Autonomous Human Follower Robot

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Abstract— The aim of this paper is to design a human following robot that can detect and track human thereby avoiding obstacles in its path. The process consist of Capturing the image, Image Processing is used to detect the object followed by tracking the object. There will be no wired connection between human and the robot, which allows us to operate it in the wide range with respect to any disturbance.

Key words: Autonomous Human, Capturing the image

I. INTRODUCTION

Autonomous robots-an actively researched and developed field provides various applications in day to day life .The fact that Autonomous robots do not require human intervention makes it more reliable and suitable for a number of applications .A typical robot comprises of various additional and supporting components with respect to application .The additional components may be Sensors , Modules ,Drivers and so on .A typical sensor will take input from the environment which is processed by the controller of the robot and gives a result .As said earlier, the type of sensors used depends on the application, thus a human following robot will require a camera as a sensor for Visual Navigation .Visual Navigation took much attention after the introduction of Web Camera which work in co-ordination with Image Processing. In order to achieve tasks, autonomous robots are designed to be intelligent and should decide on their own depending on their tasks. Human following robots usually have the following components-a target tracking system, an obstacle sensing system and a robot control system .A Visual Navigation Robot uses a camera for detection and tracking purposes .As human beings learn from the environment around themselves based on following behaviors of the others during growing phase, a human following robot with visual navigation system is also required to learn from its environment based on its database. Especially, robots have to know structures, maps and objects in human living environment in order to cooperate with human Visual Navigation System might be efficient for mobile robots to learn them effectively in unknown and dynamic environments. This study aims to develop human following robots for supporting human and learning environments without missing the target human.

II. TECHNICAL BACKGROUND

The literature available in the robotics, image processing and wireless communications domains is vast, emerging and continuously growing. We took appropriate ideas from various papers and all of these ideas together along with the input of our own ideas to implement our project. Referring several standard technical papers we have got a brief idea about our project, how the project idea is to be implemented using different methods, different approaches, we will be illustrating it briefly. The first basic idea of this work was Implementation of robot which itself detects and tracks. The idea was put forward by Nobutaka Hirai, Hiroshi Miroguchi in the paper "Visual Tracking of Human Back and Shoulder for Person Following Robot" [1]. There are some projects Based on Improved Genetic Algorithm. This paper comes up with a two-layer genetic algorithm mechanism The first layer is responsible for static obstacles Avoidance and the second layer is responsible for dynamic obstacles avoidance, and these two-layer genetic algorithm mechanism has different fitness functions. Paper named was "Robot Path Planning Based on Improved Genetic Algorithm"[2] by Yuan Zhao and Jason Gu . There is another approach used to carry the same task, by using Kinect sensor. But in order to achieve human following without restriction of movement, the sensors that can monitor wide areas such as laser range scanners must be installed in the robot. This paper was published by Fumiaki Hoshino, Kazuyuki Morioka and named was "Human Following Robot based on Control of Particle Distribution with Integrated Range Sensors"[3].With this approach a single camera mounted in the front of the robot can be used to detect the region of pedestrian crossing, the obstacles and also the pedestrians present on the pedestrian crossing.

The paper titled "Person Following Robot with Vision-based and Sensor Fusion Tracking Algorithm" [4] by Takafumi Sonoura, Takashi Yoshimi, Manabu Nishiyama, Hideichi Nakamoto, Seiji Tokura and Nobuto Matsuhira. In this paper the robot Tracks the specified people, Following at his/her pace, avoiding obstacles in their path and resuming contacting when the robot misses the target.

A. Organization of The Report

The report consists of a detailed explanation of the project working. At the beginning we have explained the reason behind selecting the specific components in our project. Later we have described image processing which mainly stresses on color tracking. We have concluded this paper with the software and hardware implementation and simulation results. The last section of the report gives the list of references that we had referred in completing the project. We achieved the human movements by tracking the red color band on the human's back. Then it was decided to detect and track texture of the back of clothes by using the "Color Detection & Object Tracking" technique.

B. Proposed Solution

After referring the above papers we have proposed the solution for our project. The camera is used as a sensor which captures the image of the human movement. This image is fed into the computer in analog form and the computer will perform the image processing on the image which yields the centroid of the object. These coordinates are useful in positioning and orientation of the robot.

Depending upon the coordinates the signals are passed to the robot. The signals are fed to the

Microcontroller which controls the robots movement to the desired location. After finalizing the solution we decided on the components to be used for our project. The significant components of our project are camera, wireless Bluetooth module and microcontroller.

