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SIMPLE DELIVERY ROBOT SYSTEM BASED ON LINE MAPPING METHOD

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ABSTRACT

Simple delivery robot system was made to make daily activities easier because the robot can deliver things to another place as long as it is in the same floor and has line mapping. This research is different from previous line follower research; the robot used has a dimension of 40 cm (length) x 40 cm (wide) x 40 cm (height), it can be summoned from several rooms using RF remote and can be ordered to deliver things and send messages. The robot uses seven infrared sensors to trace the line which is within 1.5 cm from underneath its body. In this research, the robot can go to four designated rooms plus one base camp. The robot also has several features i.e.: alarm system which can indicate when the robot arrived at the destination, LCD and keyboard so the user can write message, obstacle sensor to avoid crash, and emergency system which will active when the robot stray out of the line. The emergency system activates video camera and alarm so the user can control the robot with remote control to position it back in the line map. All activities are controlled by microcontroller AT89C51. The focuses of this research are robot mapping system using line mapping, special remote system using radio frequency, message delivery system using LCD and emergency system using video camera and remote control. Maximum speed of the robot is 1.045 m/s, and it can accommodate maximum load of 3.5 kg.

Keywords: robot, line mapping, RF transmitter, delivery robot, microcontroller.

1. INTRODUCTION

In the rapid development of technology, there are many types of robots with various specifications and capabilities. The Automatic Delivery Robots are being used in a United States' hospital to deliver medicines, juice, water bottles, etc. Some problems are faced regarding the localization of specific places around and within the hospital because they were using landmark recognition and RFID [1, 2]. Compared to this research in which the robot can deliver things from any room which has RF remote, the hospital's robot can only deliver things from main base to patient room. It was eventually equipped with Multilateration Technique using Smart Global Positioning System (S-GPS), whereas in this research the robot uses line mapping to go to specific rooms using autonomous intelligent line follower [3].

Line mapping method was used to facilitate room recognition. In this initial research, the robot was limited to deliver things to four rooms only. Main focuses of this research are room mapping on robot's controller, maximum weight that can be carried, robot summon algorithm, and item delivery. Final goal of this study is to develop a robot which can deliver things between floors inside a building.

Experimentation research which based on the existing theory and data was done to design the hardware and software. The challenges of this research are how to understand the characteristic of the robot's DC motor movement and summon concept using special remote. Infrared sensor was used to detect where the lines are and ultrasonic sensor was used to prevent the robot from crashing when moving from one point to another. There are also emergency system in form of video camera, remote control, and alarm to alert the user if the robot stray out of the line. The whole system is controlled by microcontroller.

2. SYSTEM DESIGN

The systems are divided into four types, i.e.: robot summon system, main system, message writing system, and emergency system. The system diagram block can be seen in Figure-1.

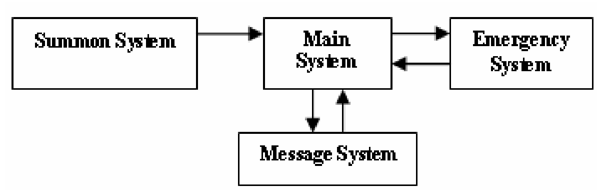

Figure-1. Main system design.

Summon system consists of two parts, i.e. transmitter system and receiver system. Transmitter system is a special remote used to call the robot, and each designated room has a remote of its own with different coding data. Receiver system is put in the robot so it could know which room to go to.

Main system consists of actuator as main motor, destination room button, line reader sensor, alarm, and ultrasonic system. The robot also equipped with emergency system which will trigger the alarm and activate video camera and the user's remote control when it went out of the line. There is also LCD for the user to send message to one another. Below is the layout of delivery robot:

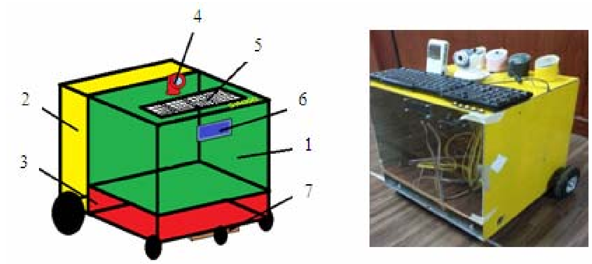

Figure-2. Layout system.

