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RESEARCH ARTICLE

Automation Based StairBOT for Security Application

B Kirubakaran[1], *K Baveena[2], M Keerthana[2], R Ramya[2]

[1]Assistant Professor, Department of ECE, N.S.N College of Engineering and Technology, Karur, India.

[2]Department of ECE, N.S.N College of Engineering and Technology, Karur, India.

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ABSTRACT

In the present scenario, application of robots plays an important role in many fields as they can be operated in hazardous and urban environments. Many robots are utilized to reduce the human effort in several areas. The stair climbing robot copes with stairs and terrain areas. But in security and rescue operations, they are not efficient due to their wheel structures like wheeled, legged and tracked type. To overcome this problem, an automation based stairBOT is developed. The wheel structure of the robots has tri-star wheel configuration. Web camera captures the pictures and videos of the affected areas, which further helps in rescue operations. Temperature, gas, smoke and metal sensors are used in robots to provide better performance of security operations.

Keywords: Automation, Microcontroller, Security purpose, Sensors, Tri-star wheel.

1. INTRODUCTION

Due to technological advances of robotics, handling natural and virtual atmospheres such as staircases and rough terrain areas becomes possible, which are the most known obstacles for the movement of robots [1]. StairBOTs are available in different designs and dimensions such as legged and wheeled configuration. It gives better performance in both legged and wheeled conceptual designs. The development of this design is carefully done with the basics of climbing stability, which minimizes the complexity range and becomes more practical. The wheeled robot is equipped with step sensors, but it relies on user steering. The legged robot depends on an open-loop control algorithm, which is implemented as a finite state machine. But it needs manual recalibration for different staircase. The robots are highly utilized in security and rescue operations. This work focuses on important parameters like energy consumption by minimizing the weight.

This paper describes about the development of an automation based stairBOT to handle critical situations that include urban disasters, explosions and artificial environments. It has a tri-star wheel configuration, which refers to a system of three wheels sandwiched between two Y frames. These wheels are arranged in a triangle pattern. StairBOT with automation is achieved using microcontroller that is connected along with PC. It totally controls the motion of the robot. In case of any obstacles or disturbances, it automatically detects using IR sensor. It comprises temperature and smoke sensor for fire detection. Gas sensor is used to sense the toxic and hazardous gases, and metal sensor is used for landmine detection. Rover takes a video of disaster areas using web camera. The area of automation includes various technologies like sensors, artificial intelligence, embedded systems and control units. Effective design parameter and experimental result of the stairBOT design are analyzed. Section 2 explains in detail about various robotic applications and control unit.

*Corresponding author. Tel.: +919080896492
Email address: baveenaksm97@gmail.com (K.Baveena)
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Section 3 focuses on its structural and constructional details and the obtained results are discussed. Section 4 concludes the article.

2. LITERATURE SURVEY

A wheel based robot with tusk, passive and protruded elements in front of it is developed, which can create an angle-of-attack when it climb stairs. It does not require additional active mechanisms. The structure is based on the geometrical relationship between the wheels and the stairs in each phase during the stair climb. PID controller has limitation of hall sensors [2]. The wireless robotic system is able to perform a specific task, which is controlled by a respective user, who is far apart. It uses joystick in input side to control movement of robot and potentiometer to control the speed of the robot [3]. Robot can move the obstacles up and down autonomously. It has two stage upslope cases without sensor feedback. If the edge is close to rover, then it moves away from the wall [4]. An adjustable mechanical staircase climbing robot is designed with front and back wheels driven by DC motor for climbing stairs. It is based on the geometrical interactions between the robot legs. Quasi static stability of the robot shows that the stability is usually maintained at unstable posture [5]. The robot is built to discover areas where people cannot reach. Here IR sensor, which is a trans-receiver device, is used to measure the step size of robot. The stair climbing robot has a capability to carry 10kg of weight. It is loaded by fire extinguisher cylinders to douse fire [6]. A search and rescue robot describes an automated system for obstacle recognition using 3D system to locate people in a disaster area. The robot has an acceleration sensor to automate its function on slopes and stairs [7]. Visual recognition of the robot has been developed to recognize the optimal route and position of the stairs [8]. Visual recognition and detection of the stairway are tracked down using Gabor filter [9] and fuzzy logic unit [10].

A stair climbing robot consists of five wheel and motor structure. The robot is built based on the fundamental flexibility and deformation. It is equipped with three sonars, which operates in a cooperative manner. The central body has circuitry and power source. It can be designed using aluminum bars because of its low weight which makes the robot more flexible [11]. Adaptive locomotion and reactive backbone joint controllers have distributed implementations [12]. An adjustable stair case climbing robot is designed to climb the stairs up and down according to the dimensions of the stairs. The robot comes to rest momentarily after each step. If the wheel touches the step, then the top wheel lifts the front part which further lifts the rear wheel [13]. An autonomous cross floor navigation system for stair climbing mobile robot using wireless sensors is designed. By using upward and forward looking camera, image based navigation is conducted. Robot can adjust and continue its motion based on wireless and vision sensor [14]. Caterpillar design has an ability to move on any places such as steps and holes, but it faces problem of poor ground contact, so that it produces noise and the wheel damages the floor on the run [15]. Hence it is mainly suitable to work in outdoor areas.

3. PROPOSED WORK

Figure 1 shows the block diagram for stair climbing robot. Microcontroller, the main part of the robot is powered by +5 V and +12 V supply for the stepper motor. The inputs are taken from temperature, metal and IR sensors, which are fed to microcontroller, in which the communication is done using personal computer.

