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Ultra Modern Robotic Helping Hand

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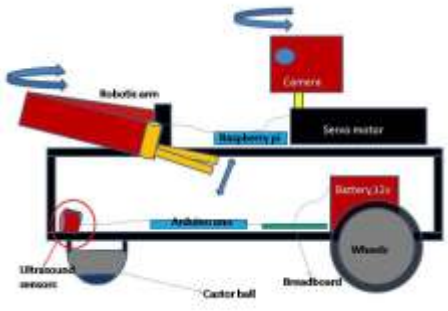
***Abstract*: --- imagine a robot that follows you and does work under your guidance. This is Helping Hand. It has a robotic arm that symbolizes human hand thus its name Helping Hand. The robot has two parts, the ultrasonic follower part and an advanced computing part which has the robotic arm. The Ultrasound follower part detects the direction and distance of a human source which emits ultrasound. It is powered by an Atmega328 based Arduino Uno. The advanced human detector part consists of a Camera and a robotic arm both of which are under a computer on chip such as Raspberry Pi 3. The overall design consists of a base ultrasonic follower on a rover platform and an advanced computing part laid upon the base. It follows a suitable ultrasound emitter with a human and along with image processing the exact distance, direction of movement is found and a host of other features like gesture control can be added. When the robot is start up, it suitably follows the human, when he stops, the robot looks around it to find for objects and if found, it goes near objects to pick up and keep it on its base or a suitable platform, it then searches for the human, it continues to follow until the human stops again and shows his hand gesture, which tells the robot which side the object has to be placed back. After placing it again starts to follow the human.**

I. INTRODUCTION

All of us have come across various types of human following robots. The problem in making a successful human following robot arises when we use it in a real life scenario. For example, when the robot has to follow a person in a crowded place. Various approaches have been used so as to make it as accurate as possible. Through this paper we would like to investigate the use an Ultrasound sensor system in the same regard. Further, with the usage of image processing, the robot is made capable of recognizing different kinds of object that the bot would have to work with. Studies relating to adding of extra features such as object lifting have also been dealt with.

II. SYSTEM MODEL



Two wheels connected by the motor shaft and a castor ball are used for the motion of the robot. They are placed on a platform which basically forms the rover platform. This is the base platform. On the base platform we have the components required for ultrasound detection and processing. They are parts like an arduino board, breadboard for circuit connections and ultrasound receivers. A lithium ion battery supplies power to all the components. The ultrasound sensor input goes to breadboard after which it goes to the arduino board. It then controls the motors required for movement with the help of L293D IC. The arduino also has inputs from the Raspberry pi which allows it to use both image processing and ultrasound data.

The platform over the base is the advanced computing part of the project. It consists of computer on chip such as a raspberry pi. Raspberry pi forms the controller of the robotic arm and it gets input from the camera which can rotate with the help of a servo motor.
The robotic arm uses servo motors for accurate pick up and drop of object.

a. Working:

The robot is started up. It starts to follow the human source. When the person stops, that is, the ultrasound received input is a constant input, and in the image processing a stable image of person is detected then, it waits for the gesture signal from the person then, the camera atop starts to rotate, it searches for images to find a matching code, when found, it inputs the Pi to activate arm as well and directs the camera to focus upon the object. So

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even if the rover moves while going towards the object, the camera is focused, it estimates distance by comparing image with stored code. When it reaches a suitable distance, the arm starts to move towards the object. It picks up object, keeps it on the platform. The input to raspberry is given that the job is complete. Raspberry then activates arduino to listen for Ultrasound, then the robot continues to follow the human. When the person stops next time, the robot waits for a gesture sign from the person which directs the Pi, hence the arm to keep the object. Thus the job is completed and the bot continues to wait for the gesture from the person to pick up an object and again it follows the human for the place where the object to be placed.

III.BASIC BLOCK DIAGRAM

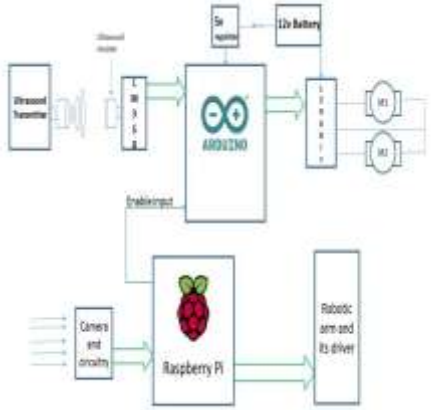

Fig. 2 Block diagram

The block diagram above consists of two parts, the ultrasound detector and follower and second one being the image processing and robotic arm unit. The first part consists of an ultrasound transmitter emitting ultrasound by the use of a transducer. The sound is received by the receiver transducer which produces small voltages which has to be amplified by a suitable amplifier, here LM358 Op amp is used. The output of amplifier is fed to arduino board which analyses the input and gives suitable output in terms of Pulse Width Modulation to a suitable H-Bridge which allows running motor in both possible directions. Here a suitable motor driver such as L293d IC has been used. It has been discussed in upcoming sections. The second part is the Image Processing and robotic arm unit.