Number 1 indicate a space with dimension 40 cm (length) x 34 cm (width) x 34 cm (height) to place things which will be delivered. Number 2 and 3 indicate a space to put electronic components. Number 4 is the camera, and number 5 is the keyboard to write message which will be displayed on number 6, the LCD. Line sensors are placed on number 7 and used to detect the line map by differentiate light and dark color. Total dimension of the robot is 40 cm (length) x 40 cm (wide) x 40 cm (height).

In this model, the robot is designed to be able to distribute things from and to four designated rooms and one base camp. Base camp is the robot's start point when it is put off. Figure-3 below displays the line mapping system used in this research. The black line used as a track for the robot to move from one place to another.

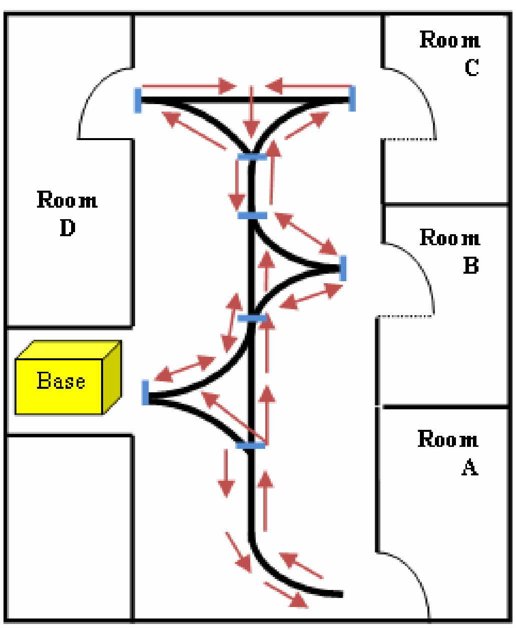

Figure-3. Layout room line mapping.

2.1. SUMMON SYSTEM SCHEME

As mentioned before, the summon system consists of transmitter system which is placed inside each room and receiver system which is placed inside the robot. Communication between those two was performed using radio frequency 315 MHz. To summon the robot to different rooms, each room must have unique code so the robot can recognize which room to go. Every transmitter remote is using RF transmitter connected to PT2262 as remote encoder to convert the data code.

Figure-4 shows datasheet of PT2262 as the remote control encoder utilizing CMOS technology. It encodes data and address pins into a serial coded waveform suitable for RF or IR modulation. PT2262 has a maximum of 12 bits of tri-state address pins providing up to 531.441 (or 312) address codes; thereby, drastically reducing any code collision and unauthorized code scanning possibilities [4].

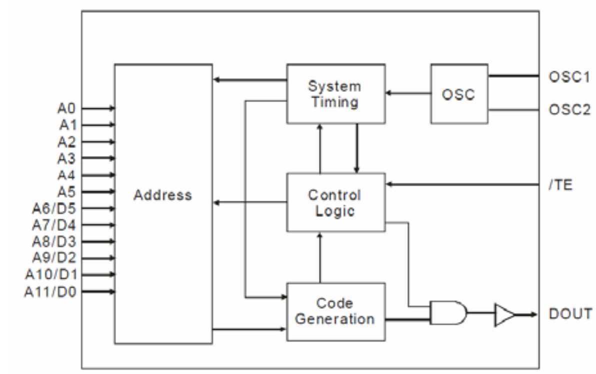

Figure-4. Remote control encoder [5].

There are two types of receivers in the system. The first one use PT2272, which is remote control decoder PT2262 as receiver utilizing CMOS technology. It is mainly applied to data acquisition of the front-end. The second one use RX3310, which is a fully integrated, amplitude-shift-keying (ASK) modulation, single chip receiver. It is designed to operate in a variety of low power radio applications. All popular radio frequencies from 250 MHz to 450 MHz may be supported by simply choosing the appropriate external components. Figure-5 shows the datasheet from PT2272 as remote control encoder utilizing CMOS technology.

