Automatic Stair Climbing Robot

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Abstract. Nowadays, robots are used to lighten man's job and to reduce workload or burden of a human being. The stair climbing robots are used to climb the stairs for different purposes such as in military and in rescue operation. This project is a challenge for the student to invent a robot which can climb a stair automatically and detect a black line to stop immediately. The main component for this robot are PIC 16F877A , DC motor and auto calibrating line sensor besides the software part such as programming using LD MICRO and simulation using PROTEUS. All the codings are burned in PIC 16F877A to make the robot move and stop automatically.

Introduction

The interest in development of climbing robots has grown rapidly in recent years. Climbing robots are very significant because it can be adopted in a variety of applications such as maintenance, building, inspection and safety, mainly in the process and construction industries [1]. Stairways and steps are omnipresent in man-made environment. Designed to easily bridge large vertical distances for humans, stairs represent a serious challenge to vehicles and robots. In order for robots to operate efficiently in urban environment, this challenge needs to be addressed. In many current applications mobile robot is still tele -operated with only limited autonomy. Climbing stairs for example is required in searching and rescuing missions in urban areas and very demanding in human operator.

Usually the robot maneuvers outside the field of view of the operators, forcing them to rely only on feedback from the robot's camera. The latter is usually mounted very close to the ground, has a narrow field of view, and the returned images are often blurred due to the robot's highly dynamic motion. This greatly impairs the operator's perception of the vehicle's current spatial orientation. Combined with the latency in data transmission and the robot's high slippage on the stair edges, this can result in inaccurate and slow stair climbing, collisions with the stair walls, and even in toppling of the vehicle. It is therefore desirable to endow a robot with autonomous *stair climbing capabilities*, thus enable for faster, safer, and more precise operation while at the same time reducing the user load [2].

The challenge

This project is done for the final semester students in Electrical & Engineering Department. Their challenge is to develop a robot which can climb a stair automatically and stop immediately when it detects a black line at the end of the stair.

Related Work

Stair climbing robots can be carried out with different types of mechanisms such as wheeled robot, legged robot or tracked robot [3].

Wheeled Robots. Lawn and Shiatsu [4] present a stair-climbing wheelchair using two (forward and rear) articulated wheel clusters attached to movable appendages. The robot is equipped with step-contact sensors, but relies on user steering and is thus only semi-autonomous.

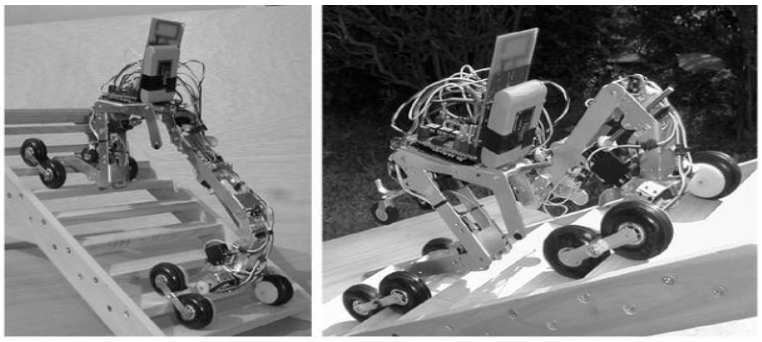

Figure 1: Wheeled Robots

Legged Robots. Figliolini and Ceccarelli [5] design a bipedal robot EP-WAR2, which uses electro pneumatic actuators and suction cups for locomotion. In order to climb stairs, the robot relies on an open-loop control algorithm implemented as a finite-state machine. The main limitation of the approach is that operating in a different staircase necessitates manual recalibration.

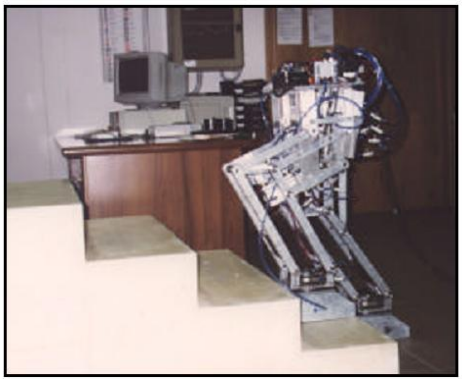

Figure 2: Legged robot

Tracked Robots. Tracked robots have larger ground contact surface than wheeled vehicles and are more stable than bipeds due to their low center of gravity. Liu et al. [6] derived the fundamental dynamics of the stair-climbing process for a tracked robotic element, analyzing the different phases of riser climbing, nose crossing, nose line climbing and the effects of grouser bars or cleats. The analysis is limited to 2D, and slippage, shocks, and intermittent loss of track-surface contact, phenomena that are commonly encountered during stair climbing.

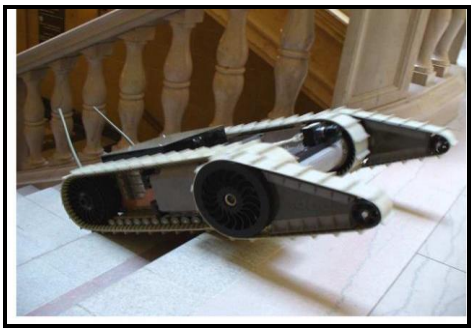

Figure 3: Tracked robot

For the purpose of this project, we have created a climbing stair wheeled robot. It will stop automatically when it detects a black line at the end of the stair.

