ICMIEE18-307

Design & Fabrication of Low Cost GSM Based Wireless Controlled Robot

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ABSTRACT
Many projects are taking place based on design & fabrications of low cost Robots with GSM-based communication system. This paper represents a simplified form of a robot which can be operated from a long distance using DTMF Technology. In this project a four-wheeled platform is made, where a position is created to mount a mobile phone to do real-time video through calling from user's mobile and rotate it up to 180-degree angle. In the front side, two robotic arms are mounted which is controlled by three motors for pick and place operation. We present a whole structure whereby the GSM network can control a mobile robot including Real-time video recording by only a call from user mobile. This paper introduces the steering mechanism which is engaged with the front wheels of the robot to ensure left, right, forward and backward movement of the robot. It can be a low-cost solution for industrial, rescue and surveillance related applications.

Keywords: Design Prototype, Tele-operated control, Extraction arm system, video capturing, Low Cost.

1. Introduction

General-purpose autonomous robots can perform a variety of functions independently [1]. An example of a mobile robot that is used commonly today is the Automated Guided Vehicle (AGV) [2]. An AGV is a mobile robot that follows markers or wires in the floor, or uses vision or lasers. Mobile robots are also found in industry, military and security environments.A demo model of the robot is structured which is small in size and easily movable to any area to serve rescue operation where a human can't reach. The corporation and robot can be managed by a remote coordinator, who is located in a remote place outside of the area [3]. This robotics system is fitted with a Global System for Mobile Communication (GSM) so it can be controlled from a far distance. A mobile camera is inflicted on the top of four-wheeled platform, so it can act as an eye for the robot. By using this appropriate perception equipment, the GSM-based robot can localize itself and also sense a surrounding. A simple, lightweight and efficient extraction system is included in this robot. The main functions of this robot are to monitor the specific area and to extract the obstacle in the way. The software interface protocol of this robot is identical with the embedded system on AVR Microcontroller. This robot is based on the same control system using Dual Tone Multi-Frequency system (DTMF).

2. Working Principle

The robot hardware system can be operated remotely without direct visual and auditory access to the hardware. Data and video originating from the robot during monitoring can be used to operate it. According to the signal from the GSM module, the microcontroller operates the robot. The motor drive runs by the signal of a microcontroller. This robot is a wireless GSM-based system which can be operated from any corner of the world where networking system available [4,5]. But this project has some limitations. It can't run perfectly on a rough surface and hence not waterproof, so cannot work in water. It's also not efficient in a dark environment.

3.Flow chart

MCU processor provides instruction to motor drivers and servo motor according to the information of Cell phone detector circuit when a particular key of the Cell phone is pressed according to the inputted program. The passed signal through pressed mobile key decides movement of platform, camera, and gripper.