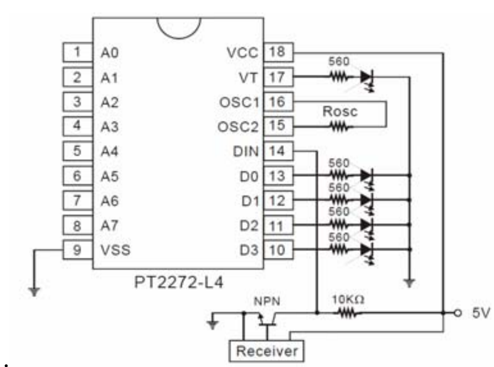

Figure-5. Remote control decoder.

Remote control decoder as a receiver is connected with main microcontroller in the robot. Every command was based on the designated room's data in the

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receiver. Each room data coding table can be seen in Table-1. Because there are only four rooms, data coding was done digitally using four combination.

Table-1. Room to room data initialization.

ROOM NAME	CODING DATA (D3 D2 D1 D0)
Room A	1110
Room B	1101
Room C	1011
Room D	0111

2.2. MAIN SYSTEM DESIGN

The robot's main system is the data processing of entire input system. Input system consist of summon system and line sensor. The robot will move to the caller's room by processing the line map according to the data inputted in the memory. Diagram block of data processing can be seen in Figure-6.

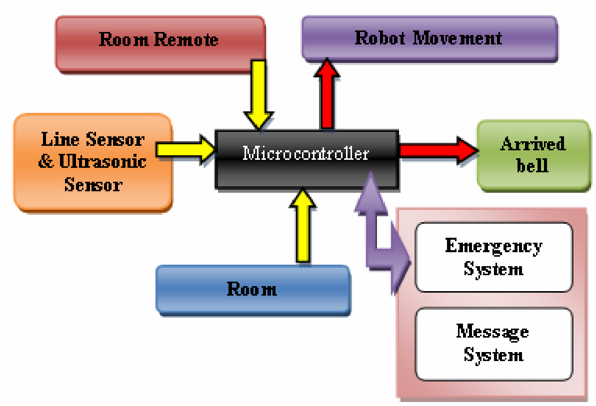

Figure-6. Flow diagram for delivery robot.

Microcontroller has the most important role in data processing of the entire robot's system. The order of data processing is as follows:

a. Base camp as the stand by and finish point
b. Using the room remote, user can command the robot to move to specific room. The robot is equipped with line sensor to identifying the line map and ultrasonic sensor to avoid collision on the way
c. When it has arrive on the destination, the robot will sound a bell (arrived bell)
d. User can put things on the robot which will be delivered
e. Repeat step b and c
f. After finishing its task, the robot will go back to the base camp and stand by

Schematic design of main system can be seen in Figure-7 below:

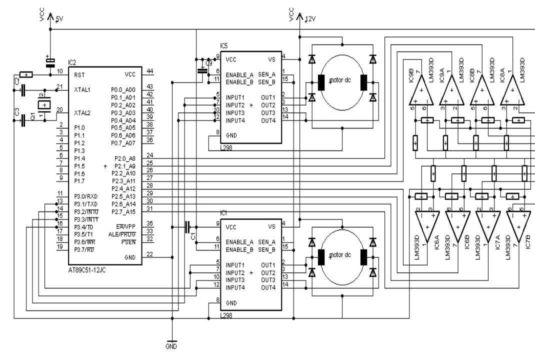

Figure-7. Schematic main system.

