DESIGN & IMPLEMENTATION OF AUTOMATIC STAIRCASE CLIMBING PLATFORM

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ABSTRACT

In today's life, technology related with robots plays a key role in many fields because they are used to operate in dangerous and urban environments, for different operations. Some of the E robots are designed to operate only on natural terrains, but it can also use for rough terrains and artificial environments including stairways. Our previous paper represents the mechanism of how will robot climb the stairs carrying load. [1] Its mechanical design is suitable with front wheel and back wheel driven by DC motor for climbing stairs. Although many robots had been introduced earlier have some problems like need of special device or software to control the robot etc. This paper suggests an advance method for robotics control using the mechanical links. Until recent years, the stair climbing robots are designed with huge hardware and robots are furnished with chain roller to climb stairs or to move on a flat surface. [1] The mechanical design of the this robot contains the fixed and flexible links of wheel legs instead of chain roller moves relative to each other to generate high friction with stairs.

Keyword: - *ATMEGA 32, platform , Bluetooth Robo Controller, wheels*

1. INTRODUCTION

The old constructions in the heavily crowded areas of cities do not have lifts. The task of climbing stairs is a major challenge for physically handicapped people or for elderly people because of the age-dependent impaired mobility.

Also transferring a material from the ground floor to the upper floors is another challenge even for a normal person living in old and high buildings which do not have lifts. Hence, a platform for climbing steps of the stairs is a major requirement at least in underdeveloped regions.

The platform serves the purpose of a chassis. Different versions, such as staircase-climbing wheelchair or staircase-climbing trolley for material transferring, staircase climbing stretcher can be derived depending on the object built on the platform. [5]

These platforms can also be useful in the buildings with lifts, particularly when power backup is unavailable. Several rehabilitation devices are currently available or in development.

This platform is controlled by using microcontroller ATMEGA 32. The body of the model is being prepared mechanically and electronic components are being selected to be suitable for the task.

The movement of this model is controlled by controlling the directions by DC motor. (Forward, reverse, right and left). [5]
The Stair-climbing Robot will be controlled by the Bluetooth application which is available openly.

2. DESIGN

Design consists of mathematical calculations, technical information, and creativity for development of certain different mechanism with maximum economy and efficiency. Hence careful design approach has to be acquired. The full design work has been split into two parts.
2.1 System Design
2.2 Mechanical Design

2.1 System Design:

The system design is a process where the physical and logical architecture is defined. We are mainly focusing on the concept of compact design which will require less space.
The block diagram shown in Figure (1) shows the main
design of the stair climbing platform which consists of:
Power supply, DC motors, LCD. The main part of the robot is ATMEGA32APU1018. The various system components are explained below:

- ATMEGA 32: It is the heart of the system. It is a 32bit programmable controller used for controlling the operations of the system.
- Sensors: IR sensors are used to sense the motion of robotic platform.
- Motor Driver: L293D motor driver is used to drive the DC motors.
- DC Motor: The DC motor of low RPM and high torque is used.

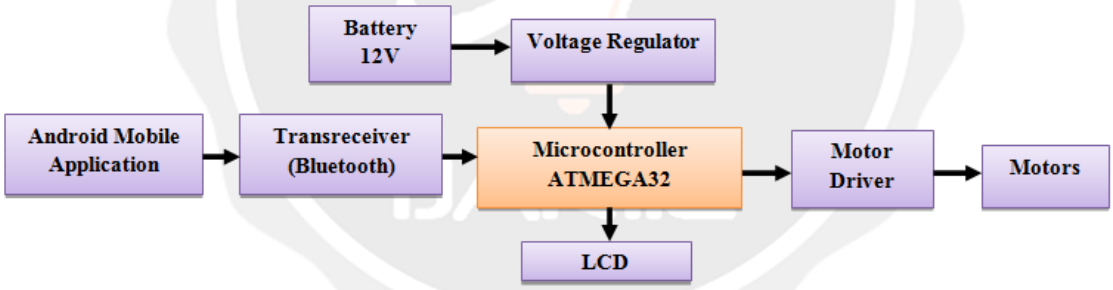

Fig -1: Block Diagram of Transreceiver Section

2.2 Electromechanical Design:

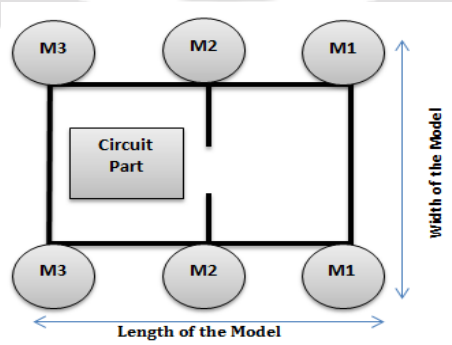

Fig- 2: Rough structure of Robot (A pair of motors M2 and motors M3 are aligned by conveyer belt)

Mechanical design is very important from the view of designer as whole success of project depends on the correct design analysis of the problem. Designer should have an adequate knowledge about physical properties of material, load stresses and failure.

