Home Assistant Robot

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***Abstract* - This work proposes a prototype Home Assistant Robot. Main aim of this project is to make managing home easier and more automated. This paper will explain the design and implementation of the proposed robot. Although there are a variety of assistant robots available in the market, through this robot we aim to provide a unique and easy to use combination of features and abilities. It is a multi-wheeled robot designed to help user with variety of everyday tasks. It is an intelligent robot can integrate itself with various other automated systems in order to make your life easier. The robot comes with variety of control options. Some of the features that the robot will provide are automation, security, leisure, etc.**

1. INTRODUCTION

There has been a mass trend shift in the robot market recently. As the time passes by we see more and more robots in our daily life. The personal robot market is growing at a much faster rate than the industrial robot market. Many specific function robots are present in market these days that provide help in certain tasks like vacuum cleaning. But the proposed robot would be multi-disciplinary and help out in a range of tasks rather than focusing on specific tasks.

In the early stages the robot might be able to do a limited number of tasks but as the research progresses, changes can be made in the software part to carry on a wide variety of tasks. You can use the robot to secure your home in case of your absence. It can control other automated systems in your house using BACNet integration. Apart from these specific functions the robot would perform some tasks that would make it an integral part of your life. Clicking your picture, telling bedtime stories to children, waking you up in the morning, be your helper in the kitchen and much more.

Various functions of the robot including the movement can be controlled using a touch screen mounted on top of the robot. Apart from the touch screen, in the near future you would also be able to control the robot using your voice. For various features like voice control the robot will first verify the identity of the person giving the command using facial recognition. So many major features and some of the little things will make this robot an inseparable part of your family.

2. HARDWARE ARCHITECTURE

A. Mechanical Structure

A prototype robot has been designed and constructed for experiment purpose. The robot consists of a 5 feet long rod resting on a platform. Below the platform is the movement system of the robot. It is a multi-wheeled robot designed for movement on plain terrains. As the robot designed for home use, wheel arrangement was best suited for the purpose. A Raspberry Pi is acting as the control center of the robot. The onboard Raspberry Pi handles and communicates with all the devices inside and outside of the robot. Raspberry Pi is selected as the central control of the robot because of the broad supply of its software and hardware modules.

Majority of the electronic circuitry including the motors have been placed inside the platform at the bottom. All the components are placed in such a way so as to balance the center of mass of the robot and to ensure smooth operation. The component placement is also done taking into consideration heat dissipation of various devices. The Movement of the robot is done with the help of low RPM, high torque DC motors. These motors ensure that the robot can handle its own weight while travelling at a decent speed.A polyvinyl chloride rod is used with a stainless steel core to ensure firmness of the robot.

B. Components Used

I. ARDUINO UNO

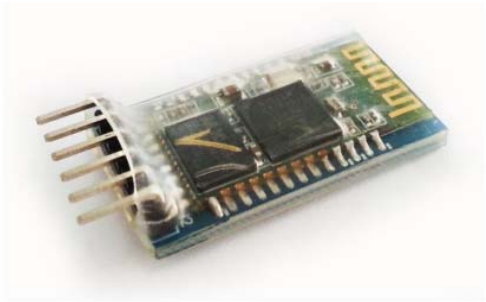
Arduino is an AVR based microcontroller which carries an 8 bit microcontroller i.e. Atmega328. It consists of 14 digital input/output pins of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. Its compact design makes it suitable for various applications.

In the project we are using this as a secondary processing unit to process commands via the Bluetooth terminal which is accessed by the user from the phone itself.

