Controlling of Remote Robot through mobile phone using DTMF Signal

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Abstract— In the age of quotidian systems it is important to be able to control robots everywhere. Although different mode to remotely control robots have been devised, the mode have the difficulty such as the need for unique devices or software to control the robots. This paper suggests a methodology of robot control using the DTMF tone generated when the user press mobile phone keypad buttons when connected with a remote mobile robot.

Keywords— DTMF , Robot, Mobile, Atmega 16L

I. INTRODUCTION

The remote robot control technologies have been used in the areas like production industry, factory automation or space exploration, which it is tough for human to deal. In the present scenario, application of the home robot [1] is turn on, numerous corporations, MNC, and laboratories are exploring the methods which enable human to control efficiently and easily in the firm or outdoor. Especially, controlling the home robot regardless of time and space is important challenge.

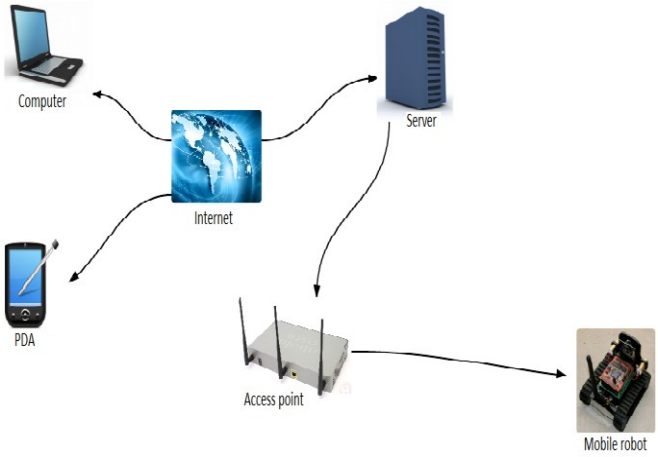
Since mobile phone enables human to connect across the globe via Telecommunication network. Mobile phone is a qualified device to control the home robot. This paper suggests a method to control a robot through DTMF (Dual Tone Multiple Frequency) signal of mobile phone. The system that we generally preferred consists of the mobile phone normally registered in Telecommunication service and the robot that can call a mobile phone. Existing methods for robot control using mobile phones have usage problems because the cost and requirement for continuous control. The method of robot control suggested in this paper can solve the problems of existing methods control that use simple voice calls. Our method uses the DTMF tone[2] generated when a keypad button of the mobile phone called by the robot is pressed. A mobile phone user controls the robot by sending the DTMF tone to the robot. Mobile communication network is more effective than that of LANs, thus users can take benefit of mobile phones to control the robot. DTMF is a global communication term for touch tone (Trademark of AT&T).The tone is generated when the key of mobile phone is being pressed by the user, and a different tone is used for each digit. However, there is always a chance that a random sound will be on the same frequency which will destroy the system. It was suggested that if two different tones were used to portray a single digit, then the false signal which may occurred is signed out by using DTMF signal. The removal unwanted signal is done by using dual tone in DTMF communication. Dual tone multi frequency signaling is used for telecommunication signaling over analog telephone lines in the voice frequency band between telephone handsets and other communication devices and the switching centre. Dual tone multi frequency (DTMF) signaling is used for telephone signaling over the line in the voice frequency band to the call switching center. The version of DTMF used for telephone tone dialing is known by the trademarked term Touch-Tone. DTMF assigns a specific frequency (consisting of two separate tones) to each key so that it can easily be identified by a microprocessor. The signal generated by a DTMF encoder is a direct algebraic summation, in real time, of the amplitudes of two sine (cosine) waves of different frequencies, i.e. pressing '5' will send a tone made by adding 1336 Hz and 770 Hz to the other end of the line. This paper outlines existing methods for robot control using mobile phone in section 2. Section 3 presents the structure and components of robot control using the DTMF tone of mobile phones. Section 4 explains how we implement the suggested method for robot control. We conclude this paper and mention future work in the last section

