

Development and Implementation of an Automatic Braking System using MATLAB, Arduino, and Ultrasonic Sensor Technology

Rohan Desai, Karan Kulkarni, Aarav Patel, and Dr. Nalini Singh

Department of Mechanical Engineering, Mumbai College of Technology (MCT), Mumbai, India; Department of Mechanical Engineering, Mumbai College of Technology (MCT), Mumbai, India

Abstract

Context: The increased utilisation of vehicles and carelessness has resulted in increased road accidents and hence deaths. Therefore there is a need to enhance the safety of driver, passengers and all the associated people.

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Objective: To design and develop real time red colour and distance detection with the help of MATLAB and ARDUINO platform respectively.

Research Methodology: - Identify the different needs from practitioners. Identify different alternatives to satisfy the needs. Select the best alternative and develop the model. Validate the design through prototype.

Conclusion: The proposed system can be utilised in any vehicle. Reduction in the occurrence of accidents is achieved with the solution which is cost effective with respect to functionality.

Impact on Technology: Enhances driver and vehicle safety as compared with the conventional system, by preventing the occurrence of accidents.

Key words: Delphi method, Video Processing, MATLAB, Arduino.

INTRODUCTION

Accidents are one of the major cause of death in India. According to a TOI article (8th of February, 2018), about 1.46 lakh deaths solely due to road accidents in 2017 were reported. Some of the underlying reasons for the same are driver carelessness, running a red light or stop signal, reckless driving, distracted driving etc. Therefore, in this paper we introduce a technique in automobile technology wherein real time detection of distance between two vehicles and red colour detection go hand in hand to ultimately prevent road mishaps and thus loss to life and property. The proposed system utilises software such as MATLAB and Arduino IDE and hardware such as camera, Ultrasonic sensor, Motor etc. The colour detection algorithm has been developed on MATLAB platform. The main advantage of using MATLAB as an image processing software is it's built in image processing functions and compatibility with various hardware such as Arduino, camera, Ultrasonic sensors etc. Ultrasonic sensors detect the real time distance between the driver's vehicle and vehicle upfront. This Input from the Ultrasonic sensors are then fed to Arduino IDE wherein it is processed. The Webcam is used to monitor the specified region of interest. The Image acquisition algorithm is then applied on live feed captured through camera. If the red colour is detected in the frame, the serial output will be sent to the arduino through serial communication port. The ultrasonic sensor is also connected with the arduino, helps to detect the obstruction in specified range. The output of ultrasonic



sensor is then compared with the serial output from MATLAB and depending on the logic the brakes are actuated.

PROBLEM SELECTION

The following projects were identified as they were related to vehicle control. Therefore to choose anyone from these, implementation of Delphi method was necessary.

Table -1 List of projects related to vehicle control

| Project Code | Project Description |
|--------------|--|
| P1 | Vehicle control using hand gestures |
| P2 | Interfacing of MATLAB with arduino for Real Time red object and distance detection |
| P3 | Smart car parking with Voice Assistant in Smartphone |

A team of 14 experts was selected to perform Delphi method. In the first stage different projects were discussed and the criteria to rank the projects was set accordingly. In the second stage the expert's opinion were analysed.

Table -2 Votes from Expert panel

| Project | Experts | No. of experts | Percentage |
|---------|-----------------------|----------------|------------|
| P1 | Top level managers | 3 | 21.43 |
| P2 | Middle level managers | 7 | 50 |
| P3 | Low level managers | 4 | 28.57 |

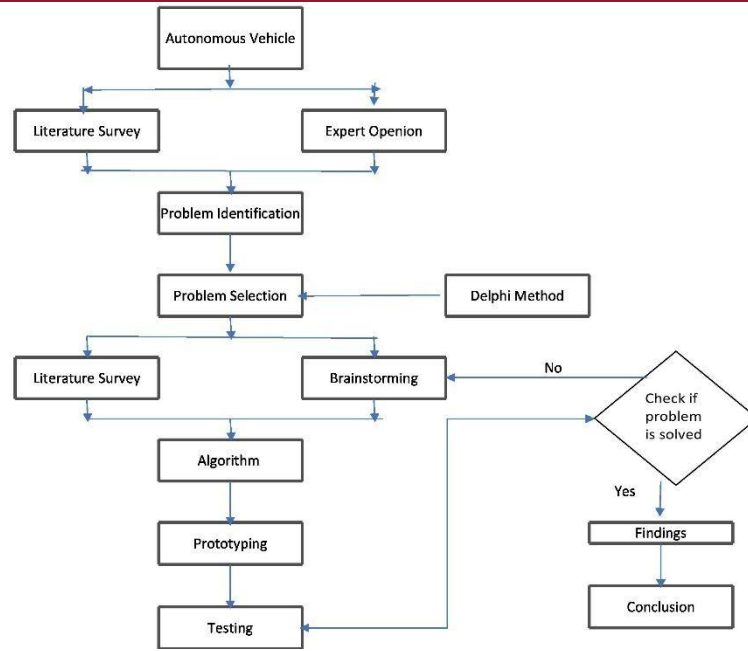
Table -3 Overall review Problem selection matrix