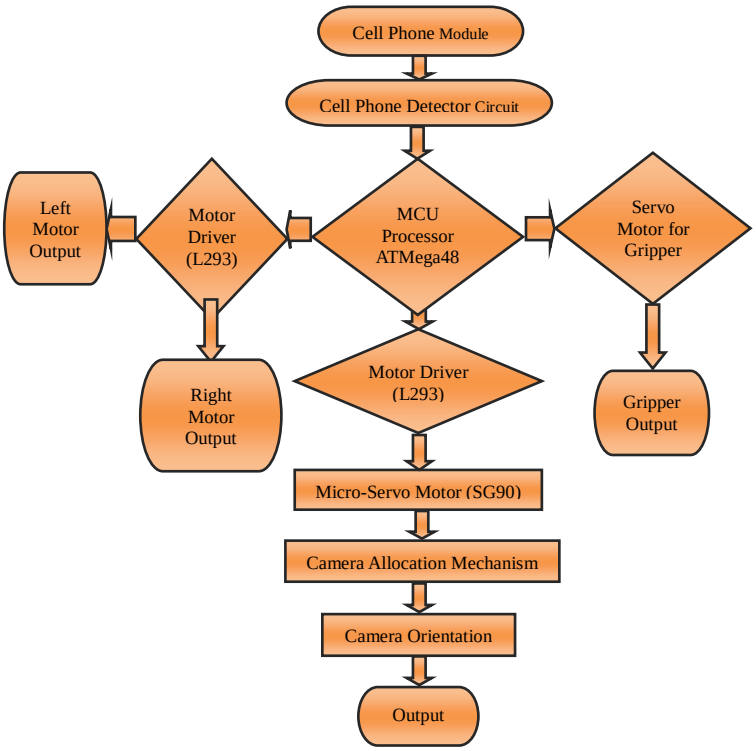

Fig 1: Operation Cycle of Robotic System

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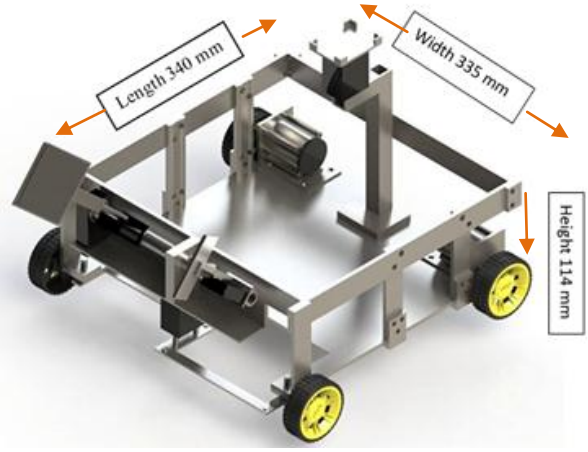

Fig 2: Proposed Design for Robot(340*335*114mm)

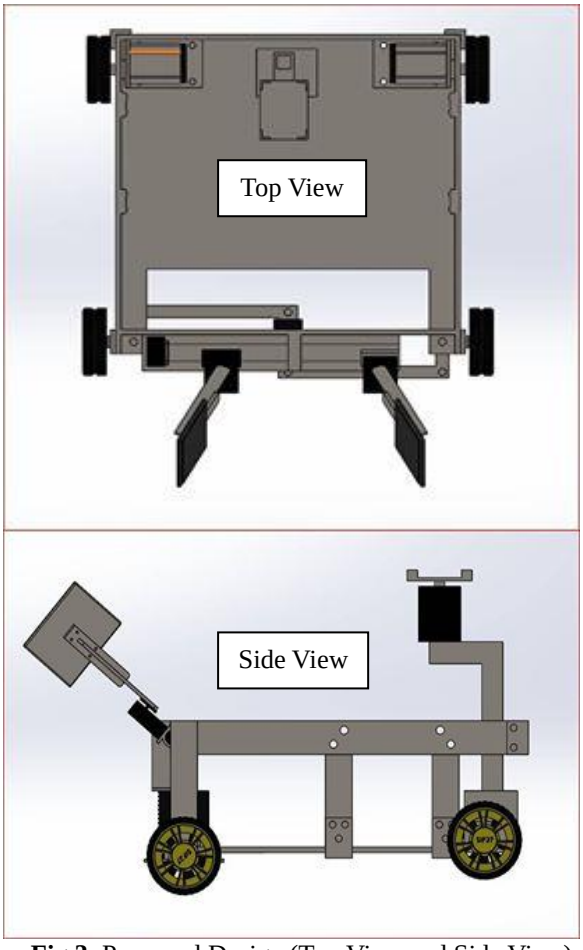

Fig 3: Proposed Design (Top View and Side View)

4. Project Overview

The design procedure mainly focused to keep the robot simple so that the risk can be reduced and reliability can be increased. A simple design system is easy to implement. It is also helpful for having a good operational system. Since the team had multiple solutions for driving different subsystems, a preference list for solutions was made. Reduction through trial and error method is the basis for solutions elimination process.

Table 1: Design Consideration Parameters:

Parameters	Expected Value	Margin
Weight	2kg	10%
Dimension	340*335*114mm	15%
Torque	Motor-1>SG5010 Motor-2>SG90 Motor -3	11.00kg-cm 1.80kg-cm 20.00kg-cm
Control Functionality	Artificial intelligence	
Cost	150$	10%

4.1Design and Fabrication

Estimating the proper resource for the project was done in the initial phase of the design. Since the project was divided into different subgroup design margin for each subgroup were defined. Margins have been primarily established from an initial design. Design margin for the design consideration parameters are shown in table 1 above.

Architecting the system is a major requirement for functional analysis and design process. System architecture gives the hierarchy of the system that helped to define deliverables for different subgroups. The GSM-based robotic system is comprised of three main mechanical parts: the drive system, the extraction arm system and camera allocation system which are controlled remotely using control circuit through a GSM-based communication. The robotic system can be divided into several subsystems which are built separately [6].