II. RELATED WORK

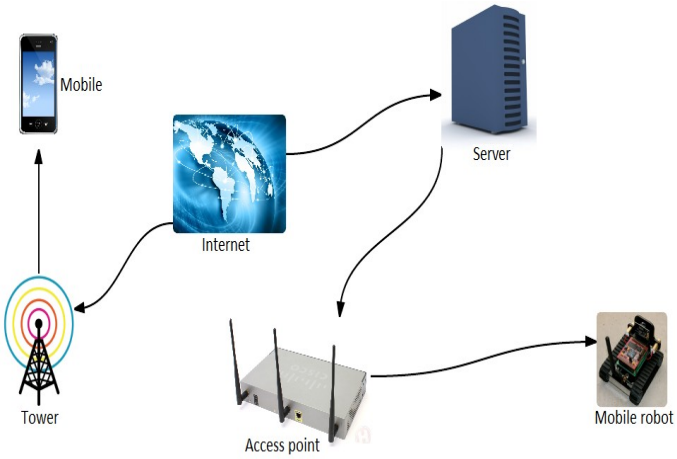
A. The robot control using the wireless internet platform of mobile phone:

Generally the wireless internet platform of mobile phones is used for robot control. Wireless internet platforms support connecting to the IP (internet protocol) network via the mobile communication network. Once the mobile phone connects to the IP network, it can use the services related with the IP network. The representative method of robot control based on *an IP network [3] is to use the WWW protocol like Figure 1(a)* Components of this control system include the robot and the server that sends the control signal to the robot and the client that request the action of the robot to the server. The user can control the robot using the video and voice data, because the IP network allows much data to be transferred. This robot control system can be constructed at low cost, because the

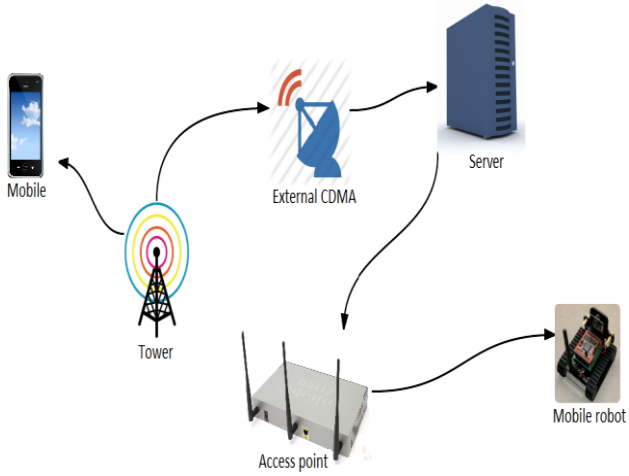
PC or PDA can be used as the client in this system .Several mobile operators commercialized services for robot control using the wireless internet platform on the mobile phone network. These services adopted the server-client model in the IP network.



(a)



(b)



(c)

Fig. 1. The diagram of robot control system based on IP network via mobile communication network.

wireless internet platform on mobile phones connects to the IP network via mobile communication network like Figure 1(b). The mobile phone connects to the server for robot control and controls the robot in the IP network via the server in IP network. This method works well but has some problems. First, because the mobile phone connects to the IP network over a mobile communication network, the user pays the connection time cost of the mobile communication network and the cost for packets in the IP network. In practice users do not use this service due to high usage cost. Another problem is that this service is dependent on the mobile operator. So if a mobile phone subscriber of a mobile operator switches to another mobile network provider the subscriber cannot use the previous service to control the remote robot, or needs to learn how to use the new service of the new provider to control the robot.

B. The robot control using SMS of mobile phone

Another method for robot control using mobile phones is to mobile phone use SMS (Short Message Service). SMS transmits a short message to a mobile phone connected to a mobile communication network. An SMS message is sent to an external server that connects to the IP network and sends the control signal to the remote robot over the IP network like Figure 1(c). A mobile phone sends the SMS message defined as a special protocol for robot control to an external server. The server analyzes the content of the SMS message and sends the control signal to the robot over the IP network. The remote robot reacts based on the control signal received. The cost for a SMS message is comparatively cheap and most mobile phone providers support SMS. Continuous control of the robot is impossible, because there is delay in transmitting the SMS message from the mobile phone to the robot. It is inadequate to adopt SMS to control the robot in systems that need continuous control of the robot

III. THE STRUCTURE OF OUR WORK

The method suggested in this paper for robot control adopts the DTMF tone of the mobile phone. As the Figure 2 shows, the components of this system consist of the mobile phone,robot control system and mobile robot. The robot control system is physically included in the mobile robot. It consists of an external CDMA modem, DTMF receiver board and