| Project | Criteria | | | | Total |
|-----------|-------------|--------------------|-----------------------------|-----------|------------|
| | Safety(0.4) | Effectiveness(0.3) | Ease of implementation(0.2) | Cost(0.1) | |
| P1 | 3 | 5 | 7 | 7 | 4.8 |
| P2 | 7 | 9 | 6 | 8 | 7.5 |
| P3 | 6 | 4 | 6 | 5 | 5.3 |

The result of Delphi method is as shown in Table 3. The outcome from the Delphi method suggested Interfacing of MATLAB with Arduino for Real Time red object and distance detection as the most critical project.

RESEARCH METHODOLOGY

In this section the methodology was developed and as shown in figure 1. The various problems are identified based on literature survey and expert discussion. The Delphi method was used to identify critical problem. In next part of methodology prototype was developed and validate by performance testing.

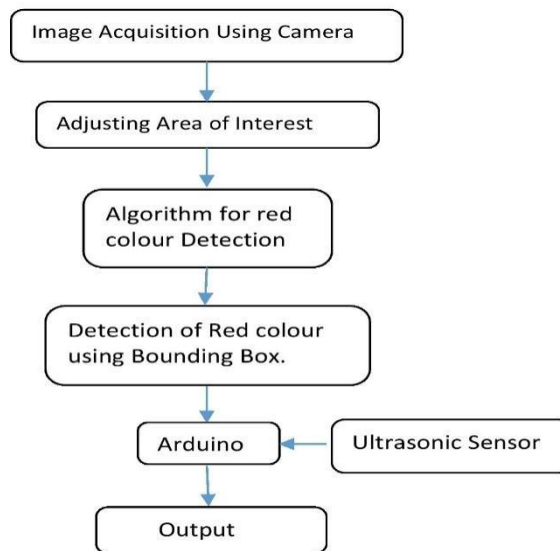


Flowchart 1

MECHANISM

Live Feed (Real Time Red Colour Detection):

The real time video tracking algorithm works on the image processing. The MATLAB is used as platform for image processing. For the acquisition of image a hardware camera or Laptop Webcam can be used. The live video feed can be saved in the laptop memory, which can be deleted at the end of the process. The camera continuously monitors the specified area and if the red colour object is detected in the frame then it builds a bounding box around it. To get an info about the hardware camera “imaqhwinfo” command can be used.



Flowchart 2

Image Acquisition:

After starting a live feed from camera connected to laptop, the snapshots are taken after particular intervals (Milliseconds) in order to apply further image processing algorithm of red colour detection. The image acquisition toolbox is widely used for real time video input processing. The commands used in the MATLAB code are given below.

Table -4 MATLAB Functions

| Function/Command | Use |
|------------------|--|
| imaqtool | It launches an interactive GUI to allow you to explore, configure, and acquire data from your installed and supported image acquisition devices. |

| | |
|-------------|---|
| videoinput | It creates video input objects. |
| Regionprop | It measures properties of region which is monitored by camera |
| Getsnapshot | It immediately returns one single image frame |

An algorithm to detect Red colour in an image:

To start detecting the red colour in an image the very first requirement is to have an image with red colour part embedded in it. The image can be read from live feed through a Web Cam provided on laptop, by taking snapshots after particular intervals. After getting an image snapshot from the live video input, the algorithm stores the RGB component of the image in the specified 3D array. After this, The RGB colour bands are extracted from input image and stored into three separate two dimensional arrays using the command “rgb2gray(X)”. The RGB image is then converted into the greyscale image followed by the binary image. During greyscale conversion the maximum limit of pixels are set up for these RGB colour bands. The red colour is detected by subtracting greyscale image from blue band and green band using the command “imsubtract (B, G)”. After subtraction the unwanted noise is reduced from the image is reduced and the image is converted into binary image using command “im2bw(X, limit)” to focus and work only on interested area of image.