In the main system design, there are two parts of line sensor: LED IR as the transmitter and photo-diode as the receiver of infrared light. The line sensor concept is very simple: when it detects luminous color, the infrared will reflect the light which then collected by photo-diode; when it detects illicit color, the infrared could not reflect the light. The color reading can minimize errors due to the influence of outside light intensity because the photo-diode can only receive infrared light [6, 7]. Seven line sensors to detect the line in the mapping arena are placed at the bottom of the robot and can be seen in Figure-8. DC motor drive is used in this paper as a dual full bridge driver, chip L298. The operating supply voltage of chip L298 is up to 46V and the total DC current is up to 4A [8].

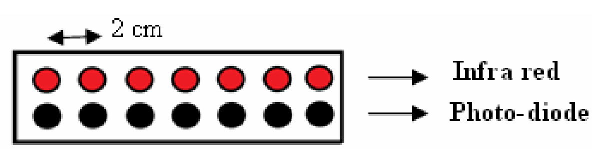

Figure-8. Line sensor position.

Figure-9 shows the input system which consists of an infrared transmitter, a photodiode, and a comparator (LM339). These are the main components in designing the line sensor. The sensors are connected to the microcontroller to interpret the color line. All data processing will be generated at the microcontroller as the main brain of this system.

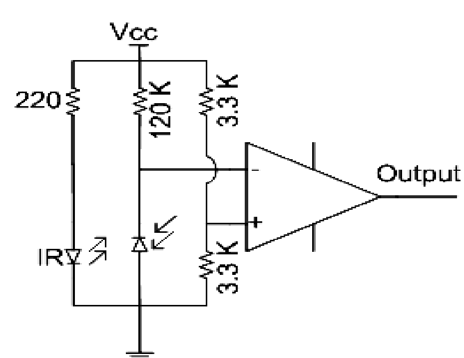

Figure-9. Schematic line sensor.

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The robot also has ultrasonic sensor to detect obstacle on the way. When the robot encounter an obstacle, it will stop and sound the alarm. After the obstacle has been removed the robot will continue its task. The GH-311 ultrasonic motion sensor is used to transmit an ultrasonic burst and providing an output pulse that corresponds to the time required for the burst echo to return to the sensor [9]. The output pulse will terminate when the echo is detected; hence the width of those pulses corresponds to the distance of the target. By measuring the echo pulse width, the distance to the target can be easily calculated by the microcontroller. The ultrasonic sensor PIN connections can be seen in Figure-10.

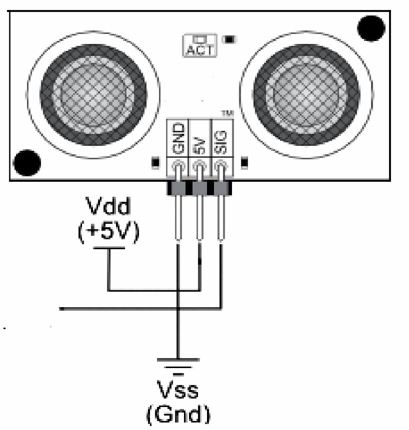

Figure-10. Ultrasonic Sensor.

The robot is equipped with four buttons, each for specific destination room, and also an arrived bell to indicate when the robot has reach the targeted room. The robot movement is designed using two DC motor connected with driver motor L298. This movement system is controlled by microcontroller.

2.3. ADDITIONAL SYSTEM DESIGN

Additional system consists of emergency system and message system. Emergency system composed of camera, alarm, and remote control (RC). When the robot lost track, the microcontroller will activate the emergency system which trigger the alarm and video camera so the user get warned and can move the robot manually using RC and see its movement through camera monitor. In this research, the RC has 2.4 GHz frequency and two channel. The quantity of channel is in accordance with the amount of device which can be controlled using RC. RC's channel 1 is used to control forward and backward movement, and channel 2 is for side to side movement. The microcontroller which command the RC will translate the data send by RC and use it to cause the movement. The magnitude of frequency which can be read by microcontroller can be seen in Figure-11 below:

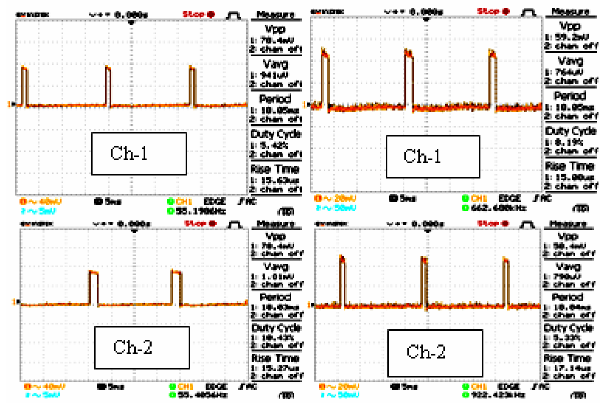

Figure-11. Frequency receive in remote control.

Figure-12 show the test which conducted on a project with a circuit board.

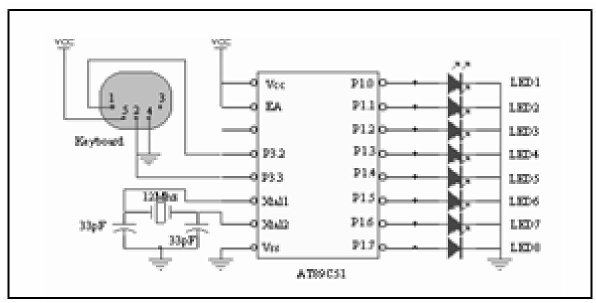

Figure-12. Schematic Diagram of Test Modules Keyboard.

Testing was done by pressing 'a', 'h', 'space', and '1'. Example: At the time of pressing 'a', LED5, LED4, and LED3 will lit. It shows that port 1.4, port 1.3, and port 1.2 give logic 1, and the other give logic 0. Key 'a' has the hexadecimal 1Ch or equal to the binary number 00011100B. Port 1.7 is the most significant bit, it means port 1.6 and port 1.5 should be valued logic 0, whereas at port 1.4, ports 1.3 and port 1.2 should be worth logic 1. Ports 1.1 and 1.0 should be valued logic 0. The test continues with key 'h' which has hexadecimal value of 33h or 00110011B. When this button pressed, LED1, LED2, LED5, and LED6 are lit. When the space key pressed, LED1, LED4, and LED6 are lit. It means the space bar has a binary number 00101001B or 29H, according to the code table scan in Appendix H. The latter carried out tests on Figure-1, and will turn on LED2, LED3, and LED5. Binary number obtained by the lit LED is 00010110B or 16H.

The message system is designed for the user to send short message to other user which displayed in the LCD. It is very simple to interface with the controller as well as cost effective. The ALPHANUMERIC display used is *4x20* (four lines and twenty characters per line) and controlled by microcontroller [10, 11, 12]. The diagram block can be seen in Figure-13 below:

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Figure-13. Message system diagram block.

3. RESULT AND DISCUSSIONS

Room remote system is designed using RF transmission and encoder system to decode the encryption on each room's data. Transmission system and signal receiver were measured using oscilloscope and the result can be seen in Figure-14 and Figure-15. (R = Receiver wave; T= Transmitter wave). Figure-14 indicates that when the transmitter has yet to send any signal, the receiver got abstract signal in form of noise; and Figure-15 indicates that when the data has been encripted and sent, data transmitting and receiving process occurred well, meaning there is no invalidity in data encryption.

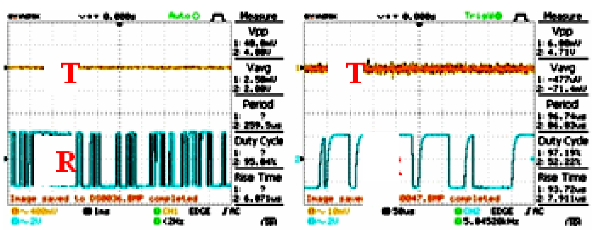

Figure-14. Signal at the transmitter without input wave.

