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Hand Gesture Controlled Robot

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Abstract: Most of the people in this world are known to gestures, which is a means of communication amongst humans. They say actions speak louder than words, hence communicating using gestures is also a strong method. Robots are used for industrial and domestic purpose which are often controlled by the remote controllers. The employment of gestures as one of the way to manage people providing ease and will be more useful for the physically challenged. Gestures provide a special correlative manner to speech for expressing their objective. The main purpose of gesture recognition is that to associate a specific human gesture and convey information to the user with respect to individual gesture. Gesture recognition from hand motions or postures may be a lively area in gesture recognition research for Human Computer Interaction (HCI).

We propose a gesture controlled wireless robot that performs the task of a spy robot serving security and monitoring purpose. The aim of gesture recognition is to spot a specific human gesture and convey information to the user regarding each gesture. Image processing is the foremost effective method accustomed process image signals. Training Image Classifier using Tensor flow Object Detection API (application programming interface) is followed where Convolution Neural Network (CNN) technique, coordinate value based algorithm is involved. Wireless interface is developed between controller and the robot that allows it to work in directions like front, back, right and left as per the commands received.

Key words **– Faster R CNN, Oblong detection boxes, Region Proposal Network (RPN), Region of Interest (ROI).**

I. INTRODUCTION

In present scenario, the robotic industry is developing many new trends to improve the organization, efficiency, accessibility and reliability of the systems. Basic tasks may be jobs that are harmful to human, repetitive jobs which are boring, stressful etc. A gesture could be a style of non-verbal communication within which visible bodily actions communicate specific messages, either in a situation or in unification with, speech. Gestures are a strong means of communication among humans. Face gesturing is so deeply involved in our communication system where individuals often continue gesturing when speaking on phone, mobiles or with each other. Hand gestures provide a definite corresponding modality to speech for expressing ones notions.

In the present world majority of the work done by the military is unsafe for themselves. During a war field or safeguard task a warrior has to take his own specific manner to realize the goal. The inordinate number of ways are perilous for a warrior or an official. Consequently robot replaces this requirement entering the places which are not accessible for human intervention, for surveillance purpose that may be controlled by an official within the room. Thus reduces the life risk of a person. The evolution of robotics seems in some ways to mirror the evolution of computer system. Today's robotic industry has been developing many trends to extend efficiency, accessibility of the system. Though robots will be a replacement to humans, they still must be controlled by humans itself. Hence we proposed such a system in our paper.

1.1. ROPOSED SYSTEM

We propose a system named Hand Gesture Controlled Robot, in which the user can navigate the wireless robot within the specified environment using various gestures commands. The principal objective is to produce reliable and a more convenient technique for the user to move a wireless robot within the environment using gestures. The proposed system will provide more natural way of controlling and facilitates rich and intuitive style of interaction with the robot. Gesture controlled robot uses hand gestures to regulate the motion of the robot, rather than employing a device with buttons or a joystick. This mainly includes Image Processing and Machine Learning for the system or the application development. Beyond this, it also requires some moderate hardware for interfacing with the system for gesture control.

In this system, user operates the robot from epicenter station that may be a laptop or a PC with a quality in-built webcam or external webcam. This webcam is employed to capture real time video stream of hand gestures to come up with commands for the robot. Gesture commands are given using hand palm. In accordance with the gesture technique used, robot is moved in all possible directions within the assigned environment using four possible sorts of commands which are Forward, Backward, Right and Left. Image frame is taken as an input and processed using Image Processing. This processed image is further used to extract the gesture command for detection. From this generated gesture command, signal is generated to pass the resultant command to the robot. The project is constructed based on wireless communication, where specifications from the hand gesture is given to the robot through Bluetooth. Robot is navigated within the environment as per the generated signal.