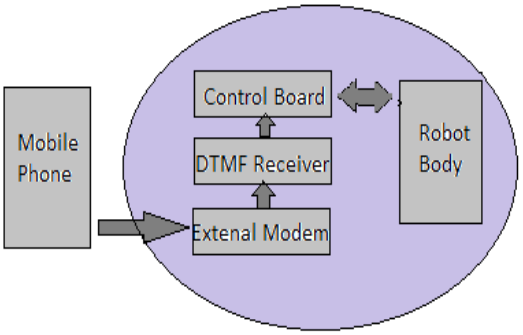


Fig 2. Block diagram mobile robot control system using DTMF.

microprocessor-based control board. This system connects the voice call between the mobile phone and robot. If call connection succeeds, the DTMF tone generated from the mobile phone is transmitted to the CDMA external modem of the mobile robot over the mobile communication network. The DTMF tone of the analog signal moves from the CDMA external modem to the DTMF receiver. This DTMF signal is converted to a digital binary signal. The converted digital binary signal is transmitted to the microprocessor-based control board. When the DTMF receiver is about to transmit the converted digital signal to the control board, it interrupts the control board. Then, the microprocessor-based control board receives the digital binary data based on the DTMF tone from the DTMF receiver when handing the interrupt. The control board analyzes the digital binary data and finds whether it is same with one among predefined defined values. If it is same with one of predefined values, the control board sends the corresponding control signal to the robot. The value of this control signal is PWM (Pulse Width Modulation) [4] and selects the motor action in the robot. Thus the system
controls the mobile robot using the mobile phone DTMF.

A. DTMF signal of mobile phone and DTMF receiver

DTMF is the signal to be transmitted to the counterpart when the keypad buttons (Figure 3) of the mobile phone are pushed. Each button pushed creates two tones of differing frequency.

TABLE I
PHONE DTMF FREQUENCY

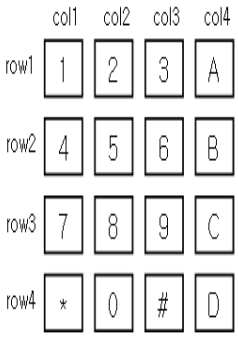


Fig 3. Phone Keypad layout.

Low Frequency	High Frequency
row 1 = 696Hz	Col 1 = 1209Hz
row 2 = 770Hz	Col 2 = 1336Hz
row 3 = 852Hz	Col 3 = 1477Hz
row 4 = 941Hz	Col 4 = 1633Hz

One tone belongs to the high frequency range and the other tone low frequency. Voice tones generally range from 0Hz to 4000Hz. A DTMF tone includes two frequencies in this range (Table I). The DTMF tone corresponding to five buttons consist of mixed frequencies of 770Hz and 1336Hz corresponding to row 1 and column 1 in Table 1. The A, B, C,D buttons are not used in general mobile phone. These buttons are reserved for special use. The DTMF tones of mobile phones are generated by the same process as with general telephone.

Table II
Digital output of DTMF receiver

No	Low Freq.	High Freq.	Q4	Q3	Q2	Q1
1	697	1209	0	0	0	1
2	697	1336	0	0	1	0
3	697	1477	0	0	1	1
4	770	1209	0	1	0	0
5	770	1336	0	1	0	1
6	770	1477	0	1	1	0
7	852	1209	0	1	1	1
8	852	1336	1	0	0	0
9	852	1477	1	0	0	1
0	941	1336	1	0	1	0
*	941	1209	1	0	1	1
#	941	1477	1	1	0	0
A	647	1633	1	1	0	1
B	770	1633	1	1	1	0
C	852	1633	1	1	1	1
D	941	1633	0	0	0	0

The DTMF tones generated from mobile phones are transmitted over mobile communication networks to a CDMA external modem that is incorporated in the mobile robot. The CDMA external modem sends the voice signals with the DTMF tone to the DTMF receiver through a stereo ear phone jack. As the Figure 4 shows, the DTMF receiver passes the DTMF tone through a zero crossing detector [5] and divides the width frequency and the height frequency into a high group filter and a low group filters. The DTMF receiver calculates a point of intersection between the two frequencies. The DTMF receiver modulates this signal through a digital detection