Selection of factors of safety to find working or design stress is another important step in design of working dimensions of machine elements. The correction in the theoretical stress values are to be made according in the kind of loads, shape of parts & service requirements Selection of material should be made according to the condition of loading shapes of products environment conditions & desirable properties of material. [4]

The robot has length and width respectively, as shown in Fig. 3.

Fig- 3: Top view of Robot

2.2.1 Wheels and its Dimensions:

The robot uses 6 tracked wheels, the specification of which is given below.

- 6.1 mm hole
- Diameter 90 mm
- Made from high quality virgin Nylon.
- Hole on shank for screw.
- Comes with screw to lock on standard motor shaft of 6 mm.

The rubber conveyer belt is wounded on the tracked wheels in order provide them a proper alignment. Fig. 5 and 6 shows the used tracked wheels and conveyer belt.

Fig-4: Tracked wheels with conveyer belt arrangement

Fig-5: Wheels and conveyer belt assembly of robot

2.2.2 Robot movement process:

The movement of the robot is basically depends on its front and rear wheels. At front side we have used a pair of two wheels [1] and a conveyer belt is wounded across two wheels on both sides in order to provide a better provision to climb stairs.

The rare wheel pair is again wounded with conveyer belt but it is just to handle the load while stair climbing.

2.2.3 More Mechanical parts:

Fiber and wood are the other materials used for designing a model. The case of the model is made up of fiber sheets. Cutting these fiber sheets in a required shape and then after we have used it.

Plastic wheels and conveyer belt is used for climbing always down to the body.

60 R.P.M. DC motors are used for which four relays are used to drive the extra load of the robot.

3. MATHEMATICAL MODELLING:

The base and height calculations of the stair model is done with the help of mathematical concept of Calculus of Variation

We have taken base of the stair as (3 inches) and height of the stair as (2 inches).

So it will be calculated theoretically by the calculations as given below.

Base= 3" ……. (1)

Height=2" …… (2)

Let the function $y=f(x) = x^2+1$ …….. (3)

Here y is a function of x

So y= ratio of stair base and height

x= variable used for stair base and height

i.e the value of stair base and height varies with x

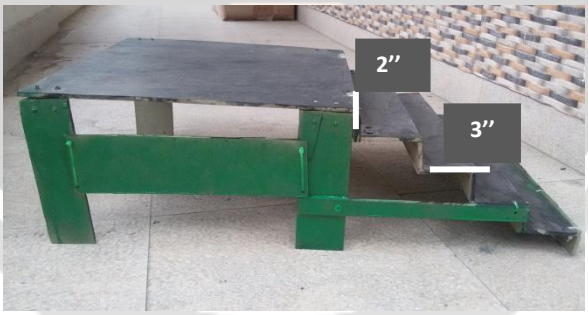

Fig-6: Stair model

Then by using Calculus of Variation,

$F\{f(x)\}= \int_{x0}^{x1} \sqrt{(1 + (y')^2)}\, dx$

$(y') = 2x$

$(y')^2 = 4x^2$ …… (4)

Now from Equation 4,

$= \int_0^1 \sqrt{(1 + 4x^2)}\, dx$

Limits are used as 0 to 1 because we are considering stair 1 first. So its limit will be from 0 to 1 only.

$$=\int_0^1 \sqrt{(1+4x^2)}^{\frac{1}{2}}\, dx$$

As we have taken the height to base ratio of stair to be 2:3
Therefore, 2x=3x …… (5)

So, y= $\frac{3}{2}$ x and y' = $\frac{3}{2}$ ….. (6)

Therefore,

$$=\int_0^1 \sqrt{(1+\left(\frac{3}{2}\right)^2)}\, dx$$

$$=\int_0^1 \sqrt{\frac{13}{4}}\, dx$$

$$=\sqrt{\frac{13}{4}}\,[x]_0^1$$

$$=\sqrt{\frac{13}{4}}=\frac{\sqrt{13}}{2}$$

=1.80 approx. to 2 i.e. height

This it is proved that by considering the ratio of base and height we can theoretically find the value taken.

4. SOFTWARE TOOLS

4.1 Embedded C program:

Embedded C is nothing but a subset of C which is compatible with ATMEGA 32 very efficiently. [5]
It is very easiest for the programmer to develop applications of embedded systems using this.