II. LITERATURE SURVEY

Neethu P S et al. in paper [1] proposed an automatic detection and classification of hand sign language recognition system. The RGB image is converted into grey scale image as a preprocessing method and usingGabor transform this image is converted into multi resolution image.From this multi resolution image features are extracted and these features are classified using Adaptive Neuro Fuzzy Inference System (ANFIS) classifier.MahbubaAlam and Mohammad Abu Yousuf in paper [2], described a gesture controlled robot for physically challenged and elderly people. The robot makes use of motion sensors to recognize five gestures of hand. In this paper, the hand gestures are recognized by motion sensors and without any image processing to make the system simple &efficient. Machine learning is used to classify hand gesture accurately. Gaurav Chauhan and Prasad Chaudhari in [3] used gestures as a way of controlling a device and can help a lot providing ease and more useful for the handicapped. Gestures provide a distinct complementary modality to speech for expressing ones ideas. Recognizing Sign language from hand motions or postures is a functional area in gesture recognition research for Human Computer Interaction (HCI). This paper aims to brief the convenient method of robotics through an effective and efficient practice of image processing using hand gestures as a mode of control.Ibrahim Barancelik and Dr. Mehmet kuntalp [4], proposed a model that deals with the robotic arm controller using image processing in the field of Human-Machine Interaction (HMI). After segmentation of the hand, the first method is comparison of all pre-stored data which is present in database at the Template Matching Algorithm, the second method is Signature Signal, that is the distance signal between centre of the hand and edge of the hand, Signature Signal is used to realize fingertips where the fingertips are and to count the number of them.

Naveen Kumar.C in [5], developed a project that deals with the interface of robots through gesture controlled technique but far away from the user. This can be achieved by using image processing technique. The command signals are formed from these gestures using image processing technique. These signals are subsequently passed to the robot. To traverse the robot in particular direction. Harish Kumar Kaura et al. in [6], implemented a system through which the user can interact with robot wirelessly means user can give commands to the robot via Bluetooth or wifi. and with respect to the command given robot moves in a particular direction. From this method, the user can control and Traverse the robot by using handgestures, Thereby he can interact with the robotic system. The command signals are formed from these hand gestures using image processing. These Command signals are passed to the robot, and it is traversed in particular direction with the help of motor driver. Premangshu Chanda et al. published a paper as in [7] that describes the look and application of a wireless gesture controlled Robot with the help of Arduino ATMEGA32 processor and an Android intervened application to regulate the gestures through Bluetooth with least, and cheap hardware requirements. The way humans communicate among themselves may be implemented in communication with the digital world by interpreting gestures via mathematical algorithm. Kavitha Sooda et al.in [8] developed a vision based hand gesture recognition system. Here computer perceives the human gestures and responds during a pre-decided way. It makes use of the Kinect sensor built on a software technology developed internally by a subsidiary of Microsoft Games Studios owned by Microsoft.The majority steps consists of pre-processing, hand segmentation and have or attribute extraction. During this work the segmentation of the hand from the remainder of the image is carried out.

Supriya Zinjad in [9], proposed a project model which is to a produce an interaction between human hand and a Robotic arm. The Arm is being administered by human hand gestures with the help of Image Processing techniques. this concept introduces the technology accustomed control the Robotic Arm for various activities. Non-contact form of implementation is getting used for kinds of hand gestures which are recognized by MATLAB Software using RGB color strips. Harika. tatipakala and D. Sreekanth in [10], developed a technique that operates by processing the gesture commands signal. The Spybot is programmed to research the gesture command signals and make route suited handy gestures, sensed by video camera operating within a particular short range. The gesture commands are used for controlling the Spybot purpose like movement of the robot or other operations of robot silently which will be executed by raspberry pi unit. By means of application, a Spybot that captures images from selected places silently and sends the capture data to the host computer. Sharvari Holey et al. in [11] developed a robot prototype for the explanation for spying in war fields and on border lines applications. A wireless camera is integrated with this module. The camera captures images and videos and transmits it remotely to a PC. This prototype spybot will be utilized by the military to get information about the enemy territories. Vijayalaxmi in [12], described a project to form a hand gesture recognition robot, this robot will be employed in both military i.e., in hostage situations which might reduce risk of harm to human life and even for physically handicapped i.e., within the variety of wheel chair. This hand gesture recognition robot will be constructed using minimum cost arm processor boards like beagle board and raspberry pi. To realize this we want to try to image processing the pictures we are able to control the robot using hand gestures.

III. METHODOLOGY

We propose a system, using which the user can navigate the wireless robot within the environment using various gestures commands. Figure 3.1 shows the diagram of the proposed system. The main objective is to supply reliable and a more convenient technique for the user to navigate a wireless robot within the environment using gestures.