The following are the key components of the robotic system hardware:

1. Structural Frame
2. Drive System
3. Excavating Arms System
4. Camera allocation System
5. Controls System
6. Power Supply

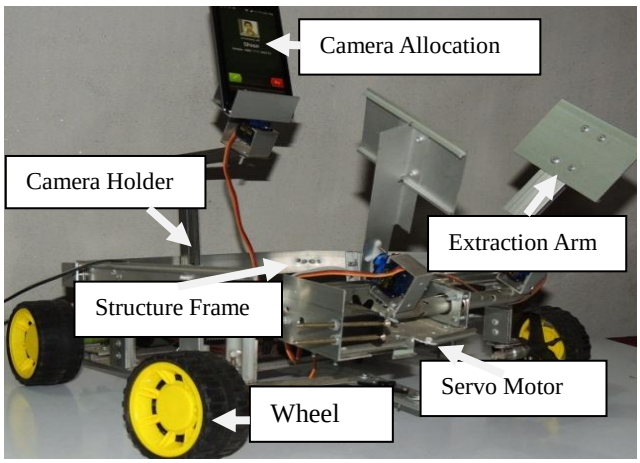

Fig 4: Structure and Frame of Robotic System

4.1.1 Frame Structure System

The frame of the robot is made of aluminum bar almost. The (340*335*114) mm frame has a rectangular shape including a cage into it to hold the battery, circuitry, GSM receiver and a camera stand on the top of the cage which is made by mild steel square bar That's why 3G video calling can come in handy in this system and a steering system in the front of the cage. Also, a hand gripper stand is built up which can hold the extraction system rigidly. Therewith, integration of the drive system by using front wheel mechanism assists the robotic system to move left, right, front and back standing in the same position.

4.1.2 Drive System

The whole robot is driven by high efficient DC gear motor which is directly coupled with the rear wheel. There is no differential speed mechanism in this robot but we can run this robot at 360 degrees by steering system which is driven by a high torque servo motor. We can easily move the robot in the back and forth direction by reversing the motor. We can also control the speed of the robot by increasing or decreasing the current flow through the DC gear motor.

4.1.3 Extraction Arm System

The extraction arm system consists a pair of micro-servo SG90 conduct pair of rigid arms which are made by an aluminum bar. These arms allow to essence different kind and size of objects which are may be malignant or nonmalignant. The pair of micro-servo aids the extraction arm system to grip the Object rigidly. And another servo (model-SG90) assists the extraction arm system for up and down movement. This servo (torque: 11 kg-cm) is highly efficient to carry heavy weight safely.

4.1.4 Camera Allocation System:

The camera allocation subsystem is built upon the camera stand which is made of mild steel and aluminum. There is a special arrangement on the stand so that the camera can monitor the lower front side and upper back side. That's why the camera stand is kept about an angle of 50 degrees with the horizontal. The camera can rotate by the wish of an operator when it is needed which is controlled by a servo motor.

4.1.5 Control System:

The control subsystem consists of different components. The main components are the system control circuit and the communication control circuit. The main functionalities of system control circuit (SCC) include wheel-extraction arm–camera allocation driving circuit, GSM-based communication module, power calculation module, data feedback system, emergency stop button etc. Microcontroller ATMEGA48PA used in this control system. In this system, a phone which supports 3G video calling is allocated in the robot and another phone is used for calling. When two phones are connected by calling then by means of DTMF technology we get signal in the communication circuit.Here MT-8870 is a DTMF

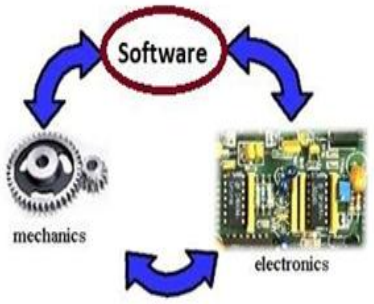

Fig 5: Control System of Robotic System

Receiver is integrated.That integrates both bands split filter and decoder functions into a single 18-pin DIP or SOIC package. Its filter section uses switched capacitor technology for both the high and low group filters and for dial tone rejection. Its decoder uses digital counting techniques to detect and decode all 16 DTMF tone pairs into a 4-bit code. The external component count is minimized by the provision of an on-chip differential input amplifier, clock generator, and latched tristate interface bus. Minimal external components required includes a low-cost 3.579545 MHz color burst crystal, a timing resistor, and a timing capacitor. The filter section is used for separation of the low-group and high group tones and it is achieved by applying the DTMF signal to the inputs of two sixth order switched capacitor band pass filters, the bandwidths of which corresponds to the low and high group frequencies. This is converted with voltage. And this voltage act as an input signal for system control circuit.By the help of algorithms,the robotic system can get different movement [7].