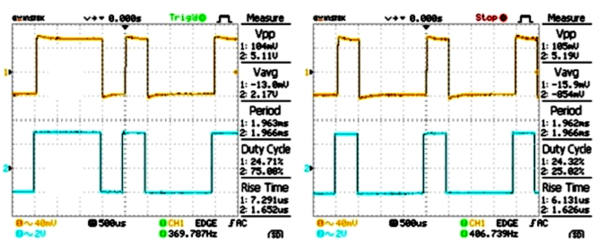

Figure-15. Compare signal at the transmitter and receiver.

The distance of robot summoning is also an important factor. From the trial-and-error experiment, the result were the farthest distance of data transmitter equals to 33 metres, using standard antenna on the modul and on the account that there were no obstacles. The system program flowchart to respond the user's summon can be seen in Figure-16. The robot can not be summoned by more than one user at one time, and can be summoned again only when it is on stand by mode (after finishing one task).

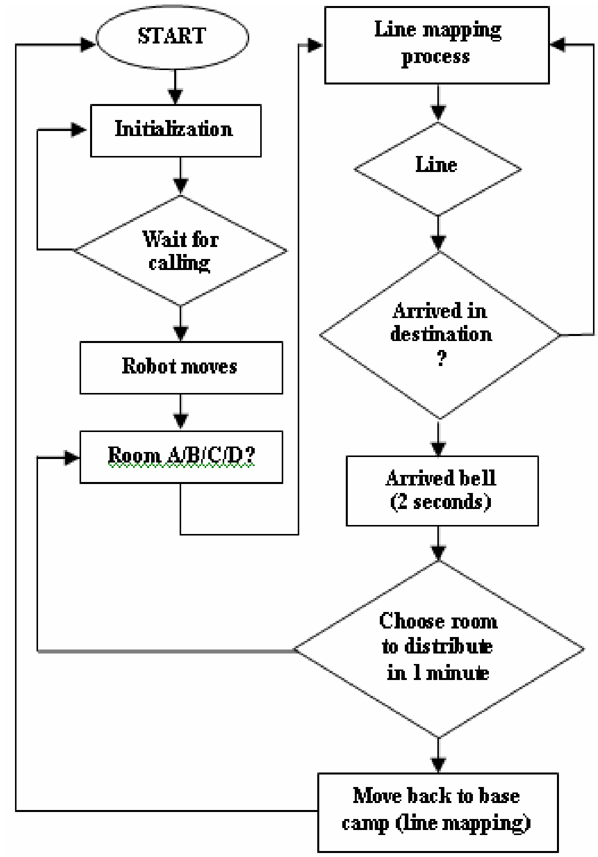

Figure-16. Flowchart microcontroller for line mapping.

Based on line sensor examination, the measurement result between the sensor and reflective surface can be seen in Table-2. Photo-diode as an input system for the line sensor becomes high resistance in the comparator system if the photo-diode receives infrared light. The voltage (V-) is more negative than the reference voltage, which result in the output of the comparator close to or equal to +5 volts. On the other hand, if the photodiode does not receive infrared light, low resistance will be detected in the comparator. The voltage in (V-) is more positive than the reference voltage, which result in the output of the comparator close to or equal to 0. In this system, the comparator circuit voltage divider will be compared with the reference voltage (V+) to determine the high/low condition of the output voltage, according to the input. Voltage divider reference is 1:1 (50%) and the distance between IR LED and photo-diode is 0.8 cm. From the experiment, line sensor can work well between space 1 - 2.5 cm in even surface.

Table-2. Line sensor distance.

Distance	Line sensor status
0.5 cm	No
1 cm	Yes
1.5 cm	Yes
2 cm	Yes
2.5 cm	Yes
3 cm	No

This system use ultrasonic sensor GH-311 because it can detect an obstacle 40 cm away without measuring the distance. Based on the robot's weight and type of motor used, 40 cm distance is enought for the robot to stop before bumping. The type of driver motor used is not the focus of this research. Overall weight of the robot is 5 kg and the formula to determine the motor speed is:

$$S = v_i.t \quad (1)$$

From the equation above, the average speed of the robot is 1.045 m/s.

