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[ijirset@gmail.com](mailto:ijirset@gmail.com)

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# Stair Climbing Robot Using Star Wheel Methodology

Mrs. Manasi Kanitkar<sup>\*1</sup>, Archit Kulkarni<sup>\*2</sup>, Vaishnavi Kshatriya<sup>\*3</sup>, Pratik Dumaldar<sup>\*4</sup>

Professor, Department of Electronics and Telecommunication, Progressive Education Society's Modern College of Engineering, Pune, India. <sup>\*1</sup>

Student, Department of Electronics and Telecommunication, Progressive Education Society's Modern College of Engineering, Pune, India. <sup>\*2,3,4,5</sup>

**ABSTRACT:** This stair climbing robot exploits star-wheel methodology, which has the capability of ascending and descending stairs and traversing obstacles and flexibility while climbing and declining sloped surfaces. The proposed system is a star-wheel based robot for climbing stairs. The important application of this robot is that it can reach places which are not accessible to humans over the stairs and obstacles. If the robot moves on flat surfaces and comes upon a stair or obstacle, the robot switches to Star-Wheels motion and one wheel of the Star-Wheels gets fixed on one stair as a base and the Star-Wheels rotation will cause stair climbing. It allows the robot to adapt itself with respect to the path curvature. Here the motion of the wheels is controlled by a DC motor. Raspberry pi is used for imaging processing. Image compression is a relatively recent technique based on the representation of an image by a contractive transform, on the space of images, for which the fixed point is close to the original image. It is a computer application for automatically identifying or verifying a person from a digital image or a video frame from a video source. It presents a real-time image processing of human face identification. It also sends a real time image from the desired location.

**KEYWORDS:** Object detection, Star-Wheel, Raspberry Pie, DC Motor, Motor driver

## I. INTRODUCTION

This stair climbing robot project exploits star-wheel methodology, which has the capability of ascending and descending stairs and traversing obstacles and being flexible while climbing and declining slopes. The proposed system is a star-wheel based robot for climbing stairs. This stair climbing robot can become a boon for rescue purposes. There are many places where human movements are not possible. Rescue operations to get carried out in such places is very much unlikely. This problem can be tackled easily with the help of this project. The climbing robot has an ability to move in places where human movements are not possible. There are different places in industries where humans are not able to work; biohazardous materials are present in such industries. In such places if an accident occurs and if someone is to be rescued from that particular area then the climbing robot comes into picture. The proposed robot in the project can travel in places which are at different altitudes from the sea levels. The climbing gears can also help the robot to travel through uneven surfaces. Moreover, the robot is installed with an image processing mechanism. This mechanism allows the robot to detect the subject which is to be rescued by the rescue team. With the help of image processing, the robot can identify the subject; a person, an animal etc. This will give the rescued team an idea about the situation in detail. [1]

Similarly, in an under-construction area there is a high risk of constructional accidents to occur. Just like the factory the robot can help the rescue team to identify their subject and work with ease. If the accident has taken place on a higher floor then with the help of climbing gears the robot can climb the stairs of the under construction building and then with image processing the rescue team can be updated. Stairs can be easily climbed with the gears. This is the advantage of this robot in this system. So, the advantages of the robot can be classified into two categories; it can go in regions where human movement is not possible and can detect the subject which is to be rescued using image processing. [2]

A system which intelligently detects a human from an image or a video is a challenging task of the modern era. From the last decade, computer vision and pattern recognition community concentrated on the human detection largely due to the variety of industrial applications, which include video surveillance, traffic surveillance, human-computer interaction, automotive safety, real-time tracking, human-robot interaction, search and rescue missions, humans'

collective behaviour analysis, anti-terrorist applications, pedestrian detection, etc. But this project is based on the technology which makes use of human detection and there are many applications of this system. [3]

This research addresses human detection in the recorded videos, which is a challenging task in terms of variations in colour, movement, appearance, etc. Several techniques are implemented for human detection which includes segmentation techniques, feature extraction techniques, classification-based detections, etc. [4]

Segmentation techniques for human detection include template matching foreground detection and background subtraction but these methods failed with multiple humans in a scene. Additionally, several feature extraction techniques are implemented for human detection such as histogram of oriented gradient (HOG), motion features, etc. These feature extraction techniques do not perform well when humans are not clearly visible or have extreme variations in their poses. In this project enough care is taken regarding detection techniques. [5]

## II. LITERATURE SURVEY

### 1. Study of Object Detection (2016)

- Author: Prof. Lakshmi Tamilselvan
- Focus: Visual surveillance system
- Components: Background modelling, motion segmentation, object classification, target tracking
- Challenges: Low resolution, illumination variation

