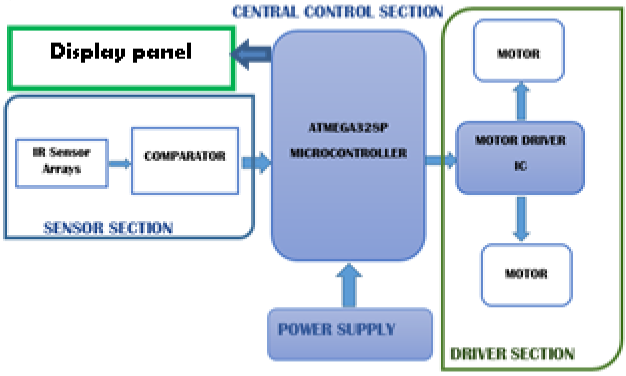

Figure 1: The block diagram of a line follower robot

3.1 Power Supply Section

The power supply section is designed based on the voltages required to power various components of the system. The two required voltages are +5V and + 12V DC. The regulated +5V DC (figure 2) would power the microcontroller, motor driver and liquid crystal display (LCD) while four 12V DC batteries would power each of the four DC motors used.

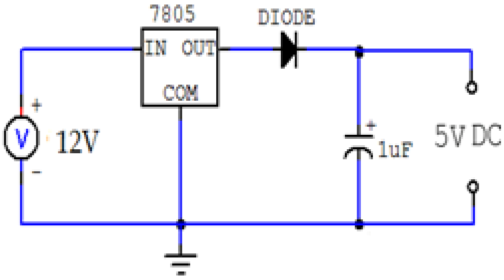

Figure 2: Regulated +5V DC

3.2 Liquid Crystal Display Section (LCD)

A 16x2 Liquid Crystal Display (LCD) is used by the robot to display message to its operator. Each character is displayed in 5x7 pixel matrix. The LCD uses its command register to store instruction and Data register to store data to be displayed on its screen. The data to be displayed is always ASCII value of the character. The diagram of the 16x2 LCD is shown in figure 3.

Figure 3: 16x2 Liquid Crystal Display

3.3 System Controller: Arduino Uno

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analogue inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It can be powered by connecting it to computer with a USB cable or powered with an AC-to-DC adapter or battery. It is used in the robot system to receive inputs from the sensors, process, actuate and control the robot propulsion in any direction. The picture of the Arduino Uno microcontroller board is shown in figure 4.

Figure 4: System Controller: Arduino UNO Board

3.4 Passive InfraRed Sensor (PIR) Motion sensor

Motion sensing is usually achieved using a motion detector. Passive InfraRed sensor (figure 5) is an electronic sensor that measures infrared (IR) light radiating from objects in its field of view. PIR sensor is based on Passive InfraRed Technology, hence as the human body radiates infrared waves with wavelength of 8 to 12micrometres. Therefore, any movement by a person leads to a change in the amount of infrared energy which a sensor can detect within its range. When motion is detected, the PIR sensor outputs a high signal on its output pin which is connected to the Arduino through a digital pin. This signal is collected by the microcontroller, and used to switch on the lighting system and activate the servomotors.

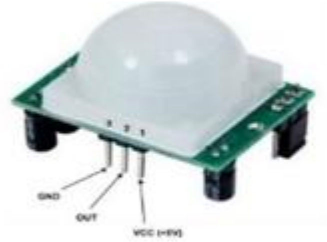

Figure 5: Passive InfraRed sensor for motion detection

3.5 L293D motor driver IC

L293D is a typical Motor Driver IC which allows DC motor to drive on either direction. L293D is a 16-pin IC which can control a set of two DC motors simultaneously in any direction. It means that you can control two DC motor with a single L293D IC. L293D (figure 6) is used to drive the robot Motors in clockwise and anti-clockwise directions at the same time.

Figure 6: L293D Motor driver IC

3.6 Mobile Robot Motors

Motors and actuators are the devices which make the robot movable. Motors (figure 7) and actuators convert electrical energy into physical motion. The vast majority of actuators produce either rotational or linear motion.

Figure 7: Robot DC motor and wheels

3.7 Ultrasonic Sensors (HC SR04)

The ultrasonic sensors are used for obstacle detection around the line track. It transmits ultrasonic waves and receives the responses that are reflected by the obstacles around continuously. The response is analyzed by the microcontroller to measure the distance between the user and the obstacle. Ultrasonic sensor (figure 8) detects the obstacles in a range of about 200 - 400 cm. The distance of the obstacle is determined based on the delay between the emission of sound and the arrival of an echo.

Figure 8: HC SR04 Ultrasonic Sensor

3.8 Mobile Robot System Flow Chart

The Mobile Robot system uses a comparative "if loop" for determining the direction of the robot based on the feeds from the PIR sensors. The geared wheels receive electric pulses to drive or stop as the program is interpreted based on sensor input. The "if loop" compares the states of the sensors based on predefined variables declared and read from the sensors and assign a corresponding actuated signal to the wheels. The PIR sensors can detect either black lines over a white surface or white lines over a black surface, thus in the real time implementation of the work ultrasonic sensors are equally deployed to the vehicle to create more intelligence in path finding and navigation. The flow chart for effective navigation of the robot system is shown in figure 9