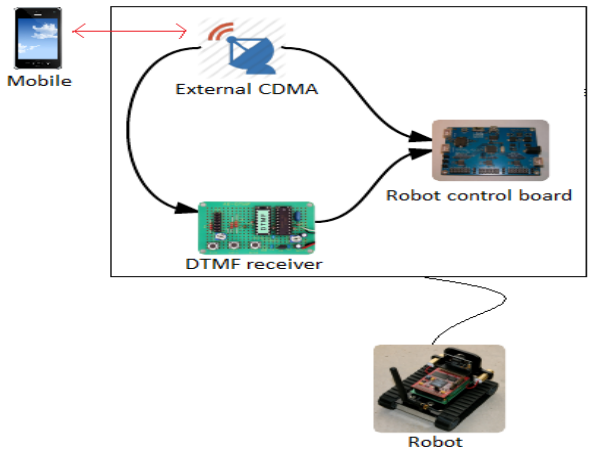


Fig. 4 The diagram of mobile robot control system using DTMF

IV. STRUCTURE OF PROPOSED WORK

Operation of the Circuit

The message is transmitted by calling the mobile phone which is attach with the robot and it work as a mobile robot. We have to call the desired number corresponding to the required control effort at the transmitter end. When the handset of the phone at the receiver end is picked up or the call is connected automatically by the use of AT commands, the messages can be typed on the number pad of the transmitting phone. The receiver end consist of input device, decoder, microcontroller, computer and a mobile phone

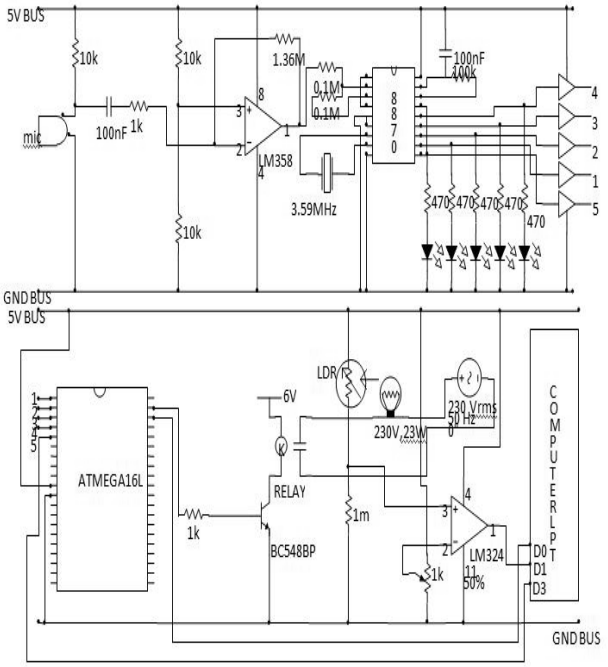


Fig. 5- Circuit Diagram

The input is given through mobile/landline phone, condenser microphone and an audio amplifier. The decoder section, Consist of the fundamental concept of DTMF signal reception and the decoded signal is send to the microcontroller through LPT [6]. The microcontroller is concatenate to the parallel port of a computer, and is joined to a relay which execuate the desired action. The computer is used here to respond on the input signal by playing a suitable audio file representing the status of the system, which can be heard at the transmitter end straightaway whether the key is pressed or not. Once the connection is made between the two phones, whatever mobile key is pressed at the transmitting end, the corresponding DTMF tone is heard in the ear phone at the receiver end. The ear phone is connected to a condenser microphone which receives the DTMF tone. Its output is amplified by the audio amplifier and this output is send to the DTMF decoder. The DTMF decoder will give the corresponding BCD value of the tone. This output, through a driver circuit is connected to PORT B of the Atmega 16L microcontroller. This microcontroller's output is send to the relay and parallel port of the computer to affect the control effort and to trigger a voice feedback.

V. IMPLEMENTATION

The robot control system through the mobile phone DTMF tone in this paper is depicted in Figure 6. The mobile phone used in this system is a general phone that is registered on a mobile communication network of a mobile network provider. The mobile robot in this system consists of a CDMA external modem, DTMF receiver, microprocessor-based robot control, DC motors and the drivers. The CDMA external modem is the Bell-wave BSM-856 and includes the Qualcomm MSM 6050 chipset. The modem is also registered in a mobile communication network, so has a unique phone number. The DTMF decoder chip is the Samsung Electronics KT3170 [7].