II. HC-05 BLUETOOTH MODULE

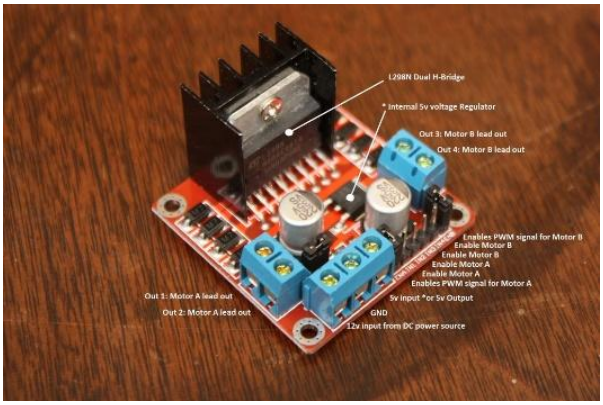
HC-05 Bluetooth Module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for wireless serial connection setup. Its communication is via serial communication which makes an easy way to interface with a controller. HC-05 Bluetooth module provides switching mode between master and slave mode which means it can be used as receiver or a transmitter.

In the project this module ensures connectivity between the application and the microcontroller.



III. MOTOR DRIVER

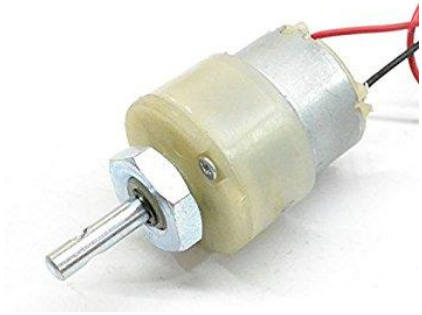
The movement of the robot is designed with the help of two DC motors which are being controlled by the motor driver IC L298N. The L298 series has operating voltage up to 46V with max current of 4A and comes with over temperature protection as well.



IV. GEARED DC MOTORS

A DC motor is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields. The used DC motor works on 12V DC supply and draws current up to 1 ampere.

In the project the robot is being controlled by the two dc motors, these when combined with the forward two free wheels allow full-fledged movement of the robot.



V. RASPBERRY PI 3 MODEL B+

Raspberry Pi 3 is system on chip based on Broadcom BCM2837 which is based on ARM cortex A53, clocked at 1.2 GHz. It has 1 GB LPDDR2 RAM (900Mhz) with other features like Ethernet support, 2.4GHz 802.11n wireless support, and Bluetooth connectivity (4.1).

In the project this system on ship is being used to perform image processing with the help of OpenCV libraries and webcam.

VI. DISPLAY PANEL

The specification of the PANEL are as follows:-

- 800×480 high resolution, touch control.
- Compatible and Direct-connect with any revision of Raspberry Pi Drivers.
- HDMI interface for displaying, no I/O's required (however, the touch panel still needs I/O's).
- Backlight can be turned off to lower power consumption.
- High quality immersion gold surface plating.

The screen is being used as an output device as well as input touch device from the user.

VII. CAMERA

A webcam is being used as an input device to capture the image these images are then fed to the raspberry pi where various image processing algorithms are implemented on the data.

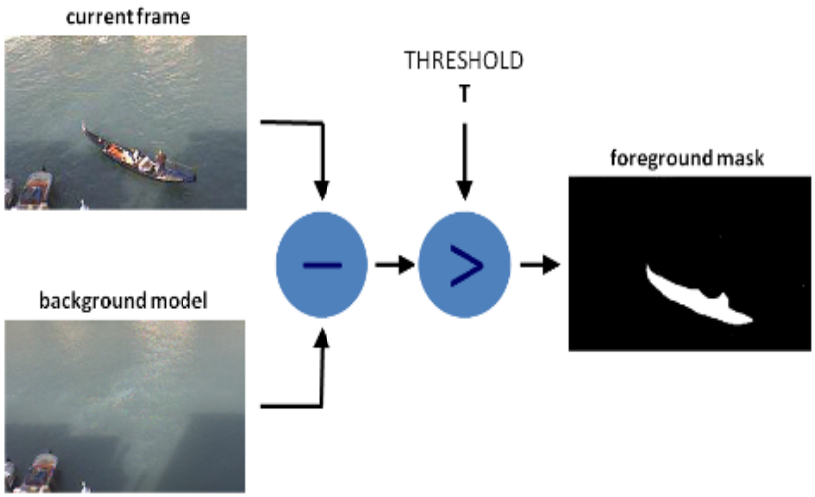
3. FUNCTIONS AND ALGORITHMS

A. Motion Detection

There is a wide variety of algorithms available in the market for detecting motion. Some of which we tried and compared before implementing in our robot are-