***Arduino Board**:*

Fig. 3 Arduino board

The Arduino UNO R3 is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller.

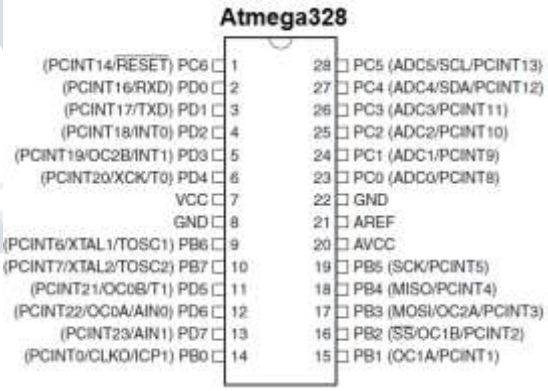

Fig. 4 Atmega328 IC

The Atmega328 has 32 KB of flash memory for storing code (of which 0.5 KB is used for boot loader).It has also 2 KB of SRAM and 1 KB of EEPROM

RASPBERRY PI 3:

The raspberry pi is a credit card sized System on Chip (SoC) computer developed in United Kingdom. Raspberry Pi series has range of models. The model which is employed in this project is Raspberry Pi 3 which uses a Broadcom BCM2837 SoC with a 1.2 GHz 64-bit quad core ARM Cortex-A53 processor, with 1GB of RAM and 512 KB shared Level 2 cache memory. The Operating system we prefer can only be flashed onto an externally inserted

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micro SD card. The foundation provides Debian and Linux distributions for the basic operating system on Raspberry pi, but many third-party distributions can also be flashed onto the memory and promotes Python as the main programming language and also supports C, C++ Java, Pearl etc.It can be powered using a micro USB or GPIO header of 5 V supply (takes 800mA).

Fig. 5 Raspberry Pi

IV. HARDWARE ON BOARD:

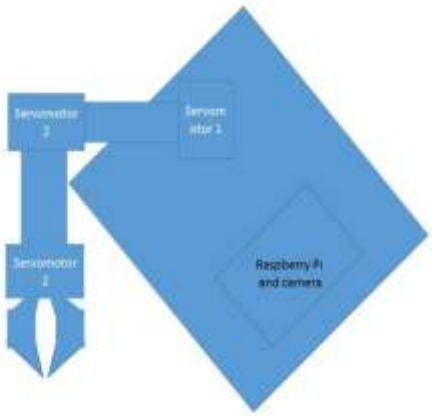
Raspberry pi 3 has HDMI port, on chip WIFI 802.11n and Bluetooth module, and a 3.5 mm phono jack for audio. Lower level output is provided by GPIO pins which support common protocols like I2C. It also has an Ethernet port for internet access. It has 4 USB 2.0 ports for external peripherals like mouse, keyboard, flash drive etc. The Raspberry Pi does not have a real-time clock, which means it cannot keep track of the time of day while it is not powered on. As an alternative, a program running on the Pi can get the time from an online time server or user input at boot up time. A real-time clock (such as the DS1307) with battery backup may be added (often via the I²C interface).

Image processing:

Image processing is processing of images using mathematical operations by using any form of signal processing for which the input is an image, a series of images, or a video, such as a photograph or video frame; the output of image processing may be either an image or a set of characteristics or parameters related to the image. Most image-processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it.

The robot uses camera connected the raspberry pi to capture the image and the image processing is done using OpenCV software which will be installed in the raspberry pi. When the object captured as an image matches with the image of the object to be lifted, the raspberry pi sends an output signal over one of the GPIO pin which is then fed to interrupt of Arduino. The controlling of the robotic arm is discussed in further sections.

Robotic arm:



The robotic arm shown above uses 3 servo motors for complete movement in cylindrical axis. The arm is placed vertically upon the platform, it is connected to arduino using input output pins. After the Image processing output from the raspberry pi, output is taken from one of the GPIO pins and fed to interrupt pin of the arduino. Usually any robotic arm has 6 degrees of freedom. According to our code and the instructions written in arduino, the roll, pitch and yaw of the arm is controlled and thereby lifting the object and carrying it to another place on top of the platform.