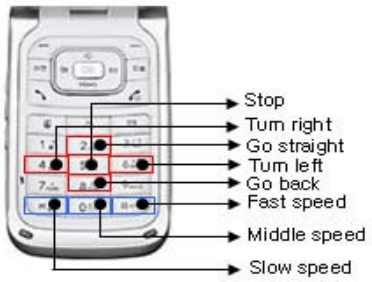


Fig. 6. The functionality of used keypad in mobile phone.

The control board microprocessor is the AVR ATmega128. We implemented hardware to convert the DTMF tone transmitted to the CDMA external modem to the 4-bits signal and output 4-bits to AVR microprocessor-based control board. We connected a pin of the DTMF receiver to the INT 4 pin of the AVR microprocessor to enable a rising-edge interrupt to be generated in the pin of the DTMF receiver. If the control board detects the INT 4, it executes the interrupt handler code. This interrupt handler read the 4-bits of PORTF connected to Q1, Q2, Q3, Q4 of DTMF receiver. The interrupt handler calls the special functions to put the already defined PWM to the mobile robot's motors. The mobile phone keypad buttons functions are depicted in Figure 7. The software code that we implement the functions in the AVR control board is shown in Figure 8. The 2, 4, 5, 6, 8 buttons of the mobile phone indicate the action of the mobile robot. The 0, *, # buttons change the speed of the robot's movement. Once the user's mobile phone is connected to the mobile robot through a voice call, the mobile robot movement depends on the buttons the user pushes. For example, if the user pushes the '2' button, the mobile robot goes forward as middle speed in current position. If the user Pushes the '8' button, the mobile robot reverses at the middle speed in the current position. When the user pushes the buttons related to speed in the state that the mobile robot goes forward or back, the mobile robot continues to move in the same direction with the speed corresponding to the pushed button. If the user pushes the '5', the mobile robot stops. If user pushes 4' 'or '6' 'in the stopped state, the mobile robot rotates to the direction corresponding to pushed button. If the user is about to stop to rotate the mobile robot, the user may push the '5'. Using this method, the mobile phone user can control the mobile robot using a mobile phone.


```
interrupt [EXT_INT4] void ext_int4_isr(void)
{
      unsigned int dtmf;
      char str[16];
      dtmf = PINF;
      dtmf = dtmf & 0x0f;

        switch(dtmf)
        {

                case 2:
                        Right_DCMotor_Speed(3500);
                        Left_DCMotor_Speed(3500);
                        direction_flag = 0;
                        start_flag = 1;
                        break;

                case 8:
                        Right_DCMotor_Speed(2500);
                        Left_DCMotor_Speed(2500);
                        direction_flag = 1;
                        start_flag = 1;
                        break;

                case 5:
                        TIMSK &= ~(0x80);
                        DCMotor_Straight(Stop);
                        direction_flag = 0;
                        start_flag = 0;
                        break;


                case 4:
                        Right_DCMotor_Speed(3250);
                        Left_DCMotor_Speed(2650);
                        start_flag = 1;
                        break;


                case 6:
                        Right_DCMotor_Speed(2650);
                        Left_DCMotor_Speed(3250);
                        start_flag = 1;
                        break;

                        ...
```

Fig. 7. The control program code for received DTMF tone.

VI. APPLICATIONS

This setup with a little modification can be used in the following applications.

1) It can Support to medical services
2) In a pitfall Environments
3) Construction and demolishing
4) Wireless Robot control
5) Assistance to handicapped or elderly people
6) Theft intimation
7) It can be used as a Remote Switches
8) Reporting during car accidents

VII. CONCLUSION AND FUTURE WORKS

This paper presented a method to control a robot using the DTMF tone generated when the user press the keypad buttons of a mobile phone connected to the remote mobile robot. This control mode uses commercial mobile communication networks as the way of data transmission. We can control the mobile robot stably. This enables the user to control the mobile robot through out the working period by sending the mobile phone DTMF tone. Users can easily control the mobile robot using the mobile phone keypad, a user-friendly device. This system was implemented in the 2G mobile communication network, so video data cannot be obtained Future work will research the robot control system in the 3G mobile communication networks. This will eventually facilitate controlling the remote robot, using the DTMF of mobile phone with video data from the remote mobile robot's camera.

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