1) Method Used

Let's consider the red colored band as an object. Object detection and segmentation is the most significant and challenging task of computer vision. It is a critical part in various applications such as image search, scene understanding etc. The easiest way to detect and segment an object from an image is the color based methods. The object(target) and the background should have a significant color difference in order to successfully segment objects by using color based methods. OpenCV Library usually captures images and videos in 8-bit, unsigned integer, BGR format. In other words, captured images can be considered as a combination of 3 matrices i.e BLUE, GREEN and RED (hence the name BGR) with the integer values that range from the value 0 to 255. In the above image, each small box represents a specific pixel of the image. In real images, these pixels are too small to be detected and differentiated by the human eye .Usually, one can think that BGR color space is usually more suitable for color based segmentation. But Hue , Saturation, Value(HSV) color space is the most suitable color space for color based image segmentation. So, in the above application, we have converted the color space of original image of the video from BGR to HSV image.The HSV color space consists of the following 3 matrices- HUE, SATURATION and VALUE. In OpenCV, value range for H, S and V are respectively 0-179, 0-255 and 0-255. HUE represents the color, SATURATION represents the amount to which that respective color is mixed with white and VALUE represents the quantity to which that respective color is mixed with black. Since we have considered RED object therefore HUE, SATURATION and VALUE ranges in between 170-180, 160-255,60-255. here the HUE is unique for that specific color distribution of that object. But SATURATION and VALUE may be varying according to lighting conditions of environment. We have to find the exact range of HUE values depending on the color of the object. The Saturation and Value is depending on the lighting condition of the environment and also the surface of the object. After we have to do thresholding of the image, we can see small white isolated objects here and there. It is due to the noises in the image or the actual small objects which have the same color as our main object. These noises or the unnecessary small white patches can be discarded by applying the morphological opening. Morphological opening operation can be achieved by erosion operation, followed by the dilation operation with the same structuring element. This has shown below.

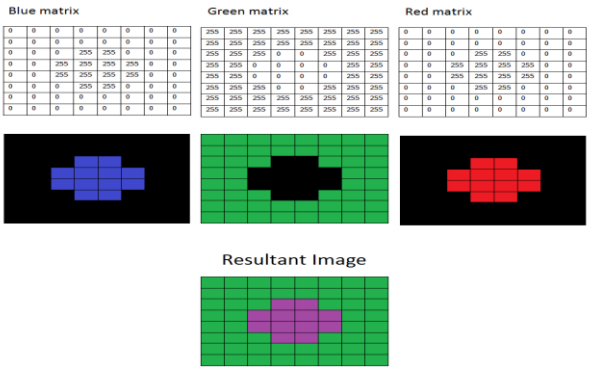

Fig. 1: BGR format

III. IMPLEMENTATION

A. Hardware Implementation

We are using following hardware components

1) Laptop
2) One HC-05 Bluetooth module
3) Arduino
4) Motor driver
5) Two gear motor

In hardware part, first we are connecting laptop's Bluetooth with HC-05 module so that data transfer become wireless. To do this we have to make connection on the receiver side. Below is figure of receiver side connection.

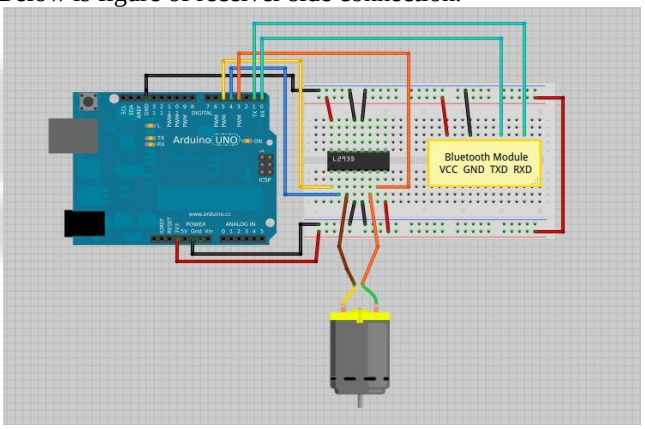

Fig. 2: Motor control connection

Steps- Connection control circuit for Robot

1) Connect all VCCs and Enables of L293D
2) Connect 4 inputs (we take 7, 8, 9 and 10 pin number) from Arduino to the input pin of L293D.
3) Connect the output pins of L293D to the motor
4) Connect Tx pin of Bluetooth module HC05 to the Rx pin of Arduino and vice versa.
5) And last connect all GND and VCCs to their respective pins.