4.2 Proteus Software:

Proteus combines ease of use with powerful features to help us design, test and layout professional PCBs.
Proteus PCB design [1] seamlessly combines Schematic capture and PCB layout to provide a powerful, integrated and easy to use suit of tools for professional design.
So, it is used to design circuit diagram and PCB layout.

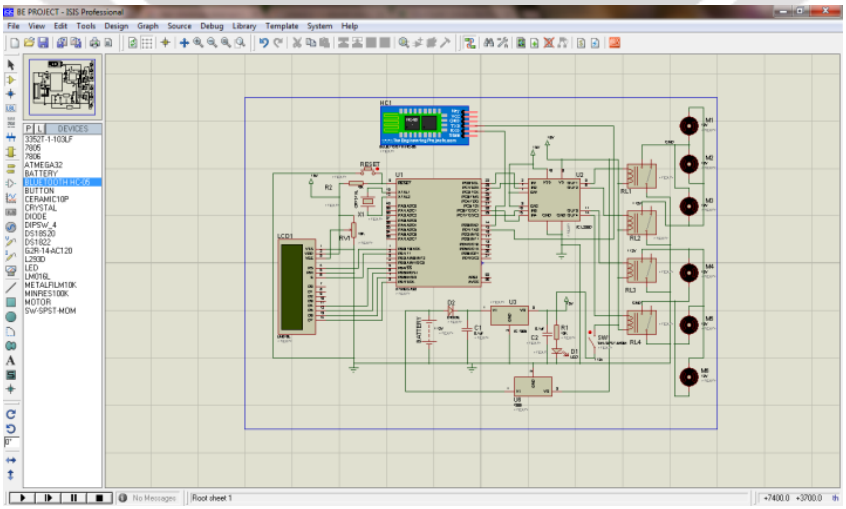

Fig-7: Overview of Proteus software

4.3 AVR studio:

AVR Studio is a software development environment developed by Atmel with an editor, simulator, programmer, etc. It comes with its own integrated C compiler the AVR GNU C Compiler (GCC).
As such you do not need a third party C compiler. [1] It provides a single environment to develop programs for both the 8-bits, 32-bits microcontrollers. So, we are using it to simulate programs.

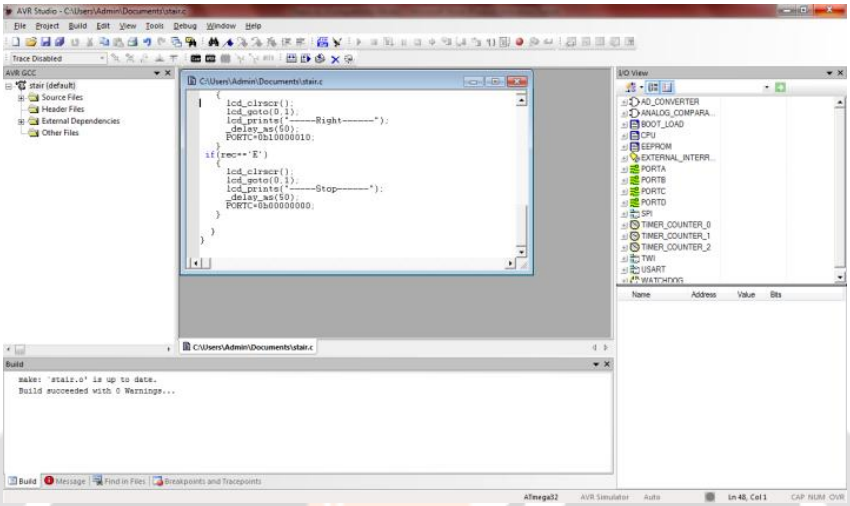

Fig-8: Coding simulation using AVR Studio software

5. PROGRAM FLOW AND CONTROLS:

5.1 Flowchart:

The flowchart of the programming flow is as given below.

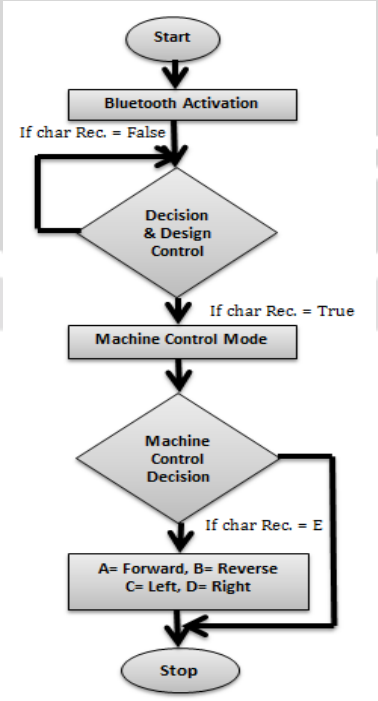

Fig-9: Flowchart

5.2 Controls:

The DC motor control is as explained below in table.