Overall system tryout was done by doing the summoning process in each room and command the robot to deliver things to another room. The robot reliability percentage can be seen in Table-3 below:

Table-3. Robot reliability percentage.

Room number	Destination	% Error
Room A	Room B	0%
	Room C	20%
	Room D	20%
	Base Camp	20%
Room B	Room A	20%
	Room C	20%
	Room D	40%
	Base Camp	0%
Room C	Room A	20%
	Room B	20%
	Room D	0%
	Base Camp	20%
Room D	Room A	40%
	Room B	20%
	Room C	0%
	Base Camp	40%

The table shows that delivery error occur most often in room D with error rate of 40% and success rate of 81.25%.

4. CONCLUSIONS

From the design, manufacture, and system testing, the conclusions are as follows:

1. The system can trace line mapping from one room to the other through the existing track with the average percent error of 18.75%, which shows that the system can run well.
2. The system room remote can receive input signals transmitted from a maximum distance of 33 m without a hitch, and the robot can also follow the line with a steady run.
3. Infrared sensor can work well while the robot moves, but the bottom of the robot must be within 1.5 cm distance from ground.
4. Installation of the antenna on the transmitter and receiver circuits were required to increase the distance that can be achieved by a series of data delivery.
5. The robot can walk straight with a maximum speed of 1, 045 m /s.

ACKNOWLEDGMENT

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REFERENCES

[1] Asd F. Carreira, T. Canas and A. Silva. 2006. Mobile Robot to Deliver Meals inside Health Services. Proceedings of 2006 IEEE/RAM.

[2] M. Dhivya and M. Pushpavalli. 2014. Automatic Delivering System in Hospital Using GPS Technology and Efficient Fault Management. The International Journal of Science and Technoledge. 2(3), ISSN: 2321-919.

[3] Roman Osorio C., Jose A. Romero, Mario Pena C. and Ismael Lopez-Juarez. 2006. Inteligent Line Follower Mini Robot System. International Journal of Computers, Communications and Control. I(2): 73-83.

[4] Syed M. A., Satish V. R., and Roohi A. 2010. Security management system for oilfield based on embedded wireless communications: A design approach. Oriental Journal of Computer Science and Technology. 3(2): 359-36.

[5] IC PT2262 datasheet. The specification of chip. Princeton Technology [Online] Available: Corp. http://www.princeton. com.

[6] Bajestani S.E.M., Vosoughinia A. 2010. Technical Report of Building a Line Follower Robot.

International Conference on Electronics and Information Engineering (ICEIE 2010). 1: v1-1 v1-5.

[7] Colak I., Yildirim D. 2009. Evolving a Line Following Robot to use in shopping centers for entertainment. Industrial Electronics, 2009. IECON '09. 35th Annual Conference of IEEE. pp. 3803-3807, 3-5 Nov.

[8] Ganiyu R. A., Shoewu O., Olatinwo S. O. and Omitola O. O. 2014. Development of a Microcontoller-Based Motor Speed Control System Using Intel 8051. Journal of Advancement in Engineering and Technology.

[9] C. Gearhart, A. Herold, B. Self, C. Birdsong, L. Slivovsky. 2009. Use of ultrasonic sensors in the development of an Electronic Travel Aid. Sensors Applications Symposium. SAS 2009, IEEE, pp.275-280.

[10] Tripathi G., Mainkar S. and Sunny S. 2014. DAC Interfacing with 8051. International Journal of Research in Advent Technology. 2(2), E-ISSN: 2321-9637.

[11] Pujari S., Panda A. and Muduli P. 2013. A Learning Model for 8051 Microcontroller Case Study on Closed Loop DC Motor Speed Control. 2013. International Journal of Emerging Technology and Advanced Engineering. ISSN 2250-2459, ISO 9001:2008 Certified Journal. 3(11).

[12] S. B. JAGADAL and S. V. HALSE. 2013. 8051 Microcontroller Based Multiple Water Tank. Control System. J. Comp. and Math. Sci. 4(5): 382-401.