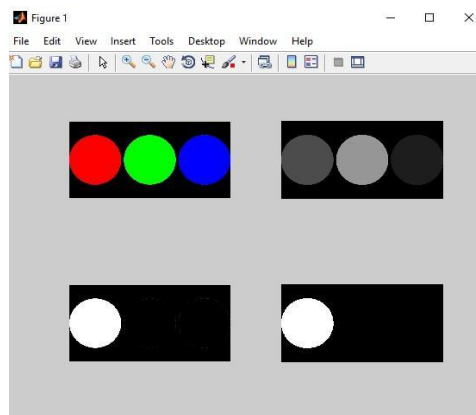


Fig. 1 Red Color Detection

INTERFACING BW MATLAB AND ARDUINO AND ULTRASONIC SENSOR

Arduino was used as a merger between the MATLAB output (red color detection) and the ultrasonic sensor signal. There were four possibilities viz. low signal output from MATLAB and low signal output from ultrasonic sensor, low signal output from MATLAB and high signal output from ultrasonic sensor, high signal output from MATLAB and low signal output from ultrasonic sensor, high.

Table -5 Interfacing with Arduino

| MATLAB | ULTRASONIC | IMPLIFICATION |
|--------|------------|---|
| Low | Low | no red color and no object detected 3 meters ahead |
| Low | High | No red color detection but presence of an object within 3 meters ahead of the vehicle. |
| High | Low | presence of red light but no object ahead of vehicle so the red color maybe be of something other than the signal |
| High | High | detection of both red color and object present within 3 meters ahead of the vehicle indicating that the red color is signal light |

Arduino programming is used to actuate the motor which further used to assist the automatic braking depending upon the situation that a driver comes upon while driving. The outcome of four possibilities are explained as follows:

CASE 1: low signal output from MATLAB and low signal output from ultrasonic sensor. Low signal output form MATLAB is when, there is no color detected by the camera and low signal output from ultrasonic sensor means that no obstruction present on the road. Hence it means that the red color detected is not of signal and can be ignored the car can keep going without alteration of its speed. Furthermore,

CASE 2: the next case i.e. low signal output from MATLAB and high signal output from ultrasonic sensor low signal from MATLAB is when, there is no color detected by the camera and high signal output from

ultrasonic sensor which shows the presence of obstruction on the path of car implying that car needs to be stopped thus the driver is alerted and motor is actuated and the car is brought to rest within seconds

CASE 3: high signal output from MATLAB and low signal output from ultrasonic sensor high signal output from MATLAB corresponds to presence of red color maybe of signal and low output signal form ultrasonic means no obstruction on the road and therefore the signal can be ignored since the red color detected is not of signal. And no actuation takes place.

CASE 4: high signal output from MATLAB and high signal output from ultrasonic sensor, when both high output signal by MATLAB and ultrasonic sensor implies that there is presence of red light which may be a red signal light and obstruction on cars path respectively. Which is a true indication of a Red traffic signal and driver is alerted hence the car is stopped gradually.

```

sketch_apr10a$
// defines pins numbers
const int trigPin = 9;
const int echoPin = 10;
// defines variables
long duration;
int distance;
void setup() {
  pinMode(trigPin, OUTPUT); // Sets the trigPin as an Output
  pinMode(echoPin, INPUT); // Sets the echoPin as an Input
  Serial.begin(9600); // Starts the serial communication
}
void loop() {
  // Clears the trigPin
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  // Sets the trigPin on HIGH state for 10 micro seconds
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
  
```

Fig. 2 Arduino Ultrasonic

```

arduino_red_cd | Arduino 1.8.5
void loop()
{
  if(Serial.available()>0)
  {
    recValue=Serial.read();
    if (recValue == 100) // If use will send value 100 from MATLAB the
    { digitalWrite(ledpin, HIGH); }
    if(recValue == 101) // If use will send value 101 from MATLAB ther
    { digitalWrite(ledpin, LOW); }
  }
}

```

Fig. 3 MATLAB Arduino

HARDWARE IMPLEMENTATION:

In developing this system, role of camera used for image acquisition purpose plays an important role. The implementation of the hardware part was done with the help of Arduino Microcontroller. Proper selection of hardware plays a vital role in this project. Here arduino board is used which was powered by Atmega 8 microcontroller. The precise coding in arduino provides an excellent platform for serial communication.