### 2. Object Detection and Recognition in Images (2018)

- Author: Prof. Sandeep Kumar
- Objective: Distinguishing objects from the background and classifying them into predefined categories
- Key Challenge: Background subtraction problem

### 3. Design and Development of Tri-Star Wheel Rover (2019)

- Authors: Majid M. Moghadam and Mojtaba Ahmadi
- Objective: Overcoming obstacles such as stairs for robotic applications
- Focus: Research on climbing and descending various stairs, obstacles, models, inclinations, and surface conditions
- Addressing: 10 obstacles to the motion of such robots

### 4. Development of an Image-Based Distance Measurement System (Nov-2020)

- Author: Lawrence Y. Deng
- System: Uses two parallel laser lights as a scale for rapid horizontal or vertical distance measurement
- Challenges: Night vision, auto white balancing in low light, tone mapping for dark scenes

### 5. Mechanical Design and Development of Tri-Star Wheel System for Stair Climbing Robot (2020)

- Authors: Mohammad Iqbal, Emir Hidayat Ismail, Ibraahim Jalil
- Objective: Design and development of a Tri-Star wheel system for surveillance mobile robots
- Application: Entering dangerous disaster sites for human rescue and data collection
- Notable Challenge: Lack of left-right motion, need for gyro meter installation for stability while moving uphill and downhill.

This paper describes a machine learning approach for visual object detection which is capable of processing images extremely rapidly and achieving high detection rates. Object Recognition is a technique used in the field of computers. It is assumed to be one of the most difficult and challenging tasks in computers. Many methods have been proposed in the past, and a model with new techniques which is not only fast but also reliable. The EasyNet model has been compared with many other models as well. At the time of prediction, our model brings forth scores for the presence of the object in a particular category. It makes predictions with a Single network evaluation. Object detection is a regression problem to spatially separated bounding boxes & associated class probabilities. [2]

This project will be a Prototype model of "TRI - STAR WHEEL ROVER". This project describes the mechanical design and development of the Tri-Star wheel system for surveillance mobile robots. The robot will be used to enter potentially dangerous disaster sites in search of human survivors and to collect some related information for rescue

teams. The climbing robot needs to overcome natural and virtual obstacles such as stairs which are the most known obstacles in the collapse buildings. The vehicle has a set of four wheels arrangement to support its weight when it moves over the flat terrain. Each wheel frame consists of three sub-wheels attached with the sun wheel through three idle gears. [3]

In this project the distance measurement shall be done using an ultrasonic sensor. Traditionally, the parallax method is frequently used to measure the distance between the camera and the measured surface. But for diminishing the computational complexity and inaccuracy caused by image processing procedure, the proposed system only uses a single ultrasonic sensor placed beside the camera which detects the distance between the objects and robot using simple physical parameters like speed, distance and time. Furthermore, in order to improve the accuracy of the experiment, the proposed algorithm also provides a mechanism to make sure the results will not be influenced by extremely small objects. The experimental results showed the proposed method provided precise measuring results in several different distances. [4]

This paper describes the mechanical design and development of a Tri-Star wheel system for surveillance mobile robots. The robot will be used to enter potentially dangerous disaster sites in search of human survivors and to collect some related information for rescue teams. Surveillance mobile robots need to be able to overcome natural and virtual obstacles such as stairs which are the most known obstacles in the collapse of buildings. The mechanical design is provided for three main parts of the robot: the Tri-Star wheel assembly, the main body of the robot and the connection shaft between the body sections. [5]

## 1.2 Motivation

After studying the above research paper and gaps, the proposed project is to build a stair climbing robot that will move forward and backward movement of the robot with object detection based on feature extraction provided by the training dataset. Based on the dataset the object is classified on the basis of feature using the YoloV3 model and also measures the distance and dimensions between the stair climbing robot and detected object. Object Detection is a computer vision task in which the goal is to detect and locate objects of interest in an image or video. The task involves identifying the position and boundaries of objects in an image, and classifying the objects into different categories. The state-of-the-art methods can be categorized into two main types: one-stage methods and two stage-methods: One-stage methods prioritize inference speed, and example models include YOLO, SSD and Retina Net and two-stage methods prioritize detection accuracy, and example models include Faster R-CNN, Mask R-CNN and Cascade R-CNN. The most popular benchmark is the MSCOCO dataset. Models are typically evaluated according to a Mean Average Precision metric.