I. BACKGROUND SUBTRACTION

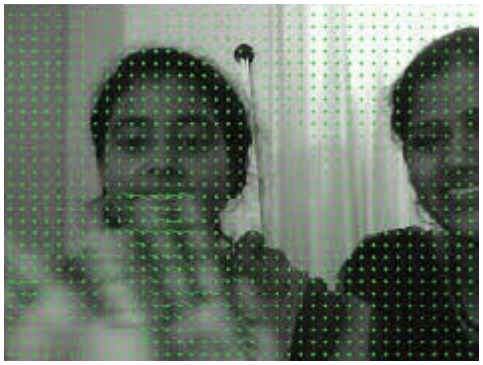
Real time motion detection was achieved by implementing background subtraction algorithm using OPENCV python directories. Background subtraction uses background images and motion depth values to detect moving objects. The background image represents an image taken at an instant by the camera with no moving objects. Motion depth values represent the movements happening in the foreground of the image taken as reference.



After subtracting the current frame from the background image, foreground mask is generated using the motion depth values. Foreground mask is nothing but a binary image containing pixels that belong to the moving objects appearing in the camera. As soon as motion is detected our robot will send a set of images to the owner as an intruder alert.

II. *OPTICAL FLOW*

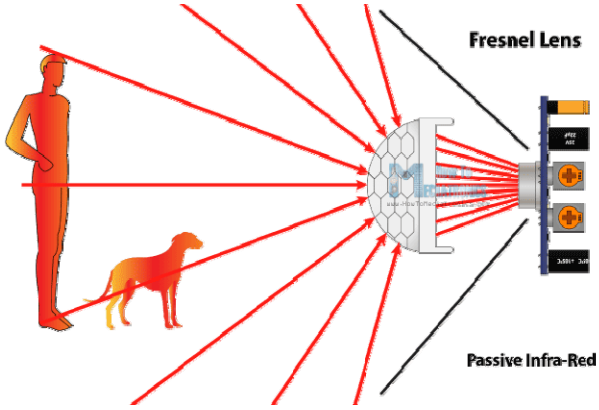
Optical flow algorithm is based on the relative motion between the objects and the camera. Optical flow is the distribution of apparent velocities of brightness patterns in an image. We can get rate of change of this arrangement or even spatial arrangement of the objects. Optical flow can be used to study a wide variety of motions that include – static observer moving object, static object moving observer or moving object and moving observer.



Optical flow returns back an array of vector for each pixel that is captured using the camera. The motion of various objects is then determined using the magnitude and direction of these vectors.

III. PYROELECTRIC INFRARED SENSOR

Pyroelectric Infrared technology is widely used as a presence trigger. Output of the sensor depends on various factors including speed and direction of the movement, body shape etc. For this project we propose an empirically aligned and modified collection of Pyroelectric Infrared Sensors.

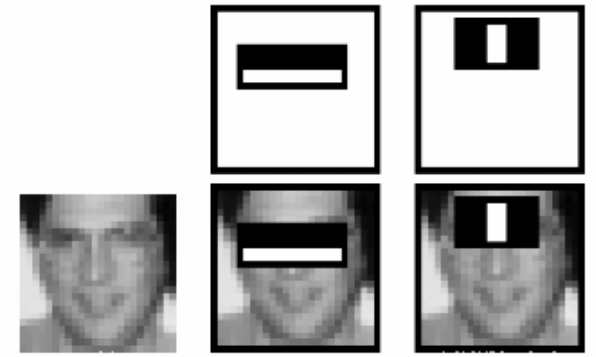


We developed a human tracking system using a sensor cluster consisting of sensors and Fresnel lens arrays to implement the desired spatial segmentations. This solution was found out to be the most promising and reliable for applications of this robot.