Image Acquisition Device

There are various cameras available in the market with various resolutions. Better the resolution better will be the effectiveness of the system. For the prototyping purpose, the build-in laptop webcam is used in this project. Here, the device takes snapshots with the prescribed triggering rate. These snapshots are further processed in MATLAB using image acquisition toolbox. **Ultrasonic Sensor**

An ultrasonic sensor usually transmits ultrasonic waves into the air and receives deflected waves from an object. The HC-SR04 Ultrasonic Module has 4 pins, Ground, VCC, Trig and Echo. The Ground and the VCC pins of the module needs to be connected to the Ground and the 5 volts pins on the Arduino Board respectively and the trig and echo pins to any Digital I/O pin on the Arduino Board.

Motor Driver L293D

Circuit diagram

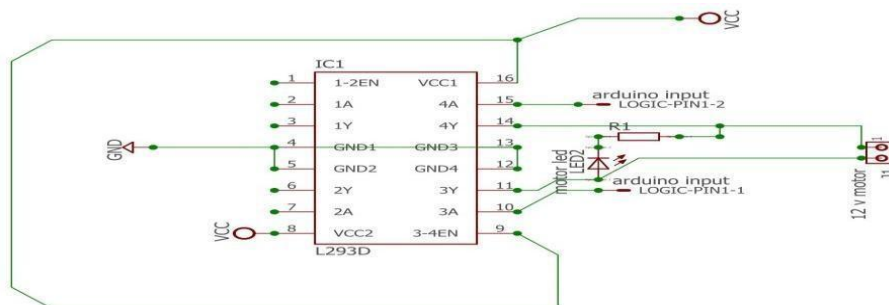


Fig. 4 Motor driver

Motor Driver L293D is used to control the motor, actuated after satisfying the given conditions mentioned in the code. The Nema 17 stepper motor which we are using can't be directly connected to the arduino. It needs to be connected through a motor driver. The motor driver circuit is shown below.

SPECIFICATIONS OF HARDWARES Table -6 PART LIST

| Sr. No. | Part | Function | Specification | Quantity |
|---------|-----------------------------|--|---------------------------------|----------|
| 1. | Wireless Cam/Inbuilt Webcam | Video feed to Matlab, adjusting the area of interest | Webcam | 1 |
| 2. | Ultrasonic Sensors | Distance Measurement | HC-SR04 | 1 |
| 3. | Arduino Uno | Microcontroller-Processing multiple inputs | Arduino Uno R3, Atmega8 | 1 |
| 4. | Motor driver | Actuation of Braking | Nema 17,1.7 ⁰ ,Step. | 1 |

PROTOTYPING FOR TESTING

This is a very important step as it gives realistic scenario of 3D model. The parts required for the assembly such as arduino uno circuit board, ultrasonic sensors, motor drivers, wireless webcam and basic vehicle structure were purchased from a local electronics market.

The resolution entered initially into the MATLAB code was set to 1240x480, because of which there existed an error of video input command. This problem incurred as the pixels were not assigned according to the hardware camera requirements. However it was solved by setting of video resolution as 620x240p

The video input used to stop abruptly when input to vid Frame Acquired command value was less than 1000. To overcome this issue the Frame Acquired was set to be less than or equal to 10000. Video input resolution was set to be YUY2_620x240 pixels

The entrance of red colour into the frame led to the stoppage of the live stream from camera. The problem persisted until the exit of red colour from the frame. However this problem was eliminated by the utilisation of command Bounding Box.

RESULTS

After a brief study, the following logic was implemented. Unless and until the Output signal from ultrasonic sensor or from both sensors combined (MATLAB and ultrasonic sensor) is not high, the actuator i.e. the motor remains unactuated. The when the output is High, and user will be alerted by means of an indication along with the automated braking system (Actuation of motor).

Table -6 Results

| INPUT FROM MATLAB | INPUT FROM ULTRASONIC SENSOR | OUTPUT/STATUS |
|-------------------|------------------------------|---------------|
| Low | Low | Unactuated |
| Low | High | Actuated |
| High | Low | Unactuated |
| High | High | Actuated |

CONCLUSION

This paper demonstrates that how a simple system consisting of functional combination of wireless webcam and ultrasonic sensors can enhance the safety of the driver, fellow passengers and pedestrians and extensive loss to property by ultimately reducing the occurrence of accidents.

The solution is cost effective, easy to manufacture and easy to install. The efficiency of prescribed system increases in adjunct to Anti-Lock Braking system. In addition it also imbibes a sense of responsibility into the driver because of the displaying warning signal that makes the driver to proceed with caution.

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