## 1.3 Problem Statement

- Today, to carry out different rescue operations it is dangerous for a human being to carry out the operations. Human life is at stake while performing different tasks in hazardous parts of the industries.

## 1.4 Objectives

- To processing the image obtained from a surveillance which has a low resolution, illumination variation.
- To implement different functions like climbing, descending on a different range of stairs, eliminate obstacles, models, adapt to inclinations and surface conditions on the path.
- To eliminate the Night vision problem
- To enhance the system with Auto white balancing (AWB)
- To Tone map the scenes that are too dark to see
- To enhance the system with left-right motions
- Gyro meter should be installed in this robot to remain the same while moving uphill and downhill.

## III. METHODOLOGY

- Connect raspberry pi to battery so that it turns 'ON'
- Use a Bluetooth controller to remotely control your robot as it climbs stairs.

- If a suspicious object is detected, the Raspberry Pi's camera will capture an image, which can be analysed using voice recognition software to determine what it is.
- The robot's distance from the suspicious object can be measured using an ultrasonic sensor.
- Again, the robot can be controlled by a Bluetooth controller.

The project includes star wheels, camera, an ultrasonic sensor, bluetooth module and a speaker. The bluetooth module is connected to the Raspberry Pi and then further connected to the mobile phone which controls the movement of the robot (Forward, Backward, Left and Right). Using the star wheel the robot can climb the stairs and travel in dangerous conditions and work further. At the start of the code, positive and negative terminals of the motor are declared. The input is given to the terminals of the motor according to commands given by the user using the mobile device. The camera is used to capture the image which is in front and compares it with the database. Using this methodology object detection is done. The compared image from the database is converted into a MP3 file using Google's Text-To-Speech and stored in a temporary mp3 file. The output is given to the speaker and the object name is played.

### 1.5.1 Algorithm:

#### a) Bluetooth Module

Step 1 :Start.

Step 2 : Do the necessary connections.

Step 3: Connect the mobile with the bluetooth module using the bluetooth terminal app.

Step 4 : Initialize the movement of the robot using the command.

Step 5 : When input=1 supply current to positive terminals of 4 motors.

Step 6 : When input=2 supply current to negative terminals of 4 motors.

Step 7 : When input=3 supply current to positive terminals of right side motors.

Step 8 : When input=4 supply current to positive terminals of left side motors.

Step 9 : When input=5 do not supply current.

Step 10 : Stop.

#### b) Ultrasonic sensor

Step 1: Start

Step 2: Connect the ultrasonic sensor to the Raspberry Pi.

Step 3: Record the initial time.

Step 4: If an object is detected, record the final time.

Step 5: Calculate the difference.

Step 6: Calculate distance using fixed speed value and difference time value.

Step 7: If distance is less than 20 cm, stop the motors.

Step 8: Stop.

#### c) Image Detection

Step 1: Start

Step 2: Turn on the camera

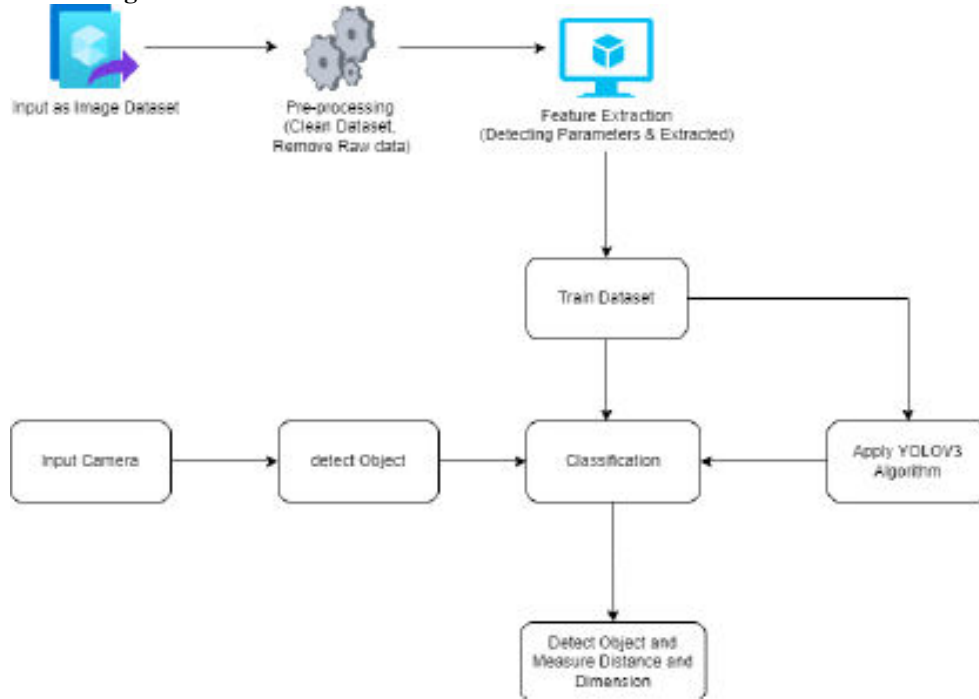
Step 3: The camera will capture the image.