B. Face Detection

It has the objective of finding the faces (location and size) in an image and probably extract them to be used by the face recognition algorithm. The face detection uses Haarfeature based cascade classifiers. This method was proposed by proposed by Paul Viola and Michael Jones in their paper, "Rapid Object Detection using a Boosted Cascade of Simple Features" in 2001. It is a machine learning based approach where a cascade function is trained from a lot of positive and negative images. Then we need to extract features from it. For this, Haar features shown in below image are used. They are just like our convolutional kernel. Each feature is a single value obtained by subtracting sum of pixels under white rectangle from sum of pixels under black rectangle.

To summarize the code basically compares the darker and lighter regions of a face. Generally the region around are eyes is darker when compared to the rest of the face. Such features helps us to detect a face in an image.



C. Face Recognition

The next step to face detection is face recognition. The main function of face recognition algorithm is to find characteristics that define an image. After the first few steps of cropping, resizing and converting to grayscale, face recognition starts finding characteristics.

Mainly, there are 2 modes of facial recognition including identification and authentication of facial image. Identification is the 1xN comparison of the image whereas authentication is just 1x1 comparison.

Some different types of face recognition algorithms are-

- Eigenfaces
- Local Binary Patterns Histograms (LBPH)
- Fisherfaces
- Scale Invariant Feature Transform (SIFT)
- Speed Up Robust Features (SURF)

LOCAL BINARY PATTERNS HISTOGRAM

In LBPH, a collection of images also known as dataset is created using all the faces you want to recognize. Now, when the camera detects a face, it performs the same analysis on each of the images in the dataset to find a match. The way we analyze each image is by identifying local patterns in each image and then matching it to the current image.

The image above shows the local binary patterns in an image.

EIGENFACES

These algorithms work on a similar basis as LBPH, the main difference being that the Eigenfaces algorithm looks at the dataset as a whole rather than matching each image one by one. Eigen faces is not considered ideal for varying light conditions.

D. Text-to-Speech

For implementing text-to-speech in our robot we are using a compact open source software known as espeak. It is one of the best available modules for speech synthesis because of its less size and higher accuracy.

4. APPLICATIONS

Robots are here to stay, and we have to believe that they are capable of doing marvels in almost all fields including health care, security, education, entertainment, manufacturing etc. But robots will truly be a part of our life when they become a part of our day to day life. With this robot our main aim is to target basic needs of a home and make this robot an inseparable part of your family. Some of the applications are-

- Intruder Alert – Now you can leave your house without having any fears as this robot has got your back. Our robot uses a smart motion detection technology to detect any kind of movements in your house and send you an alert immediately.
- Take a Picture – Your very own personal -photographer!
- Alarm Clock – It wakes you up in the morning by turning on your lights and a sweet alarm.
- Cooking Guide – It guides you in kitchen by providing you detailed recipes with pictures as you cook delicious cook for you are your loved ones.
- Story Teller – It is a wonderful story teller for your little ones with a large number of stories available to choose from.
- Home Automation – It can control all the appliances in your home and also integrate with already automated homes with BACNet integration.

5. CONCLUSION

In this paper, a prototype of personal home assistant robot is designed. The robot is equipped with several intelligent functions and can assist people in many potential ways including security, automation, daily tasks etc.

6. FUTURE WORK

In the near future every function of the robot would become more precise and accurate. Voice commands from anywhere, high level security, lighting scenes for your home, much more entertainment.

Robot will become much smarter as more artificial intelligence would be inserted into the robot. Machine learning would make things much better and unbelievably convenient. Robot will also become mechanically updated with much more moving parts and with better degree of freedom.

7. REFERENCES

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