LM358 IC:

It is a low power dual operational integrated circuit. It is designed as an amplifiers, high pass filters, low band pass filters and analog readers and these can be operated with a single power supply over a wide range of voltages it can be used as transducer amplifiers dc gain blocks it can work with 5v supply which can be easily provide the required interface electronics without any extra 15v power supply.

Here it is used to amplify the smallest input (mV) from the ultrasound receivers to readable outputs to arduino and it can amplify two different input signals.

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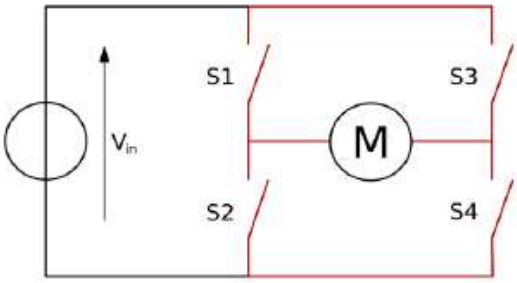


CKT.3 H-Bridge

Here, it is used to drive two motors.

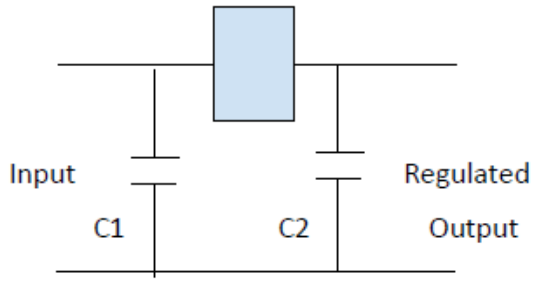
Both the h-bridges present in the IC help us in making the dc motors to move anticlockwise and clockwise. The diodes present in above circuit act as switches here.

S1 (+ve), S4 (-ve) - clockwise rotation
S3 (+ve), S4 (-ve) - anticlockwise rotation

Arduino controlled l293d IC can be programmed according to the usage and interrupts which helps to control the direction and movement of both the motors and work as per the requirements.

DC MOTOR (300RPM):

This a class of of electrical machine which converts direct current electrical supply into mechanical power, this rely on the magnetic fields produced by input electrical power supply most of the dc motors produce rotary motion; a linear motor produces force and motion in straight line. A dc motor speed can controlled by using a varied supply voltage (pulse width modulation) or by changing strength of the current in its field windings large dc motors can be used in propulsion of electric vehicles, elevators etc.



CKT. 4 Regulator

In this circuit capacitor C1 is used to filter any noises coming from the voltage source as the regulator works best when provided with pure DC input. Hence C1 acts as a bypass capacitor.

Capacitor C2 is to filter the high frequency or ac noise at the output. In the experiments conducted, a 12V battery is used since one had to satisfy the needs of the motor , hence it was required to use the voltage regulator to provide lower inputs to components such as Arduino which require only 5V.

Lithium ion battery:

Lithium ion battery is a type of rechargeable battery which charges and discharges by the movement of Li ions. We have used Li ion battery in the experiments for the following reasons: -

1) They are very light, hence can be easily placed on the bot.

2) Lithium is also a highly reactive element, meaning that a lot of energy can be stored in its atomic bonds. This translates into a very high energy density for lithium-ion batteries. Here is a way to get a perspective on the energy density. A typical lithium-ion battery can store 150 watt-hours of electricity in 1 kilogram of battery.

3) They are memory less, hence there is no need for high discharge before charging

Generally the positive terminal of the battery is made of lithium-cobalt oxide, the negative terminal is graphite and the electrolyte used is usually any Lithium salt. The basic working is as follows: - When the battery is charging up, the lithium-cobalt oxide, positive electrode gives up some of its lithium ions, which move through the electrolyte to the negative, graphite electrode and remain there. The battery takes in and stores energy during this process. When the battery is discharging, the lithium ions move back across the electrolyte to the positive electrode, producing the energy that powers the battery. In the robot we use a 200 rpm motor which requires 12v supply. This is provided by the Li ion battery. 9

Ultrasound Transducer:

Fig.10 Ultrasound transducer

The ultrasound transmitter and receiver works on the principle of piezoelectric effect. When an electrical voltage is applied to the transmitter, the piezoelectric material vibrates continuously. These vibrations generate

