International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-2 Issue-3, July 2013

ARM Based Stair Climbing Robot Controlling Through DTMF Technology

T.Sairam Vamsi, K.Radha

Abstract: ***In today's technology development, mobile robotics plays a vital role in many aspects because they are used to operate in hazardous and urban environments, for surveillance as well as military operations. Some of the mobile robots are designed to operate only on natural terrains, but some other also for rough terrains and artificial environments including stairways. In the age of ubiquitous systems it is necessary to be able to monitor the robots from everywhere. Although many methods to remotely control robots have been devised, the methods have the problems such as the need for special devices or software to control the robots. This paper suggests an advanced method for robotic control using the DTMF technology. Until recent years, the stair climbing robots are designed with vast hardware and robots are equipped with wheels to climb stairs or to move on a flat surface. The controlling mechanism has been advanced with the development of mobile robots. This paper addresses the design and implementation of DTMF controlled stair climbing robot. This climbing robot is operated with ARM7TDMI (LPC2148) controller. The mechanical design of the robot contains the roller chains instead of wheels and rubber blocks are attached to the roller chains to generate high friction with ground. Experimental trials showed that the implementation of the behavior control systems was successful.***

Index Terms—Control, mobile Robot, PIC LPC2148, DTMF technology, roller chains

I. INTRODUCTION

Robot had come to human life for the past almost 80 years ago. Robot once wascreated with the purpose as a human assistant tool. Math rulesphysics, and physics rules robots. The laws of physics and math are evident ineveryday life.
Making a vehicle that can autonomously drive around, both indoors and out seems,at first, like a simple thing. Build a chassis, add driver modules, steering wheels, pitch modules to set angle of rotationa power source, some control code that includes some navigationand obstacle avoidance routines or some other way to control it, throw some bumpsensors on it, and there it go, a robot. In a mobile robot, the obstacle avoidance must be the highest priority. Since it could crash or damage another object. This condition not only can risk the robot itself, but also third parties. Therefore the sensors have a great importance, since they can analyze the robot's environment and they provide information to processing unit of robot. Generally in mobile robotics obstacle detection and avoidance must be the highest preference, because it could crash or damage another object even robot itself.

Revised Manuscript Received on 30 July 2013.
* Correspondence Author
Sairam Vamsi.T, has completed B.Tech (ECE) in 2011 and is pursuing M.Tech (ES) in Gudlavalleru Engineering College, AP.
Mrs. Radha.K, is working as Assistant Professor in Gudlavalleru Engineering College, AP.

Therefore sensors and cameras play a vital role, since they can analyze the robot's environment and they can provide information to Processing unit of the robot and also provide information to the user by message using GSM modem.The robot is controlled using microcontroller ARM LPC2148 as the heart of control. The motion of the robot is controlled by controlling the direction of motors (forward, reverse, right and left) this action is performed by using L293D IC.The speed of the robot is controlled by generating PWM from the ARM, and thecamera can move right and left by controlling the stepper motor.
The Stair-climbing Robot will be controlled by 4 different ways:

- First, the robot is controlled trough serial joystick, it contain pushbuttons andpotentiometer. This Pushbuttons control movementof motor andpotentiometers control PWM.
- Second, the robot is controlled by interfacing climbing robot with PC using serial port.
- Third, RF module is used to control the robotwireless. 433.92 MHz RF Transmitter andReceiver is wireless data communication.
- Finally, the robot is controlled using zigbee transmitter and receiver.

II. DESIGN OF STAIR CLIMBING ROBOT

Figure1 presents the block diagram of the stair climbing robot. Here the robot is controlling through DTMF technology and robot is autonomous based on roller chains and rubber blocks. Here the robot is equipped with PIR sensor and cameras in order to provide awareness to the rescue personnel before they enter a possibly dangerous area. The ARM7TDMI (LPC2148) controller acts as processing unit. The controller is mainly interfaced to DTMF decoder (MT8870) and driver circuits (L293D) to drive the motors connected to the robot. The controller takes the signal from MT8870, which generate the 4 bit binary code equalling to the alphanumeric tone generated by mobile. The controller also connected to the GSM module, which sends information to rescue personnel about the dangerous area where robot is climbing or running.The block diagram of stair climbing robot is shown in Fig 1:

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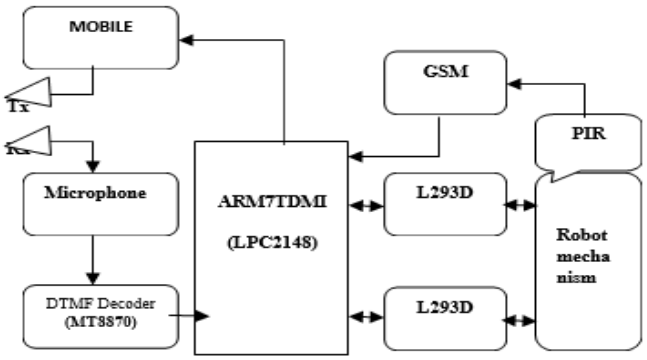

Fig 1: Block diagram

A. DTMF Decoder

DTMF Technology is one of the wireless communication methodology used to control the robots. Conventionally, past robots are controlled by using RF circuits, which have the drawbacks of limited working range, limited frequency range and limited control. That's why use of a mobile phone for robotic control can overcome these limitations; this provides the advantage of robust control, and working range as large as coverage area is available. One of the biggest advantages of mobile controlled robots is long lasting. In this paper, the robot is controlled by a mobile phone that makes a signal to the mobile phone attached to the robot. If any button is pressed then a tone corresponding to the button is heard at other end of the call. This tone is called Dual Tone Multi Frequency (DTMF) tone. Here the received tone is decoded into 4 bit binary number by using MT8870 DTMF decoder. This binary code is processed by the LPC2148 controller. The controller is preprogrammed to take the decision for the given input then motor runs and robot moves in a specified direction. MT8870 is an 18 pin DIP package, the internal diagram explains how a DTMF tone converted to 4bit code. Mainly it contains digital detection algorithm and code converter latch to perform this action.The signal generated by the DTMF encoder is the amplitudes of two sine (cosine) waves of different frequencies, i.e., pressing '7' will send a tone made by adding 1209 Hz and 852 Hz to the other end of the line. The tones and assignments in a DTMF system are shown in Table I.

Table I: frequency assignments in DTMF system

Frequencies	1209 Hz	1336 Hz	1477 Hz	1633 Hz
697 Hz	1	2	3	A
770 Hz	4	5	6	B
852 Hz	7	8	9	C
941Hz	*	0	#	D

B. Motor Driving circuit

L293D is a motor driving IC used to drive the motors attached to robot. L293D is a transistor H-bridge circuit used to drive the at most two motors at a time. H-bridge means it contains four switches which controls the direction of motor.

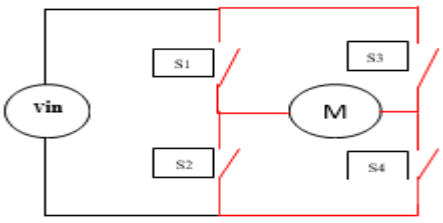

Fig 2: Structure of H-bridge (Highlighted in red color)

Table II: action of motor in different modes

1	S2	S3	S4	RESULT
1	0	0	1	ROTATE IN ONE DIRECTION
0	1	1	0	ROTATE IN OPPOSITE DIRECTION
0	0	0	0	MOTOR FREE RUNS
0	1	0	1	MOTOR BREAKS
1	0	1	0	MOTOR BREAKS

Table II& Figure 3shows the structure of H-bridge and action performed by the motor in different modes. This L293D takes PWM signal from controller in order to drive the motor. The speed of motor depends on the PWM signal on & off pulses. The motor stops rotating during off pulse and runs during on pulse. If the width of the pulse is high motor rotates fast and vice versa.

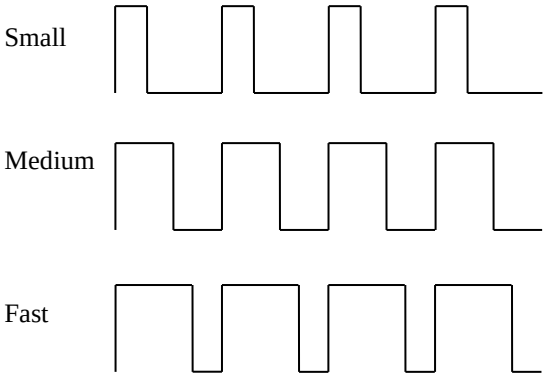

Fig 3: velocity control of motor using PWM

L293D IC is 16pin DIP package, each motor having separate enable pins. The PWM train pulses applied to the motor is shown in figure 5.