On the transmitter side there will be laptop which have inbuilt Bluetooth for communication with HC05 module on Robot.

1) Software Implementation

The fig shows the flow chart of the entire project. It includes the color tracking algorithm. As explained, the mobile cam are placed at 90 degree and camera captures the image and is capable of producing 30 frames per second. The input image is stored in the object. Since HSV color space is usually the most suitable color space for color based image segmentation. Therefore we converted this input image to

HSV image. HSV color depends upon lightning condition of surroundings.

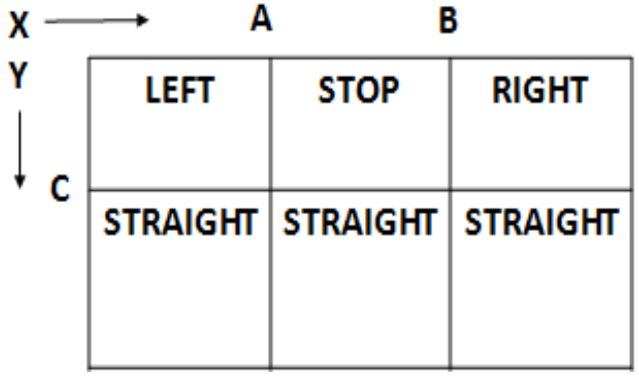

Fig. 3: Frame Divison

The figure represents the resolution wise division of a typical frame .For different resolution the frame division would be selected as per the above figure i.e each frame is divided into 3 vertical and 2 horizontal parts .The direction convention are as as per the camera view. The figure shows the operation that robot has to perform based on the position of the object in the frame. And accordingly the overall flow chart is as shown Where X and Y are the co-ordinate of centroid and X0 and Y0 are the past values of centroid.

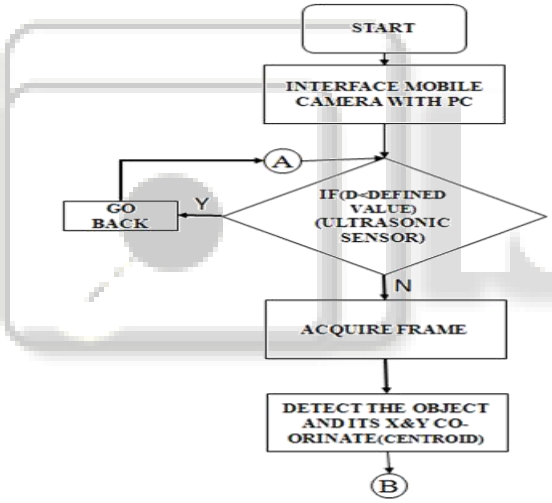

Fig. 4: Flowchart-1

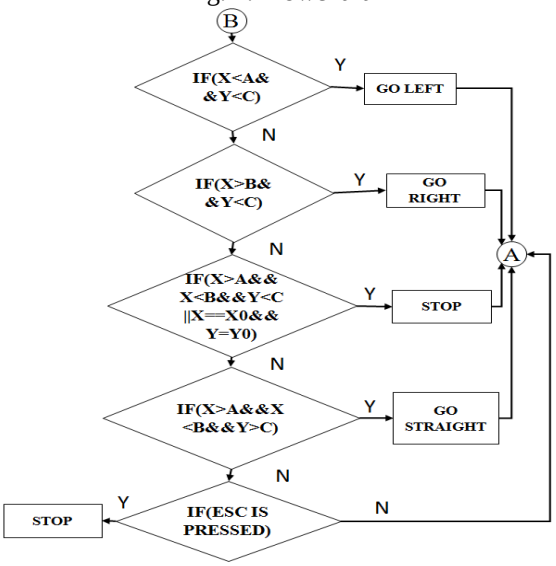

Fig. 5: Flowchart-2

After HSV we have to apply thresholding So that input image contains 1s and 0s that is binary image. This threshold image contains white patches which can be eliminated by Morphological opening. As we know Morphological opening can be achieved by a erosion operation, followed by the dilation with the same structuring element. Opening operation removes small objects from the foreground (usually taken as the dark pixels) of an image, placing them in the background. But still in thresholded image contains small white holes which can be eliminated by Morphological closing. by Morphological closing can be achieved by a dilation, followed by the erosion. Closing removes small holes in the foreground, changing small islands of background into foreground.