Methodology

This project is divided into two sections which are software and hardware. There are two types of software that will be used in this project which is LD MICRO and PROTEUS. The hardware are PIC 16F877A, DC gear motor, auto calibrating line sensor and other components.

Software. LD MICRO is a software that allows us to create a source code to command the pic to do something automatically. This software is using an output and input to declare which pin low or high. This software can give command at pin input and output. We just select the pin we want to the input and pin to the output.

Proteus is software that can build the circuit diagram and do the simulation. It has many components such as diode, power supply, ground terminal, PIC and others.

Hardware. The main part for hardware is PIC 16F877A. It has 40 pin and each has its own function. The movement of the robot can be controlled using the PIC. It controls all the functions of the robot from its motor speed rotation to detecting .line.

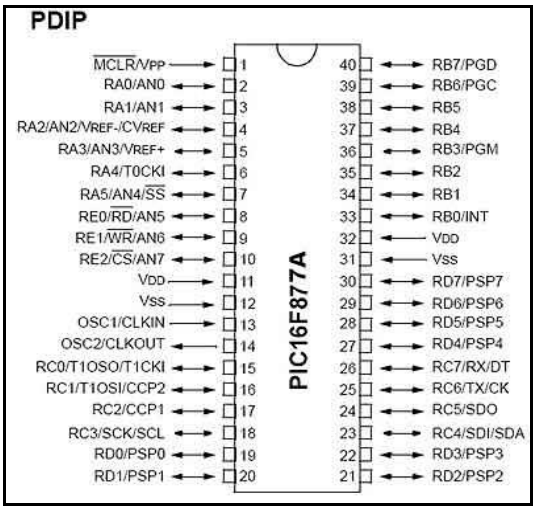

Figure 4: Structure of PIC 16f877a

Besides that we also use DC gear motor for wheels movement. The voltage nominal for our DC motor is 5V and we used 5 DC motor for our robot. There are many advantages of using DC motor and one of it is we can get enough power to make the robot to climb the ladder. The DC motor was attached with IC motor driver ULN2003 .

Other component used is crystal oscillator. Crystal is a circuit element commonly used in the clock, full name is called the crystal oscillator, crystal oscillator in the microcontroller the role of the system is very large, is a combination of MCU's internal circuitry, resulting in the need microcontroller clock frequency, single-chip implementation of all directives are built on this basis, the crystal clock frequency to provide higher speed.

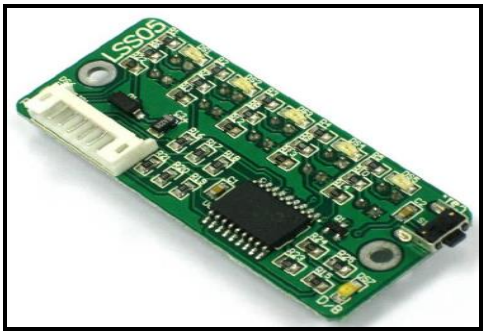

Figure 5: Auto Calibrating Line Sensor

Auto Calibrating line sensor is used in this project to detect a black line at the end of the stair. It comes with 5 pairs of IR transmitter and receiver, it can cover line detection of 1cm to 3cm wide, dark color or bright color line. By pressing 1, it will start "recognizing" the surface under it, calibrating the threshold between dark and bright. it takes 4 to 5 seconds only. Once, it is done and being stored in internal nonvolatile memory, it will still "recognize" the line though the power off and on again [9].

Mechanical Design

The mechanical design is using the PVC pipe as its body because it's cheap and effective. It is easy to bend and to be shaped so it can be designed freely.