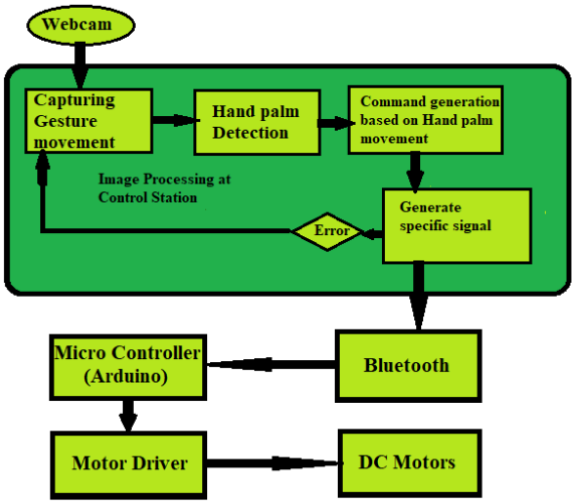

Fig 3.1 Block diagram of proposed system

Webcam:

In this system, user operates the robot from a far away station that may be a laptop or a PC with a decent quality in-built webcam or external webcam. A webcam may be a small digital video camera directly or indirectly connected to a computer or a network. This webcam is employed to capture real time video stream of hand gestures to come up with commands for the robot. The webcam specifications areHD720p (1.0MP), fixed focus model.

Capturing Gesture Movements:

The hand gesture is captured using the webcam and processed because the input at the control station is used for creating the robot to maneuver in desired direction. This involves background constraints like external body part, wall, objects to spot the hand palm correctly with minimum noise within the image. Based on information of hand gesture, the captured image is validated for a person with whom the robot will communicate.

Hand Palm Detection:

A trained model for hand palm detection using tensor flow object detection using Faster R CNN technique is created. This involves series of steps from preparing dataset, labeling the dataset, generating records for training, configuring training, training the model. We got a dataset consisting of over 2500 images of hand palm both closed and open as shown within the figure 3.2 below. A classifier is made which detects various images of palm of human hand. The dataset is the foremost significant thing in building a classifier. This could be the premise of classifier on which object detection is completed. This includes collecting various types of images consisting of the objects. The more the number of images the upper is that the precision of classifier.

Fig 3.2 Data set of hand palm images

Then Labeling begins by identifying the desired object within the image by drawing an oblong boxes over the image as shown in figure 3.3 and labeling them, an Xml file is formed accordingly here into a file named HAND_GESTURES. Then we create TF(Tensor Flow) Records that may be served as computer file for training of the item detector. So as to form the TF Records we are going to use two scripts from namely the xml_to_csv.py and generate_tfrecord.py files Thus this file is imported to further configure for training using Faster r-CNN.

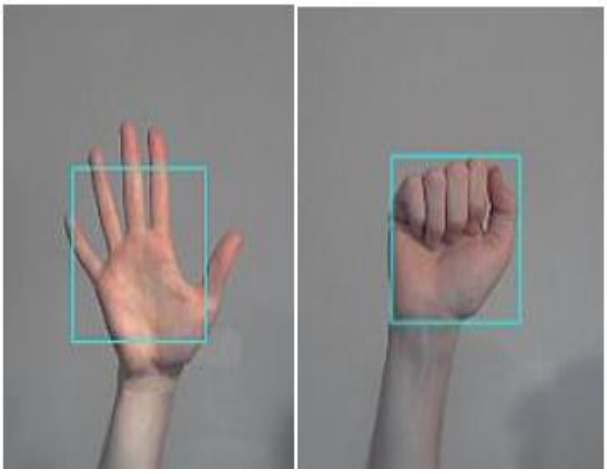

Fig 3.3 Oblong Detection boxes

In Faster R-CNN we have two processes involved namely Region Proposal Network (RPN) which is used for generating region proposals and to detect the objects and ROI (Region Of Interest) pooling. It is an algorithm to coach our classifier. The whole configuration process is performed here using this algorithm which involves a classifier and regressor which will eventually check the occurrence of objects obtained from the output of an area proposal network (RPN). Here to refine the anchor, RPN predicts the likelihood of an anchor being background or foreground followed by bounding box for the used coordinate system i.e coaching a classifier make a training dataset. The training data is that the anchors we get from the above process and also the ground-truth boxes. The essential idea here is that we would like to label the anchors having the upper overlaps with ground-truth boxes as foreground, those with lower overlaps as background. After RPN, ROI pooling is done as we get proposed regions with different sizes. Different sizes of regions means different sized CNN feature maps. It is hard to generate a systematic structure to figure on features with non-identical sizes. ROI Pooling simplifies the matter by decreasing the feature maps into the identical dimensions. Max pooling will be applied on every region for correctness. Thus hand palm detection with maximum accuracy is achieved.