C. Processing unit (LPC2148)

LPC2148 is one of the families of microcontroller from ARM7TDMI. This controller has greatest advantage compared to remaining families of controllers available like PIC and AT mega, those are on chip resources availability (two UART's, two fast I2C-bus, SPI etc) and speed of operation (operating frequency is 0 to 100MHz).This LPC2148 has 44 fast GPIO lines, hence we can interface many I/O devices and it is a 64pin controller.

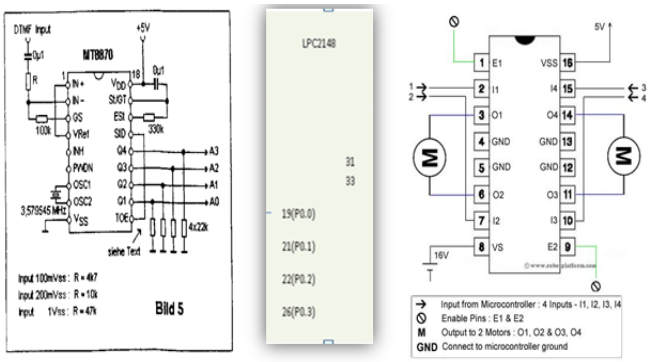

Fig 4: Interfacing of MT8870, LPC2148 and L293D

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Figure 4 shows the interfacing of controller with motor driving IC and DTMF decoder, the software coding is implemented based on this interfacing. The PIR sensor and GSM modules are also interfaced with the controller GPIO pins.

C. GSM Module

A GSM modem is a wireless modem that works with a GSM wireless network. In this paper GSM modem is used to communicate with mobile phone to which message is going to be sent. The message is stored in internal memory (ROM) of controller. 900 or 1800MHz is the frequency band used for GSM communication.

The working of GSM modem is based on commands, the commands always start with AT (which means Attention) and finish with a <CR> character. The AT commands are given to the GSM modem with the help of PC or controller. In this paper the GSM sends message only when PIR sensor is active. Once PIR is active it informs to controller then GSM modem activates then corresponding message transmitted to destination number.

III. ALGORITHMS FOR DTMF CONTROLLED ROBOT

This algorithm explains how the robot is controlled with DTMF tones. The mechanical development and design of robot is common to all designs such as wheel joints, robot chassis design and remaining hardware like roller chains etc... That's why this paper completely gives about latest methodology in controlling the robot and with advanced processing unit. This robot is converted to some rescue application by attaching GSM modem, PIR sensor and cameras rotating with the help of DC motors. The basic algorithm is as follows, Figure 5 gives algorithm for DTMF controlled robot

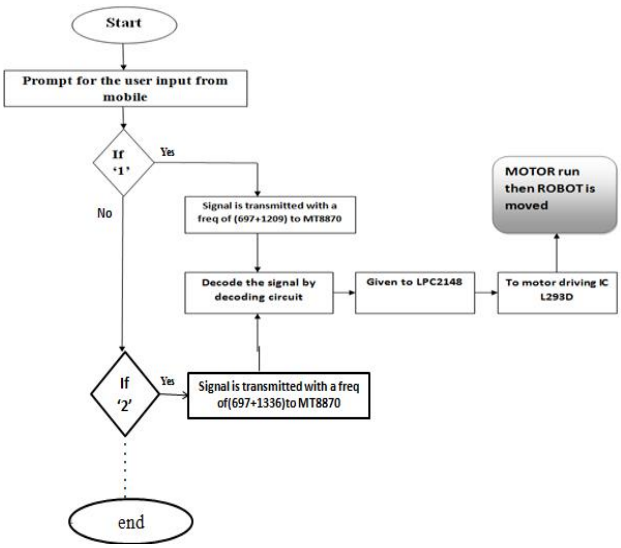

Fig 5: Algorithm for DTMF controlled robot

Command from mobile then corresponding lower and higher band frequencies are summed, resultant signal is decoded and decoded signal is processed by controller and corresponding action takes place from robot.