Sr. no	D0	D1	D2	D3	D4	D5	D6	D7	State of Motor
1.	1	0	0	0	0	0	0	1	Forward
2.	0	1	0	0	0	0	1	0	Reverse
3.	0	1	0	0	0	0	0	1	Left
4.	1	0	0	0	0	0	1	0	Right
5.	0	0	0	0	0	0	0	0	Stop

Table-1: DC motor controls

DC motors are controlled by using a Bluetooth application named as "Bluetooth Robo Control".

Fig-10: Bluetooth Robo Control Application overview

First of all the app has the Bluetooth module HC-05 so the firstly we have to interface this application with our controller by using Flash Magic software. The range of Bluetooth module is within 30 meters.

STEPS to use Application:

1. Switch on the Bluetooth of the android mobile to access the application.
2. Open the application.
3. Click on leftmost corner icon to search for the Bluetooth module HC-05. (indicated by 'Select Devices >')
4. Select the Bluetooth module HC-05.
5. After the message displayed Device Connected successfully we can use the application.

Table below shows the movement direction.

Key status	Movement Direction
UP	**Forward**
DOWN	**Reverse**
LEFT	**Left**
RIGHT	**Right**
CENTRE	**Stop**

Table-2: DC motor controls by using application

6. RESULTS:

Thus the results are found out and the figure below shows the complete module.

Fig-11(a): Forward direction

Fig-11(b): Robot climbing 1st step in Forward direction

Fig-11(c): Robot climbing 2nd step in Forward direction

Fig-11(d): Robot climbing 3rd step in Forward direction

Fig-11(e): Robot climbing 4th step in Forward direction

Fig-11(f): Robot climbing final flat step in Forward direction

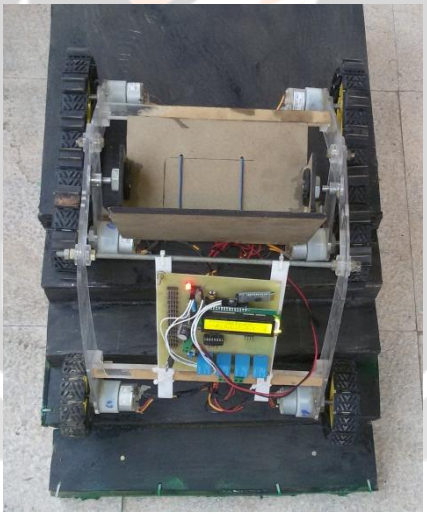

Fig-11(g): Robot climbing in Forward direction (TOP VIEW)

Fig-12(a): Reverse direction

Fig-12(b): Robot coming back in Reverse direction

Fig-13(a): Right direction

Fig-13(b): Robot taking Right turn

Fig-14(a): Left direction

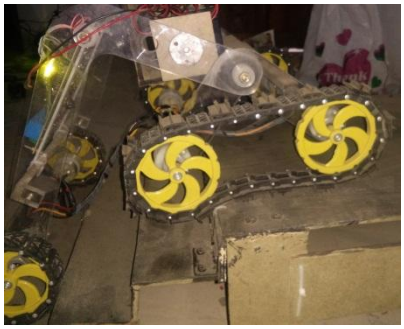

Fig-14(b): Robot taking Left turn

Fig-15(a): Stop mode

Fig-15(b): Robot acting in stop mode

7. CONCLUSIONS:

This robot is completed now and it can be always used for stair climbing and also on the flat surface.

To give a brief summary, the main purpose of this paper is to design a robot which can climb the stairs without manual help.

ATMEGA32APU1018 is used to control all the operations of the robot. The overall system worked successfully. First of all we checked the operation of the robot by placing switches on both ends of the stairs but after that it is come to know that by using switches the module will not be wireless one, so we changed our mind and moved to a concept where we used application to control the DC motors.

Now, this goes wirelessly and successfully our concept is implemented.

According to our problem solution, In villages there is need of elevators but they are not available in most cases, so there is an demanding need for some sort of solution for this problem. This project will definitely be the complete solution, so it will definitely improve the conditions up to a certain extent.

The main objective of the present project is to provide a module which can also solve the problem of disable people to climb them up and down is satisfied.

The advantage which achieved from our Idea is Disabled people can climb stairs without manual help if chair is fixed on platform, lifting patients from upper floor to ground floor in case lift is not available or electricity supply is cut off because of which lift can't be worked. This study is dedicated to schools, colleges, offices, and tall buildings.

8. FUTURE SCOPE

A robotic arm can be designed and connect to the robot which will itself take the things in its path and the things nearby it and put it in its trolley while climbing upstairs or downstairs.

Also it can be used for rescue purpose in military services.

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