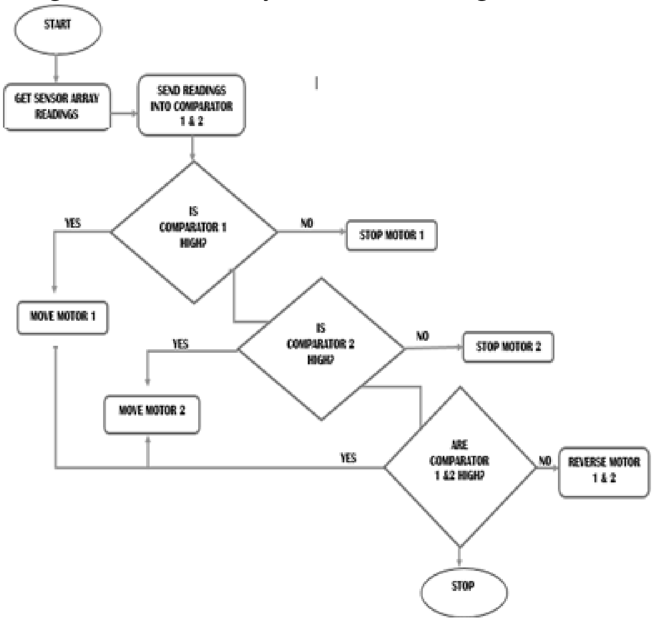

Figure 9: Robot system flow chart

3.9 Mobile Robot Controller Programming IDE

The Microcontroller is programmed in Arduino Integrated Development Environment (IDE) which contains text editor for writing code, message area, text console, toolbar with buttons for common functions and a series of menus. The Arduino IDE is installed in the computer system and connected to the Arduino Uno board. The program is written in the Arduino IDE using embedded C language and uploads in the Microcontroller memory through the interface as shown in figure 10.

Figure 10: Arduino Uno Interface with Laptop during program upload

4. Results & Discussion

4.1 System testing

A. Sensor –to-Comparator Interface test

The PIR sensor converts its input voltage into digital format with a voltage signal of 5V to serve as '1" and a signal of about 0V to serve as '0'. A good sensor should have readings lower than 3V in the absence of the reflected ray due to higher resistance and a reading above 3V in the presence of a reflected ray due to a decrease in the sensor's resistance. Shown below is the input of the sensor to the comparator IC and the output of the comparator which was fed into the microcontroller. The reference voltage of the comparator has been chosen to be 3.45V. This is done so that any input voltage higher than the reference voltage, would automatically be at 5V, but if the voltage input is lesser than the reference voltage, then the comparator outputs 0V. The result of the test conducted is shown in table 1.

Table 1: Sensor-to-comparator test result

Orientation of Sensor	Input to Comparator		Output from Comparator	
	Right	Left	Right	Left
Sensors on White Surface	4.65V	4.65V	5V	5V
Right Sensor on Black & Left Sensor on White	2.45V	4.65V	0V	5V
Right Sensor on White and Left Sensor on Black	4.65V	2.45V	5V	0V

B. Motor Actuation test

The motor driver circuit is arranged in a fashion called H-Bridge which enables a voltage to be applied across a load in either direction. The motors run at 12V so that an effective speed of 150rpm is achieved with increase in torque. Depending upon the load, the speed of motor reduces. It is better to use gearbox motors instead of common DC motors because it has gears and an axle, and its speed does not change. Thus, it is also better to choose a motor that has a more authentic Revolution per Minute measurement. The sample inputs and corresponding outputs of the L293d motor driver and test results got why moving the robot vehicle in different directions as shown in table 2.

Table 2: Motor driver calibration test

I/P 1	I/P 2	I/P 3	O/P 1	O/P 2	O/P 3	Motor 1	Motor 2

						Output (Left)	Output (Right)
Low	High	High	0	VSS	VSS	Straight	Straight
Low	High	Low	0	VSS	0	Straight	Stop
Low	Low	High	0	0	VSS	Stop	Straight
Low	High	Low	0	VSS	0	Straight	Reverse
High	Low	High	VSS	0	VSS	Reverse	Straight
High	Low	Low	VSS	0	0	Reverse	Reverse

4.2 System Packaging

After the testing of different units of the system, the system casing was carefully constructed. The interior and exterior robot units are shown in figure 11 and figure 12.

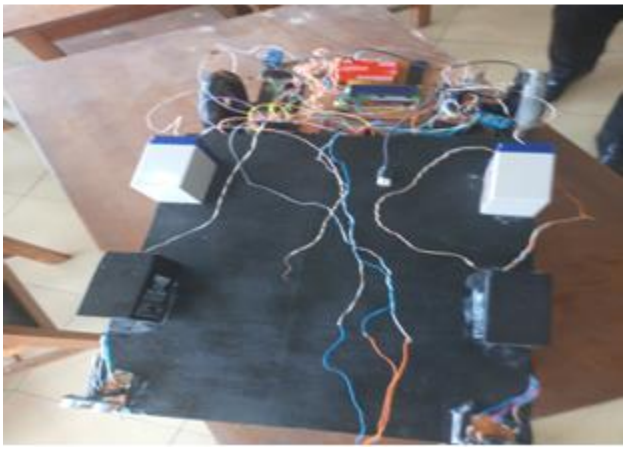

Figure 11: Interior of the robot carriage system

Figure 12: Exterior of the robot carriage system

5. Conclusion

To make passengers' luggage boarding very simple and efficient in airport, mobile robot is needed to replace the baggage handlers. This would reduce some anomalies found using human driven vehicles. This mobile robot system can be used not only in an airport for carrying luggage but in other indoor environments like libraries, factories, and houses to perform tasks like goods transportation or even surveillance

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