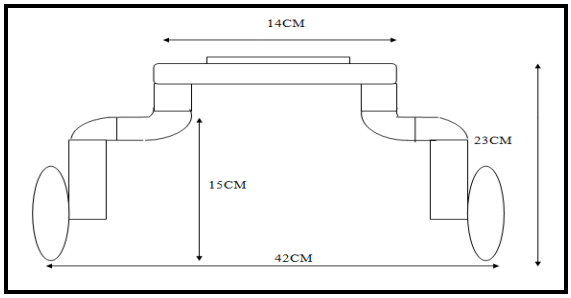

Figure 6: Front View of the Robot

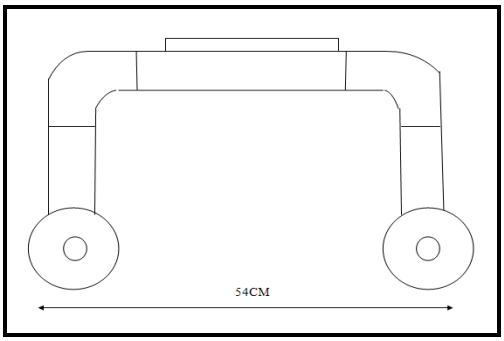

Figure 7: Side View of the Robot

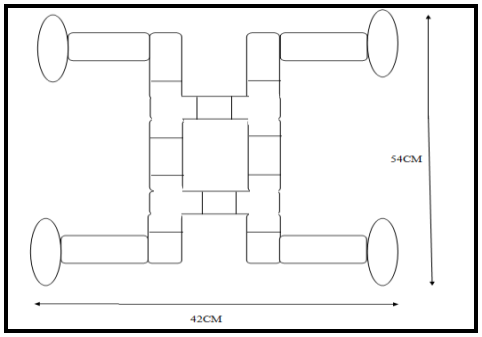

Figure 8: Top View of the Robot

Circuit Design

There are two types of circuit in this project. The first one is voltage supply circuit which converts 9V supply to 5V for PIC and motor driver. The second circuit is PIC circuit used to give the input for motor driver supply to move forward or stop.

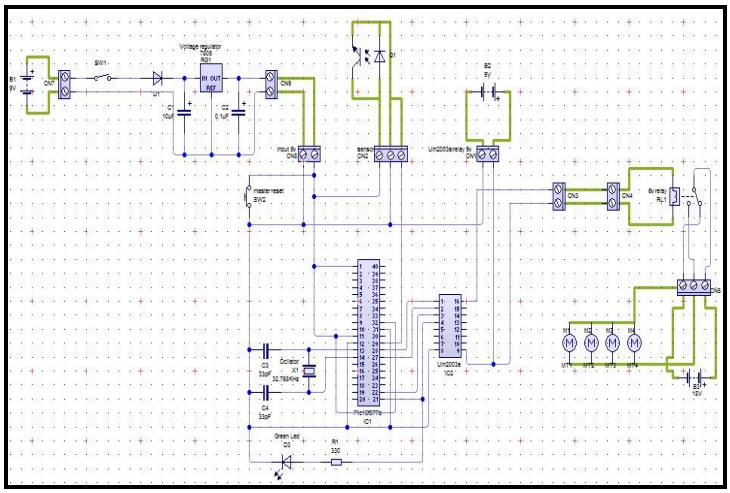

Figure 9: Circuit Design

Experimental Result

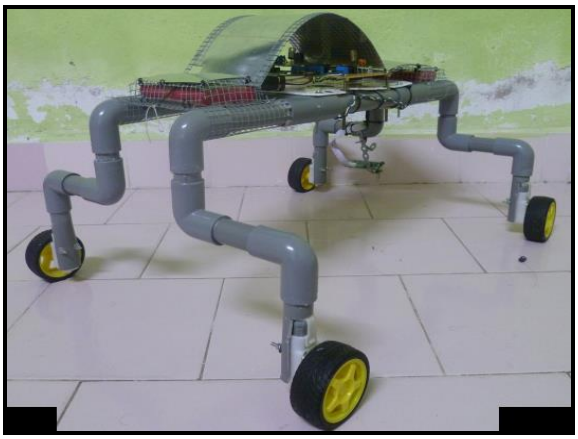

Figure 10: Prototype of the Robot

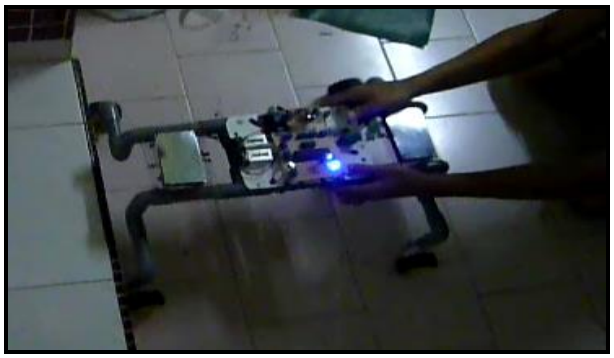

Figure 11: Robot is in Initial Position

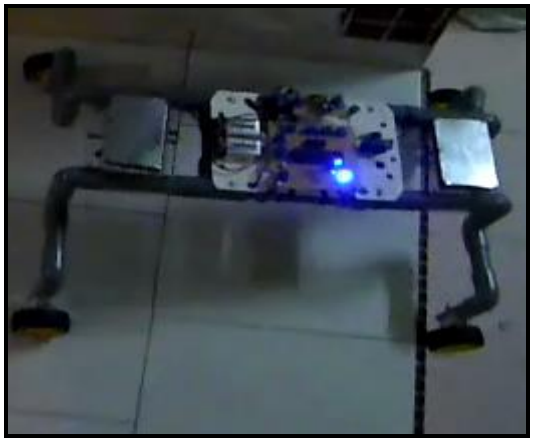

Figure 12: Robot Climbing the Stair

Figure 13: Robot Detects a Black Line and Stop Automatically

Conclusion & Future Scope

The advantages of developing the stair climbing robot is it able to climb the stair. However there are many more improvements that can be done as ensuring mechanism robot leg movements that are suitable for all types of stairs. Mechanical design can also be further enhanced by using better materials or add a camera to enable it to be used in disaster areas which cannot be access by humans.

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