4.1.6. Power System:

The power supply is to support 9 high torque 12V DC motor and 1 high torque 24V HUB motor. The 9 high torque motors require almost 12A of current in full load. Two batteries of 12V which can supply a maximum of 18A are used in the series connection. The SCC and KINECT powering module have been made using a different battery because of the noise occurred by the high torque DC motors which can damage the control circuit.

5.Description of GSM System and DTMF Technology:

Over 200 GSM networks (including DCS1800 and PCS1900) are operational in 110 countries around the world. At the beginning of 1994, there were 1.3 million subscribers worldwide [8], which had grown to more than 55 million by October 1997. GSM (Global System for Mobile communication) is a digital mobile telephony system. GSM uses a variation of time division multiple access (TDMA) and is the most widely used of the three digital wireless telephony technologies (TDMA, GSM, and CDMA).GSM digitizes and compresses data, then

sends it down a channel with two other streams of user data, each in its own time slot[9-11].

DTMF (dual tone multi-frequency) is the signal that we generate when we press an ordinary telephone's touch keys. DTMF has generally replaced loop disconnect ("pulse") dialing. With DTMF, each key we press on your phone generates two tons of specific frequencies. So that a voice can't imitate the tones, one tone is generated from a high-frequency group of tones and the other from a low-frequency group. This technology is conducted by the MT8870DE chip which is a complete DTMF receiver both the band split filter and digital decoder function. We also include HD74LS04P hex inverter which aids this technology [12].3G networks, short for third Generation, is the third generation of mobile telecommunications technology [13]. 3G finds application in wireless voice telephony, mobile Internet access, fixed wireless Internet access, video calls and mobile TV. 3G networks can be used to have the visual feedback of real time when it will be available everywhere in Bangladesh.

5. Software Interface and Circuit Diagram:

WinAVR AVR-GCC has been used for programming language writing .the simulation software named Proteus 7 professional has been used on basis of our required algorithm. Finally, the code is burned by AvrPal.Net software. The circuit which is made by simulation software is given below:

The major components used in the above circuit arethe microcontroller, motor driver and robot. Here atATMEGA48PA microcontroller is used and it requires a power supply of positive 5V DC. In order to provide regulated 5V DC voltage to the controller, use 7805 power supply circuit. Here two 12V batteries are used, one is for giving the supply to the circuit and other is to run the DC motors.

RA0, RA1,RA2,RA3 pins of MT8870DE are connected to the PD0,PD2,PD3,PD4 pins of ATMEGA48PA Microcontroller.PB0, PB1, PB2 and PB3 pins of the controller are connected to the l293D input pins and these pins are used to control the two DC motors. The operating voltage of this IC is 5V. Using this IC we can operate the 2 DC motors with a voltage ranging from 4.5 to 36V. We need to apply the motors supply at the 8th pin of l293D.