IV. WORKING PROCEDURE OF CLIMBING ROBOT

The working procedure of robot takes place in stepwise. There are roughly five to six steps are used for this process. The robot comes to rest position after climbing of each step. The designed robot is broadly categorized into three modules such as driving modules, pitch modules and linking module.

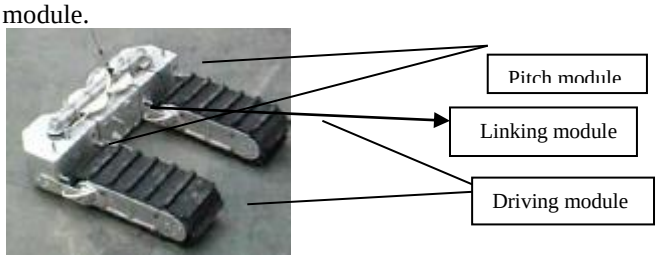

Fig 6: Prototype of climbing robot

Hardly there are four steps are needed to climb each stair,

- Lifting the front driving and pitch module.
- Lifting middle part of robot (linking module) to set direction of robot while moving forward.
- Lifting the back driving and pitch modules of robot.
- Coming to the rest/initial position.

Figure 6 shows the general prototype of robot it is having two driving modules to move forward and backward and two pitch modules used to adjust angles between driving modules and linking module, so that we can change robot position. The linking module contains a gearing system which can be used to set angles between driving modules. This robot can work in two modes, serial configuration which moves very fast in flat surfaces and parallel configuration which runs in uneven terrains also.

V. EXPERIMENTAL RESULTS

I. The experimental testing of DTMF controlled mobile robot is designed to carry out in three stages.

1) *First stage:* The first stage is testing output of DTMF decoder signal in comparison with computer matlab simulation. A robot with DTMF transceiver is programmed to output a series DTMF characters. A simulation of the DTMF signal was generated using equation (1) to compare against the result of the hardware generator.

$$x(t) = A\cos(\omega t) + B\cos(\omega t + \emptyset) \quad \text{--------- (1)}$$

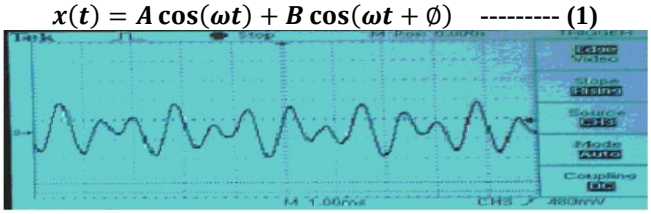

Fig 7: Signal output from hardware

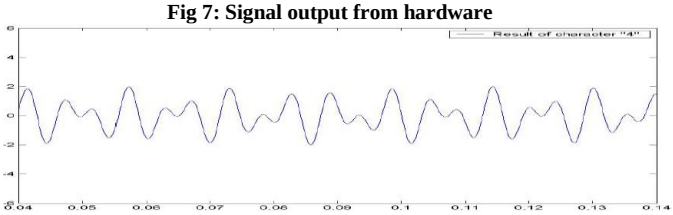

Fig 8: Simulation result of DTMF encoder for character 4

2) *Testing data transmission:* Here user test the integrity of data transmission and it is performed before the robot is operating in their test environment. The robot then go through the testing algorithm where user sends and other receives each DTMF character.

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This test is performed by keeping robot at different locations to test robustness of signal transmission through air.

3) *Third stage:* finally testing is done directly on the designed climbing robot. The user gives the DTMF characters and test weather corresponding action takes place as shown in below table:

Table III: Action of robot for each DTMF command

characters	0	1	2	3	*	#
operation	Forward	backward	Turn_rgt	Turn_lft	Start	Stop

II. Snapshots For Dtmf Testing And Robot

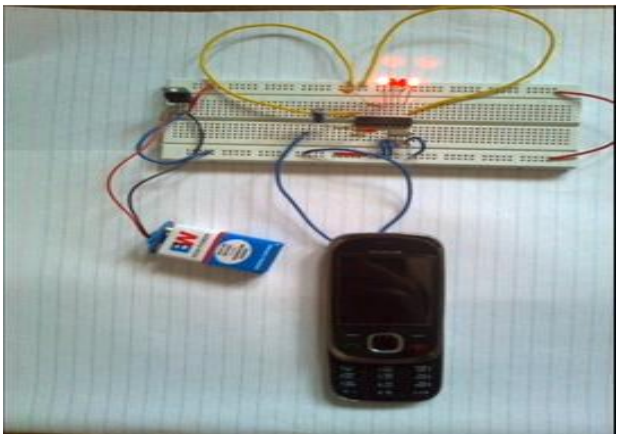

Fig9: DTMF testing on PCB

Fig10: Climbing robot

VI. CONCLUSIONS

A stair climbing robot with autonomous movement has to be designed and implemented. Here the robot is to be implemented to cope with stairs, uneven terrains, and move fast on flat surfaces. The main concern of this paper is controlling method used to operate the robot, DTMF technology is used, with which the robot can be controlled anywhere from world, and also robot is equipped with roller chains and rubber blocks such that chance of slippage of robot is very often. This robot is also helpful for industrial surveillance such as rescue/military team, for this robot is designed with PIR sensor, GSM module and camera which monitor surrounding places.LPC2148 is used in this robot which is very accurate and speed to control all devices interfaced with it. Initially after designing this robot it is tested with RF module but to overcome the limitations of RF, DTMF methodology is to be implemented. The overall benefits of the robot include reduced personal requirements, reduced fatigue, and access to unreachable areas.

REFERENCES

1. Nan Li, Shugen Ma," An Online Stair-Climbing Control Method for a Transformable Tracked Robot," *Senior Member, IEEE*, Bin Li, Minghui Wang, and Yuechao Wang, 2012.
2. P. Ben-Tzvi, S. Ito, and A. A. Goldenberg, "Autonomous stair climbing with re-configurable tracked mobile robot," in *Proc. IEEE Workshop Robot. Sens. Environ, 2007, pp. 1–6.*
3. A. Shatnawi, A. Abu-El-Haija, A. Elabdalla, "A Digital Receiver for Dual-Tone Multi-frequency (DTMF) Signals", Technology Conference, Ottawa, CA, May 1997.
4. http://seminarprojects.com/Thread-mobile-controlled-robot-using-dtmf-technology.
5. Dr. Basil Hamed, "Design and Implementation of Stair-Climbing Robot for Rescue Applications," in *International Journal of Computer and Electrical Engineering, Vol. 3, No. 3, June 2011.*
6. Saleh Ahmad, Hongwei Zhang, and Guangjun Liu, *Senior Member, IEEE*"Multiple Working Mode Control of Door-Opening With a Mobile Modular and Reconfigurable Robot" IEEE/ASME TRANSACTIONS ON MECHATRONICS, 2012.
7. http://www.nxp.com/documents/data_sheet/LPC2141_42_44_46_48.pdf
8. Junke Li1, YujunWang2, TingWan3Department of C&IS, Southwest University, Chongqing, China "Design of A Hexapod Robot".2008.
9. R. C. Luo, K. L. Su, "Amultiagentmulti sensor based real-time sensory control system for intelligent security robot" *IEEE International Conference on Robotics and Automation*, vol. 2, 2003, pp.2394 –2399.
10. Nicolai Dvinge, Ulrik P. Schultz, and David Christensen Maersk Institute University of Southern Denmark. "Roles and Self-Reconfigurable Robots"2010 IEEE.
11. Raúl A. Gonzales, Federico A. Gaona,"An Autonomous Robot Based on a Wheelchair**,"** *IEEE International Conference on Robotics and Automation*, vol. 5, ©2012 IEEE.
12. http://users.ece.utexas.edu/~valvano/Datasheets/L293D_ST.pdf.
13. Raúl A. Gonzales, Federico A. Gaona, Raúl R. Peralta."An Autonomous Robot Based on a Wheelchair", 2012 IEEE.
14. Michael Fair, "Autonomous Stair climbing With A Mobile Robot," A Thesis Report Submitted To University Of Oklahoma Graduate College, Norman, Oklahoma 2000.

AUTHOR PROFILE

Sairam vamsi.T has completed B.Tech (ECE) in 2011 and is pursuing M.Tech (ES) in Gudlavalleru Engineering College, AP.

Mrs. Radha.K is working as Assistant Professor in Gudlavalleru Engineering College, AP. So far she has 5 years of teaching experience and published 1 IJ paper and 3 IC papers.

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