After that we are calculating centroid of the white object. Its consist of coordinates which we will pass into microcontroller and according to that it will decide the direction of the robot movement. Data passing will be wireless and for that we are using Bluetooth module HC05.

IV. RESULT

We started implementing color tracking on a steady image and when we got satisfactory results, we carried on the same on Real time dynamic objects. We are using red color as a tracking object for the robot to follow human. Setting up the threshold value of the frame such that they will contain only red object. We are putting this object on the human so that robot can detect and track the human. The basic concept of red color tracking was implemented as follows.

1) Capture the frame from a IP mobilecam.
2) Convert the original image into HSV image.
3) Threshold the HSV image.
4) Perform morphological opening.
5) Perform morphological closing.
6) To find the centroid of the threshold image. We are using MOMENTS object. Which will find the centroid of the given frame as discussed earlier.
7) Separating the frame in 3 vertical parts.
    1) If the centroid present in the left part of the frame, the robot will move in left direction.
    2) If the centroid present in the right part of the frame , the robot will move in right direction.
    3) If the centroid present in the centre of the frame, the robot will move in straight direction.
8) We pass this values to the robot's microcontroller which will process and take appropriate decision.

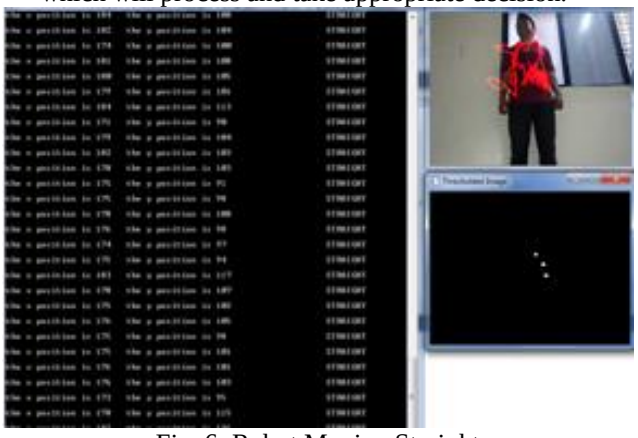

Fig. 6: Robot Moving Straight

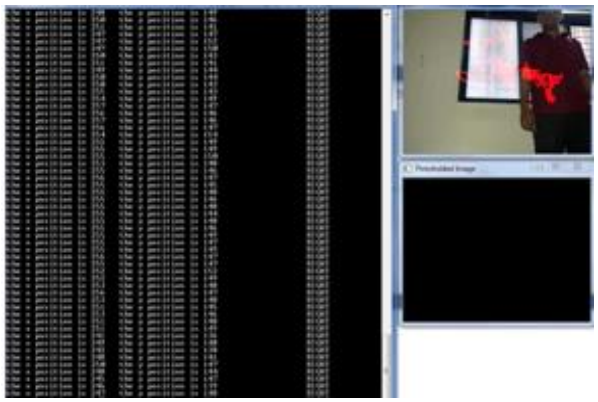

Fig. 7: Robot Moving Right

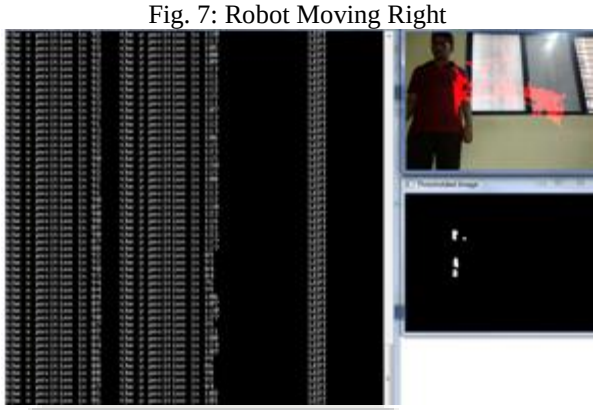

Fig. 8: Robot Moving Left

V. CONCLUSION

The main goal of the project is to make a robot which will follow the human and avoid the obstacles which was successfully achieved using Microsoft Visual Studio.
We used color detection algorithm and obstacle avoidance algorithm to get the desired outcome.

A. Strengths

1) Simple to control and implement.
2) Useful for military purposes: can handle the luggage.
3) Useful in tourism

B. Limitations

1) Whole system requires a certain amount of light illumination in order to detect a red color.
2) Weight limitation on handling objects.
3) Limited workspace due to frame size of the camera.

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