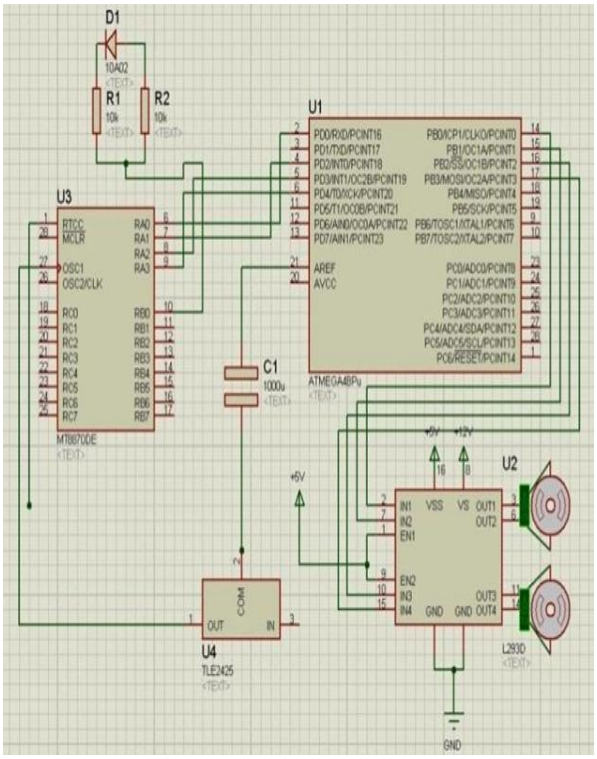

Fig 6: Circuit Diagram of Robotic System

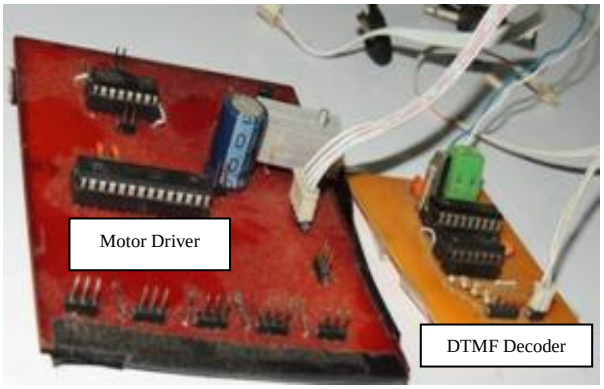

Fig 7: Electronics Hardware of Robotic System

6. Robot Arm Torque Analysis

According to the initially taken measures the exerted force value is calculated. And Torque excreted in each hand of gripper is measured. The following graph has representation Torque Vs Angle.

Torque (T) is defined as a turning or twisting “force” and is calculated using the following relation: The force (F) acts at a length (L) from a pivot point. In a vertical plane, the force acting on an object (causing it to fall) is the acceleration due to gravity (g = 9.81m/s2) multiplied by its mass: The force above is also considered the object's weight (W). The torque required to hold a mass at a given distance from a pivot. Load Weight, M=0.5 kg
Length of Extraction Arm, L= 6 inch = 0.1524m

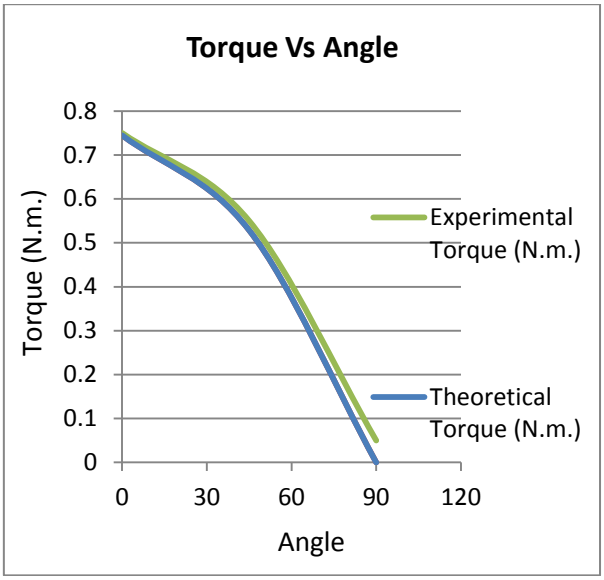

Fig 8: Torque Vs Angle Graph

Table 2: Torque Analysis Parameters

Angle	Theoretical Torque (N.m.)	Experimental Torque (N.m.)	Deviation (%)
0	0.7447	0.75	0.53 %
45	0.5285	0.55	2.15 %
90	0	0.05	5 %

7. Testing, Validation, and Verification

During the design implementation process, each subsystem has been verified multiple times to make sure the implemented design is correct and the developed system. Dimensions and weights of the different components have been noted down during the development process so that the total system does not exceed the maximum allowable weight or dimension. Among other requirements that have been verified after the integration of the total system includes:

- The communication method follows the system does not employ any physical process.
- Extraction arm system works perfectly but a suspension could make the system more efficient;
- The drive system works perfectly. It can move 360 degrees easily
- Video calling of a 3G network can come in handy
- The control circuit is equipped with the emergency stop button so that all the power can be turned off instantly.

8. Conclusion

This paper presents the GSM-based simple demo structure of the robotic system which can be used in different operations. The robots have functionalities for searching victims, investigating the dangerous area, bomb defusing, security purpose etc. We have fabricated the estimated set up within a low budget and tried to achieve the desired performance of the overall system. The principle of the project is easy to understand, low in cost and gives places for further modifications to bear a lot of fruits in the mass applications.

9.Acknowledgement

We are very much grateful to Robotic Society and especially to Dr. Md. Rokunuzzaman and Dr. Md. Emdadul Hoque Dept of Mechanical Engineering of RUET. He has given full support on this project and encouraged us. Since without 3G network our project could not be completed, so we are grateful to Teletalk 3G.

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