The main objective of the project is to design a stair and rough terrain climbing robot with automation. PIC microcontroller controls the robot during climbing process using DC motors attached to it. The wheel structure is a tri-star configuration, in which the parameter depends on the position of star wheel on stairs. Three wheels are arranged in an upright triangle with two on the ground and one above them. If either of the wheels is in contact with the ground stuck, then the whole system rotates over the obstruction. Microcontroller controls the robots based on its programming. The robot tends to move based on the indications received from all sensors. Infrared sensor with the range 10-80 cm is connected to it to detect the obstacles and send intimation to microcontroller, which further stops the robot and chooses the correct path automatically. StairBOT is mainly applicable for security purpose. It also performs fire extinguish operations.

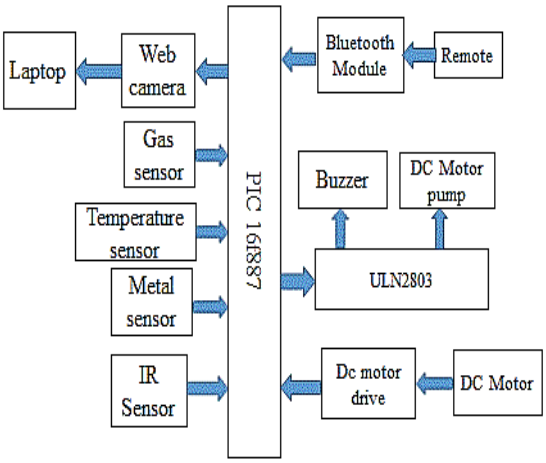

Figure 1.Block diagram

The temperature and smoke sensors measure the temperature and smoke on a particular place. If it is found to be high, then it gives information to microcontroller, which drives the DC motor pump to pump the water. StairBOT is able to travel along any type of rough areas. The metal detector detects the presence of landmine in battle field or blast hole areas and the gas sensor measures the toxic and flammable gases and gives information to microcontroller. It notes the amount of dangerous gases in the unit of Parts Per Million (PPM). Remote is used to operate the robot wirelessly from a distance. A web camera is fitted on the robot to have a wide field of view of disaster and affected areas. It takes the video of it, which is needed in security and rescue operations.

Here, microcontroller PIC16F887 is used to control the robot. It has RISC (Reduced Instruction Set Computer) architecture with 0-20 MHz operating frequency and 2-5.5 V power supply voltage. It is machine controlled and can be easily interfered with peripheral devices. To sense the obstacle or disturbance in the path, the project uses IR sensor that ranges from 10-80 cm. LED bounces off when an object is closer to the sensor. Gas sensor is used to detect the presence of toxic gases like carbon monoxide, chlorine and nitrogen oxide (gas leak or other emission) in an area often as a part of safety mechanism. When the sensor response surpasses a certain pre-set level, alarm is activated to warn the user. It ranges from 200 to 10,000 PPM. To sense landmines and bombs or any metal nearer to it, metal detector is used and its operating temperature ranges from -55℃ to 150℃. The system also includes a Bluetooth module which uses serial port protocol module, and a DC motor drive allows DC motors to run and it controls a set of two DC motors simultaneously. It is also called as Dual H-bridge motor driver integrated circuit. Additionally this work also consists of stepper motor and remote control. Stepper motor is used as arm of the robot and is used to get a good accuracy while climbing the stairs and remote control enables wireless operation to be operated from a distance.

The wheel is designed in CREO software. It has totally three wheels and arranged in an upright triangle pattern. Two are on the ground and one above them. If one touches the stair, the whole setup will rotate over the obstruction deriving the tri-star wheel that depends on the position of wheels on stairs. Star-wheel on stairs depends on two parameters (i) The distance between the wheel edge on lower stair and the face of next stair (ii) distance between the wheel edge on topper stair and the face of next stair.

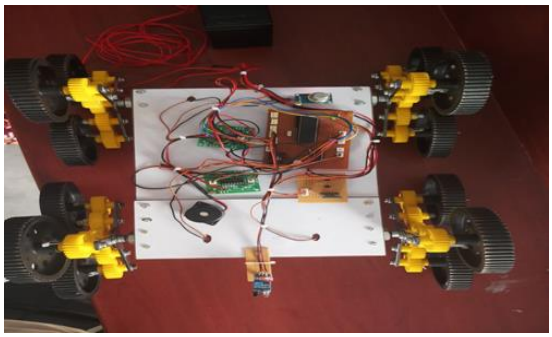

Figure 2.Top view of stairBOT

Figure 3.Side view of stairBOT

As the frame rotates, the upper wheel rests on the next step and moves forward. So, tri-star frame design helps in climbing the stairs with less effort. Figures 2 and 3 present

the top and side views of StairBOT. It is important to measure the following parameters.

- Height of stairs
- Width of stairs
- Radius of the wheel and gear
- Center to center distance

Table 1 shows the wheel dimension.

Table 1.Wheel dimension

S.no	Parts	Dimensions
1	Wheel	110 mm
2	Gear	40 mm
3	Centre to centre distance	15 cm
4	Stair height	13 cm

3.1. Merits of tri-star wheel

- Simple mechanism
- It is easy to assemble and disassemble the wheels when necessary
- No lubrication is required during the movement
- Less weight

4. CONCLUSION

An automation based stairBOT for security application is designed such that the robot can be operated with automation which is capable of climbing stairs based on tri-star wheel configuration. The controlling device of the whole system is a microcontroller. The microcontroller checks the data with the program embedded in it and performs appropriate actions on the robot. This robot is used in places, where human life is at a risk and helps in surveillance and security operations using sensors. When land mines or any type of toxic gases are identified, buzzer turns on. This robot is also able to move over irregular terrain of collapsed or destroyed buildings. A web camera on the robot sends live video into the device which is linked with it. In case, lift is not working or busy, the robot carries the materials up and down easily. The future work comprises of improving the weight carrying capacity of StairBot.

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