3.4 Command Generation:

In this approach of gesture command generation, recognition of the command signal can be done by considering movement of hand palm. Thus an hand palm movement gives direction for the robot motion. These commands are given with the open palm or closed fist. As per the generated commands, Robot is moved in all possible directions in the specified environment with four possible types of commands which are Forward, Backward, Right and Left. Image Processing technique is used to process the input image frame. Extraction of the gesture command is performed using processed image. These generated gesture command has one among four possible commands.

In the process of command generation, image is captured from the web camera in order to identify hand palm gesture.To create the area of interest a rectangular box is created inside the image frame in order separate area of interest from the image frame. Dimension of the area of interest which can be taken as point of reference for the hand palm is as follows.

Width=640mm
Height = 480mm

We have set width and height as specified above, as it is according to the user convenience. If we fix width and height as above specification, it is easy to make decision (left, right, forward, backward, to stop) of hand gesture in specified direction. It is also useful for all kinds (different size) of palms to fit in the area of interest.

Threshold value analysis

A Threshold is set to 0.6 which describes Accuracy of the captured image i.e, Threshold is the maximum point below which captured images will not be considered for further processing, where Accuracy means frame by frame comparison of captured image with the training set of images.

Threshold=T=0.6
T>0.6 Image can be considered for further processing.
T<=0.6 Further processing of the image doesn't take place.

If threshold is very low, then there is a chance of false detection. So the security is also lost. Similarly if threshold is more the algorithm rejects many possible hand gesture and further processing is not possible. Hence an intermediate value must be taken into consideration

Threshold is the measure of correctness or accuracy of the image. i.e. The gesture image is divided into 'n' number of pixels/frame. This frame is compared with the predefined trained set of images. If the compared result matches more than 60% with the trained set of images, then it will consider for further processing.

Saturation value analysis

Parameter Called Alpha is set to 0.3, which defines transparency rate/colour saturation point

Alpha= 0.3

Where Transparency rate is used to differentiate main frame from the area of interest

Alpha value is set to 0.3, in order to differentiate between the area of interest and the rest of the image.

With all these above parameters the image in the control panel is as shown in the figure 3.7. The rectangular box selected as area of interest should not be too big, as it take more time for tilting to the desired direction. The area of interest should not be too small also, since the robot will be tilted with a small change which will lead to an error. To achieve a good efficiency with trial and error method the thresh hold and alpha arefixed to the above said values.

Here we have taken threshold=0.6 and saturation value=0,3 in the below figure 3.4.This is how our controlling screen looks for the given values.The hand is detected when it is seen inside the area of interest and then according to the hand movement, the directions to the robot are given.Image flipping or mirroring is a technique which is same as rotation of image, however, it transforms rotation with a reverse direction. The image is flipped using python and openCV. The image will flip across x-axis, y-axis and then across both axes. A function called flip frame is used to avoid the mirroring effect.

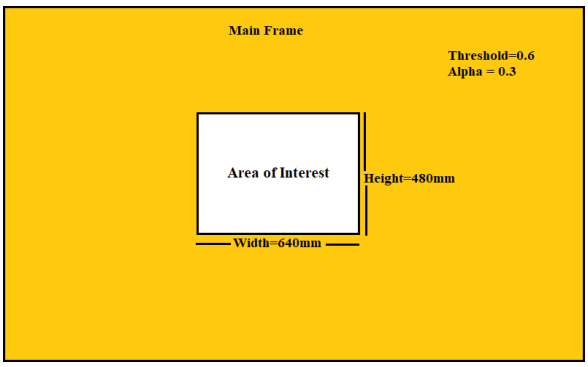

Fig 3.4 Controlling screen view

To detect the centre point of the area of interest, let us define the parameters Xmin, Xmax, Ymin, Ymax. These parameters defines the position of hand in the area of interest. From the centre point +320mm in +x-axis is Xmax and -320mm in –x-axis is Xmin. Similarly, from the centre point vertically, +240mmin+y-axis is Ymax and -240mm in –y-axis is Ymin. In the figure 3.8, below the coordinates with all four parameters are shown as described.