Step4: The captured image is compared with the database provided.

Step 5 : If the image matches with the database the result is provided on the screen and the speaker.

Step 6 : Stop.

**1.5.2. System Designs  
Architecture Diagram:**

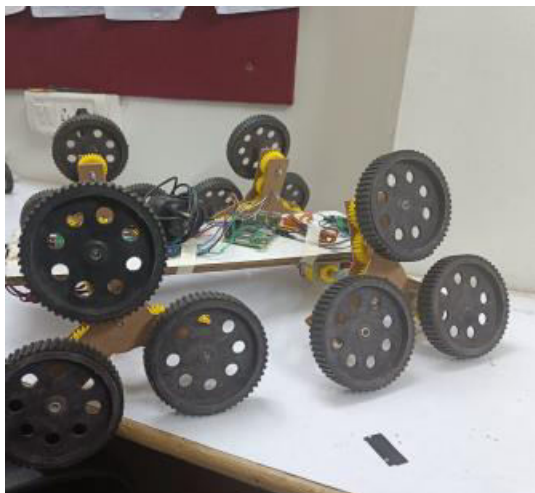


In the above System architecture, the working of the project is completely explained. The image is provided by the user to the system as sample images. Further the image is pre-processed i.e., removal of raw data is done in this block. The camera captures the image and then it is taken into the system as an input as shown in the blocks. The taken image is compared with the sample images. There are different parameters with which the image captured is compared. The YOLOV model is used to detect different objects in nature. Different objects in nature are classified i.e., the model differentiates whether the object is a car, human, animal, etc. Further the distance of the object from the camera, dimensions of the object and detection of object is done.

**IV. SCOPE**

This stair climbing robot exploits star-wheel methodology, which has the capability of ascending and descending stairs and traversing obstacles and flexibility while climbing and declining sloped surfaces. The proposed system is a star-wheel based robot for climbing stairs. The important application of this robot is that it can reach places which are not accessible to humans over the stairs and obstacles. If the robot moves on flat surfaces and comes upon a stair or obstacle, the robot switches to Star-Wheels motion and one wheel of the Star-Wheels gets fixed on one stair as a base and the Star-Wheels rotation will cause stair climbing. It allows the robot to adapt itself with respect to the path curvature. Here the motion of the wheels is controlled by a DC motor. Raspberry pi is used for imaging processing. Image compression is a relatively recent technique based on the representation of an image by a contractive transform, on the space of images, for which the fixed point is close to the original image. It is a computer application for automatically identifying or verifying a person from a digital image or a video frame from a video source. It presents a real-time image processing of human face identification. It also sends a real time image from the desired location.

## V. RESULT



The project includes star wheels, camera, an ultrasonic sensor, bluetooth module and a speaker. The bluetooth module is connected to the Raspberry Pi and then further connected to the mobile phone which controls the movement of the robot (Forward, Backward, Left and Right). Using the star wheel the robot can climb the stairs and travel in dangerous conditions and work further. At the start of the code, positive and negative terminals of the motor are declared. The input is given to the terminals of the motor according to commands given by the user using the mobile device. The camera is used to capture the image which is in front and compares it with the database. Using this methodology object detection is done. The compared image from the database is converted into a MP3 file using Google's Text-To-Speech and stored in a temporary mp3 file. The output is given to the speaker and the object name is played.

## VI. FUTURE WORK

- In the future the robot can detect known and unknown people based on the data of the database.
- The Robot can also climb the variable dimensions of the stairs with which dynamic climbing would be possible.
- GSM modules can be connected to the robot in the future for detecting the live location of the robot.
- The Bluetooth module can be connected to the android app.

## VII. CONCLUSION

In this project the climbing robot was successfully constructed. The hardware of the whole robot system was successfully understood with the help of the literature survey which was conducted before. We have successfully understood the demonstration of the working of the robot and its various functionalities. We learnt in detail about the image processing system and how the robot calculates the distance between object and robot. Once the object is detected by using YOLOv3 Algorithm for Object Detection, the size will be obtained for each object by using OpenCV functions.

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