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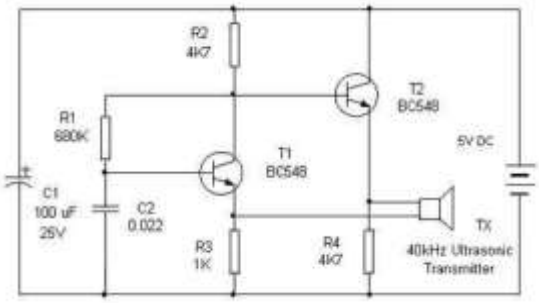
ultrasound which propagates in a straight path because of the conical shape of the resonator. Ultrasonic receiver works on the reverse concept. When ultrasonic waves strike with the resonator, the attached vibrator (metal plate) vibrates. With the vibration of the piezoceramic disc pasted on the vibrator, an electric current is produced .This electric current is further taken out as output.

IV. THE ULTRASOUND FOLLOWER

A) Ultrasound emitter:

The circuit consists of emitter coupled transistors T1 and T2. A 9v battery is used to supply the power to the circuit. The circuitry is connected to capacitors who's charging and discharging action produces a desired frequency of nearly 40 KHz. Suitable resistors of high value along with capacitors and transistors form the emitter coupled oscillators which can generate a stable frequency and provide suitable power for the ultrasound transmitter to operate. A voltage of 4v is seen across the transducer when it is connected to the transmitter circuit.



Ckt. 5 Ultrasound emitter

B) Ultrasound receiver:

The Ultrasound received input is fed to the non-inverting amplifier made using LM358 with a gain of 1000, so an input from Ultrasound receiver in range of millivolts gets converted to an order of volts. The output is fed to the analog input of arduino.

C) Arduino:

The analog inputs of arduino are 1024 values in range 0 to 5v. So a small voltage change is easily detected. For a range of values 1.5v to 2.5 volts, the robot stays at position. For voltages less than 1.5v and greater than 0v, the robot moves front. For ranges of voltage greater than 2.5v, the robot moves back. Also, arduino gets inputs from two sensors in front so a differential voltage gets generated.

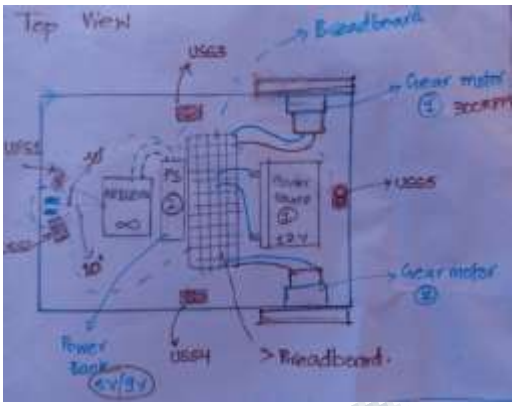


Fig. 12 Design of part 1.

So when uss1 receives more input, the robot rotates towards right and when uss2 receives more input, the robot turns left to align itself to get a balanced input.
The output of Arduino are four pins mc1 ma1, mc2 ma2, here mc means motor clockwise and ma means motor anticlockwise.

Depending upon the sensor inputs, the pins are made high, and these outputs are inputs to a motor driver IC like L293D. L293d gets a 12v source input, and its outputs are the motor terminals connected. So depending on the values of the Mc1, Mc2, Ma1, ma2, the motors are made to turn clock or anticlockwise.

D) Image Processing By Raspberry Pi 3:

The format of the image we take from the camera uses the colour model RGB, with 8 bits per colour channel. This gives us a range of values between 0 and 255 (inclusive) for each channel of each pixel. What we are going to do is iterate over every pixel in turn and set their colour to the pixels dominant channel. We use an open source software called OpenCV and Simple CV that allows high level approach for the need of image processing.
First off, the image of the object to be lifted is loaded onto the Pi and the Python code is made to execute which actually tries to match all the possible samples of the image loaded onto Pi with the live image captured by the camera. If the image captured at that time matches any of the samples, the Pi will send a signal to one of the GPIO pins for further actions to be made. The working of the robotic arm after the image processing is discussed in the earlier sections.

E) Controlling of Arm:

The robotic arm is controlled by Arduino as shown in the figure below. A supply voltage of 5v is used and using PWM outputs from the Arduino pins 11,10,9, the angular movement of the servo motors is done. These motors

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V. APPLICATIONS:

1. One of the major advantages of the robot is its industrial use, that is, it can lift heavy objects that humans can't lift and easily place it at a desired place in a fully automated way.

2. It can be used in mapping a place, where the way is just shown by a human.

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