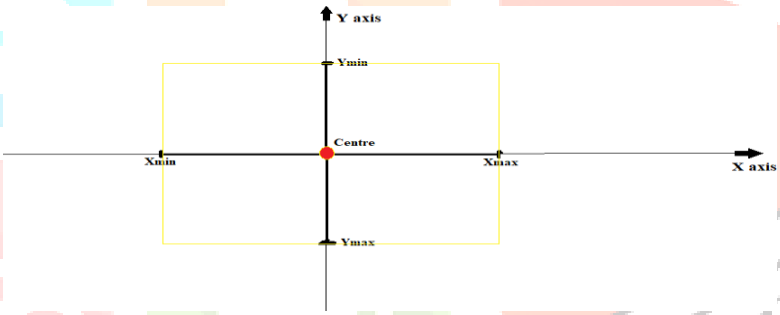

Fig 3.5 Division of controlling screen

The following mathematical equations gives the X and Y coordinate points inside the area of interest.

X=(Xmin+Xmax)/2

Y=(Ymin+Ymax)/2

As we need to find out the directions of hand movement, we should first divide the screen into horizontal and vertical divisions.

Now let us first divide the area of interest into vertical divisions to identify right and left movements of hand .As shown in figure 3.5, total width of the Area of interest is divided into 3 equal parts.

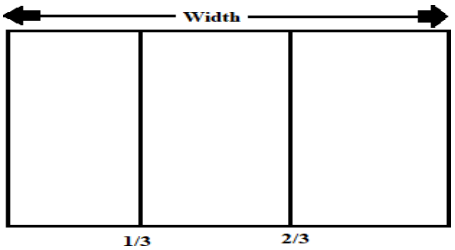

Fig 3.5 Vertical division of screen

The mathematical equations given below denotes, how the screen is divided into vertical divisions.

Let us consider for the cases below.

Width of area of interest=w

Height of area of interest=h

*Case 1:*In this case, the area of interest is divided into three equal parts vertically. Let us consider a variable A. If the value of A is greater than the value of X, which is the obtained before then direction for navigation is taken as left turn.

A = w / 3

X < A: Left Turn

*Case 2:*In this case, the area of interest is divided into 3 equal parts vertically. Similarly if the value of B is less than the value of X, then navigation direction is taken as right turn.

B = w*(2 / 3)

X > B: Right Turn

Now let us divide the area of interest into horizontal divisions to identify Forward and Backward movements of the hand palm. As shown in figure 3.6 the total Height of the Area of interest is divided into 6 equal parts.

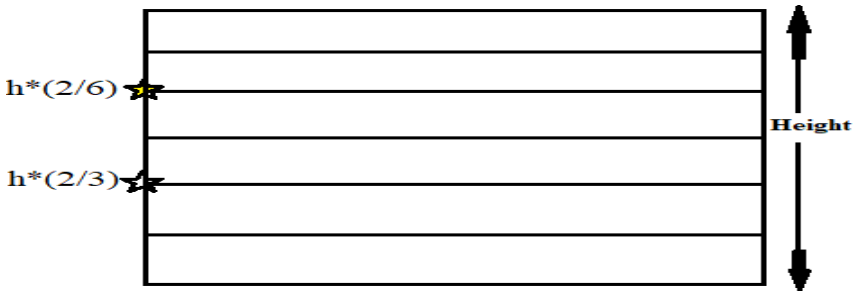

Fig 3.6 Horizontal division of screen

The mathematical equations given below denotes, how the screen is divided into horizontal divisions.

*Case 3:*In this case, the area of interest is divided into 6 equal parts horizontally. If the value of C is greater than value of Y which is obtained above, then direction is taken as forward.

C = h*(2/6)

Y <C: Move Forward

Case 4: In this case, the area of interest is divided into 6 equal parts horizontally. Similarly if the value of D is less than value of Y, then direction is taken as backward.

D = h*(2/3)

Y >D: Move Backward

*Case 5:*In this case, the area of interest is divided into 3 equal parts vertically and 6 equal parts horizontally. If the value of X lies between w/3 and w*(2/3) and if Y lies between h*(2/6) and h*(2/3), then the navigation of robot is stopped .i.e, stop command is generated as shown in figure 3.7.

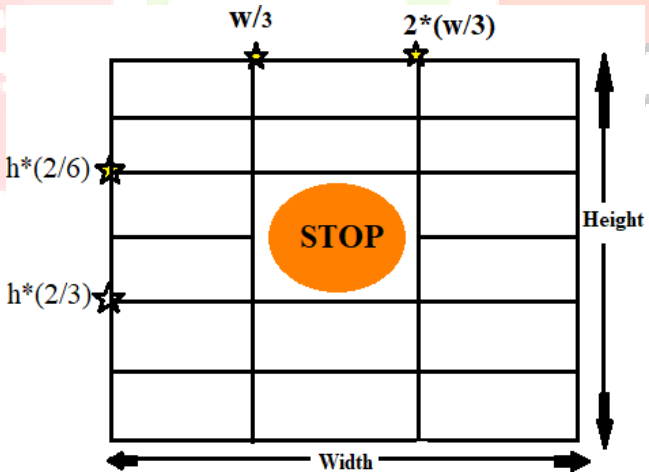

Fig 3.7 Total screen division to detect stop point

w/3< X < w*(2/3)

h*(2/6) < Y < h*(2/3)

Based on hand gesture which satisfies these conditions, the commands are generated to navigate robot in the specified direction. In this method we can detect both closed and opened hand palm. These commands are analyzed on the basis of the movement of the palm in accordance with the two coordinate system i.e, the **X coordinate value change once goes out of the bound of Area of interest corresponds to right and left command generation and similarly the Y coordinate value change for front and back commands, at control station.** The following screenshots are the Software implementation of Hand gesture controlled Robot. According to the command given, we have considered five different cases as shown in Figure 3.8.

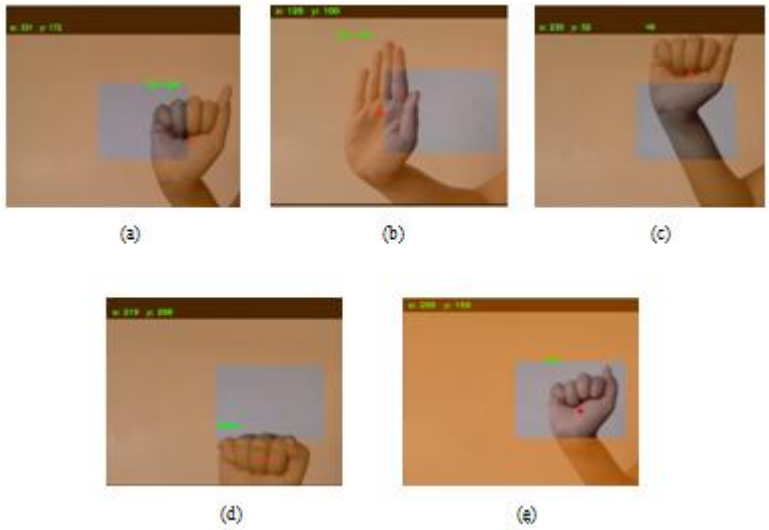

Fig 3.8: Hand gesture signals for different movements of Robot. **(a):** To move Right: The robot moves in right direction when command run right is generated. (b)**:** To move Left: The robot moves in left direction when the command run left is generated. (c)**:** To move Forward: When the command up is given to robot, it moves in forward direction. (d)**:** To move Backward: When the command down is given to robot, it moves in backward direction. (e)**:** To stay at the point: When the command stay is given to robot, it stops the navigation.

Generate Specific Signal

From the gesture command generated, the specific signal is generated so that robot will understand these commands and act accordingly. To do this we have to interface Control Station and the Robot.(Pc and Arduino). Arduino code is written using fstream library so that each and every command is tagged with a specific word. Tagged word can be anything as it is user defined. For example, to navigate the robot move in forward, backward, right and left direction, the values are written as F, B, R and L respectively

IV. While generating the specific signal, if error occurs due to lack of connection /any other interruption, new image is considered for generation of commands and all image processing steps are repeated. These commands are passed to the robot via wireless communication (Bluetooth). HC-05 Bluetooth module is used which has the ability to act as both master and slave. It uses a Serial Port Protocol (SPP) which means it communicates with Arduino and motor driver serially. The complete flow of operation is shown in the figure 3.8.

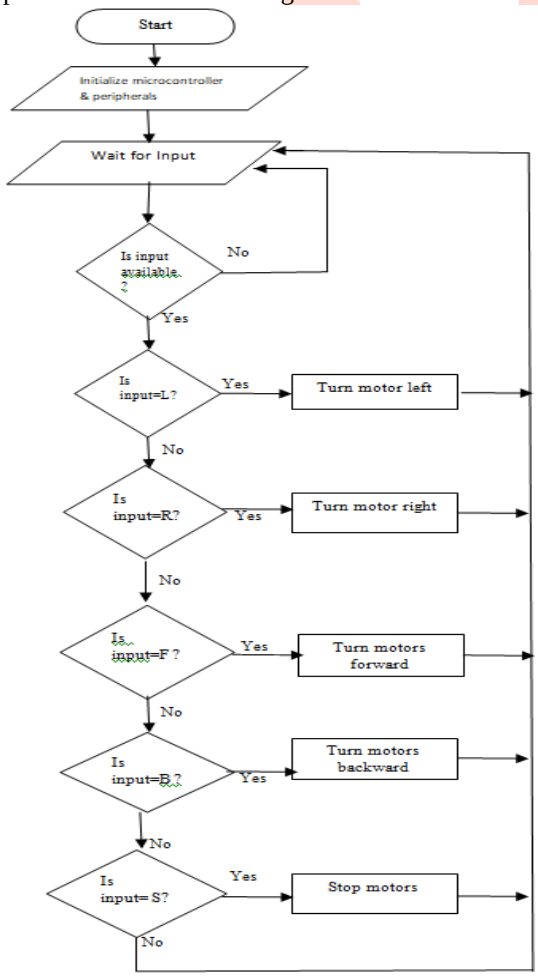

Fig 3.9 Flow diagram of robot operation

This signal is passed to the motor driver with i a H- bridge model, which is used to drive the DC motors. It consist of 4 input and output pins along with enable pin, where input pins are connected to arduino and output pins are connected to DC motors. And enable pin is used to enable the input/output pins. Vcc supplies external power to the DC motors.L293D motor driver consist of H Bridge, one H Bridge is used to give forward and reverse voltage. Hence we need two DC motors to run robot in all possible directions. For instance take if the input to Arduino is received as L it send a command of 1,0 to the controller so that power given to left motor will be 0 and right will be Vdc , similarly for other directions .Figure 4.0 shows basic flow diagram of the proposed system.

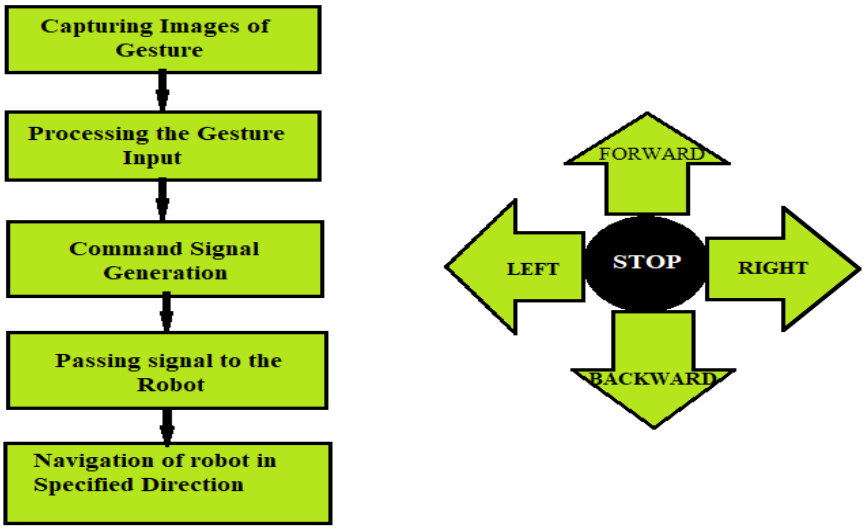

Fig 4.0 Basic flow diagram of the proposed system

4. RESULTS

The following snippets are the Software implementation of the proposed system "**Hand gesture controlled robot**". With respesct to the hand palmmovement corresonding commands are printed on the screen. Command signals are generated based on the hand movement. These generatedcommands are then given to the robot to move it in specific directions as shown in the Figure 4.1.

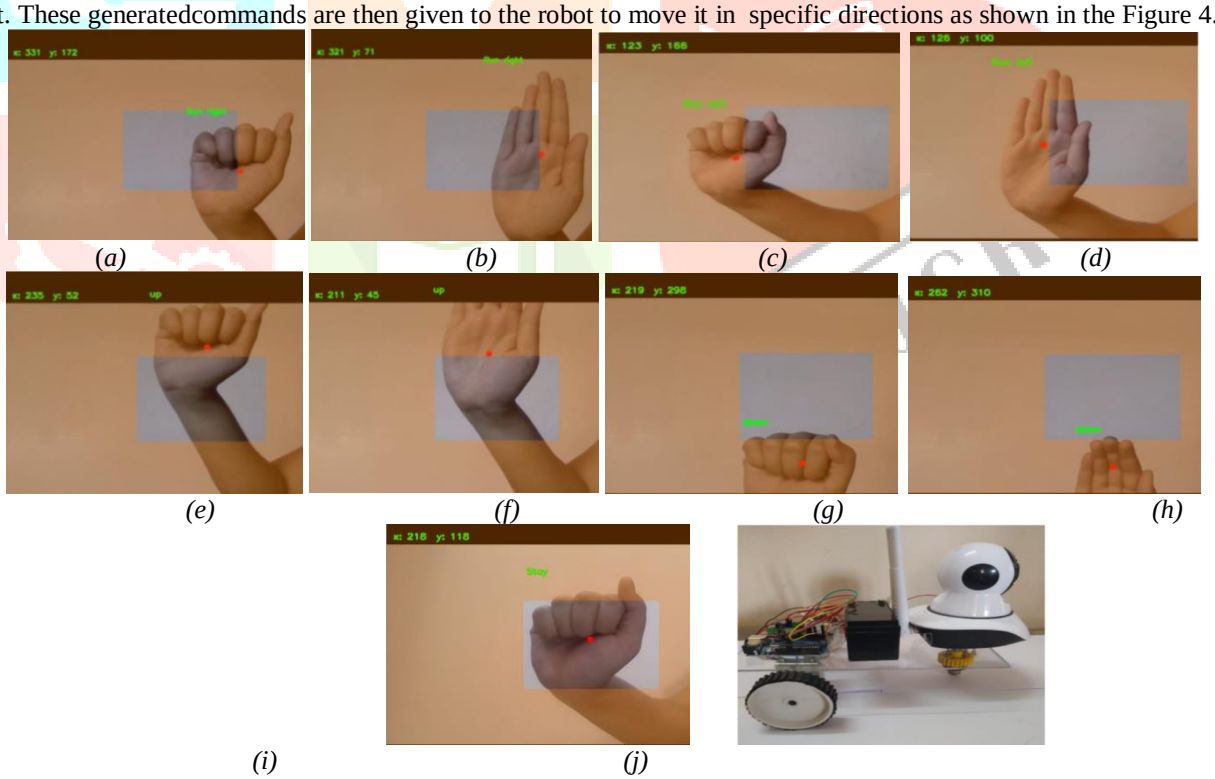

Fig 4.1 : The Hand signals for the Robot to navogate in the required direction *(a).* Run right command with closed fist. *(b).* Run right command with open palm. *(c).* Run left command with closed fist. *(d).* Run left command with open palm. *(e).* Up command with closed fist. *(f).* Up command with open palm. *(g).*Down command with closed fist. *(h).* Down command with open palm. *(i).*Stay command to stop Robot. *(j).* Hamd gesture controlled robot.

The images *(a)* and *(b)* shows the command run right. Once the palm point moves out of bound in right direction, which describes the direction of navigation for the robot to move towards right. images *(c)* and *(d)* shows the command run left, which describes the direction of navigation for the robot to move in left direction.

The images *(e)* and *(f)* shows the command up, which describes the direction of navigation for the robot to move forward. The figure *(g)* and *(h)* shows the command down, which describes the direction of navigation for the robot to move backwards. The image *(i)* shows the command stay, which describes the direction of navigation for the robot to stop.Thus the command generation is complete. The image *(j)* shows the complete device of Hand Gesture Controlled Robot.

5. CONCLUSION

The Hand Gesture Controlled Robotic system provides another way of controlling robots. Controlling robots using Gesture recognition has become a more convenient way of controlling devices, this makes robotic control more easy and efficient. A programmed component has been built up that works in accordance with the hand signal. The system moves remotely in accordance with the hand movement to carry out the surveillance activities as a spy robot. The hand signal generation has been accomplished by using hand palm movement based on the method which compares the index numbers of current hand image with pre-defined index numbers successively. The hand movement from center of the screen to the center of the palm is recognized by coordinate system based algorithm to generate commands for the robot. Thus the robot moves in accordance with the operator commands, which makes the robot to enter inaccessible places to monitor the scene.

The usage of this particular technology extends in the fields of advancing Human Computer Interaction(HCI) such as sign language transition that can translate the symbols represented through sign language into written form. In the world of virtual gamming the actions and interfaces within video games are controlled using gestures which makes game player to immensely involve in the game. This robot finds application in industrial areas which are dangerous for human intervention, hence reduces risk of life. This technology can be incorporated to assist physically disabled people to conduct their daily chores.

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