Design and Development of Advanced Driver Assistance System using MATLAB

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Abstract - To meet the demands of growing population the numbers of vehicles are continuously increasing on the road and thereby it become necessary to ensure the safety of the drivers. Therefore it is need of the time to find a viable embedded solution in order to assist the driver. In this paper, a low cost and user friendly system has been designed that will assist driver in order to prevent accidents. Radar sensor HB100 has been used to detect the distance between the prototype vehicle and object in front. After safe distance, this system keeps on decreasing the speed of vehicle when an object keeps on coming more towards prototype vehicle. In this system collision mitigation is achieved by stopping vehicle at the threshold distance after accessing the relative velocity of vehicle from both front and back side of the vehicle. A graphical user interface has been developed in MATLAB. This GUI display the distance between vehicle and object, vehicle type, distance between headlights and the pictures taken by the camera. This picture displays the image of an object in front and vehicle will be categorized into different types on the basis of headlight distance. In this system, a new algorithm of image processing has been developed especially for night time so as to overcome problems such as Visual acuity, contrast sensitivity, spatial resolution, angular resolution and distance perception. In the previous developed algorithms only rear light lamp pairing was used and distance perception was not employed. In this algorithm combination of results of cross correlation of headlight and rear lamp pairs and distance from ultrasonic sensor has been used.Robust detection of targets is achieved by the system, with fewer occurrences of false targets such as street light. Thus more accurate results are obtained by this algorithm.

***Keywords* -** *ADAS, ECUs, MATLAB, Kalman Filtering, Global-based detection.*

I. INTRODUCTION

Embedded systems in automobiles started from the space program developed by NASA. After that, the advancement in the field of automobiles has gained popularity; many ECUs (Electronic Control units) have been developed by different car manufacturing companies. Out of which, few ECUs include that of driver assistance system.

A. Levels of Driving Automation

Various levels of Driving Automation are described in Table 1.1, different part are as follows:

- Non-Automated Driver Assistance
- Combination of Longitudinal and Lateral Driver Assistance: Driver needs to supervise and ready to take over
- Full automation in selected in selected situations and roads e.g., freeway
- Full automation

The ADAS in case of automation provides two to three of the following features namely:

In case of emergency it provides facility of automatic steering and braking intervention. The designing of Predictive ADAS is done to prevent the accidents. They can take partial control of the car’s movement. These automated safety systems are leading the way for future’s fully automatic vehicles.

Type of Sensors used for Monitoring Driver Automation for Driver Assistance is achieved by usage of different sensors. The description of such sensors is described as:

- CMOS sensor:Video and images cameras that use the CMOS sensor are considerably less costly and more susceptible to heat changes as compared to CCD systems. They are comparatively flexible that adjusts effortlessly to variable amount to differences in brightness.
- Lidar sensor:Lidar is the acronym of Light detection and ranging. It consists of laser that radiates light pulses. The aforementioned system receives the reflected light back from objects and thereafter approximates the range (approx. 150 m).
- Radar sensor:It emits EM waves in the GHz range. It analyzes the reflection or echo of these waves. The distance and speed of the object reflecting of the waves is calculated. They range between 50 m to 150 m.
- Infra red sensor:It identifies and detects the reflected EM waves in the spectrum between visible light and microwave radiations.
- Thermal imaging camera:It employs a special photo sensor to identify heat sources and thus recognizes the shapes of living beings.

Fig 1 : Range of different sensors

II. PREVIOUS WORK

Jianqiang Wang *et al.***,** proposed Region tracking-based vehicle detection algorithm employing image processing technique Tail lights were paired with the help of global detection algorithm [6]. AkhanAlmagambetov*et al.*, used kalman filter algorithm and a codebook for detection of braking and turn signals of vehicles both in night and daytime [8]. Ye Li, Qingming Yao*et al.*,employed Kalman filtering tracking algorithm for detection of rear lamp pairs of vehicles. Threshold segmentation was performed in order to extract the information about both the unlit and lighted lamps. In the HSV space threshold value were opted automatically with the help of method of Maximal stable extrema region (MSER).Two adjacent lamp candidates moving together were categorised together as ROI.Rear lamp based vehicle detection and tracking for complex traffic conditions was presented in this paper [11].

III. HARDWARE DESCRIPTION

A. Arduino ATMEGA 2560

Controller is the main component as it works as the mind for the whole system designed. Microcontroller has crucial role in any control unit.The main component of Arduino AT MEGA module is the microcontroller. The internal capacity is the difference between the types of microcontrollers used. Moreover, this microcontroller is very common for its simplicity and low cost. Following section discuss input and output pins of AT mega 2560 module.

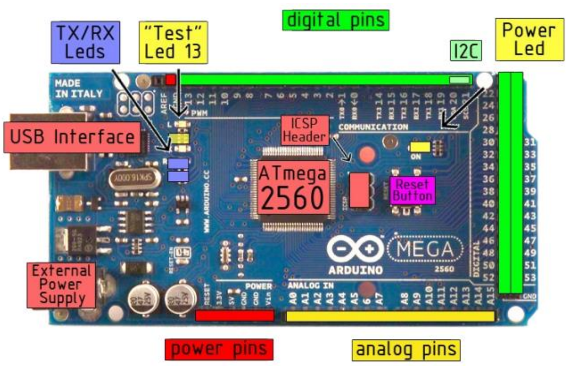

Fig 2: Arduino prototype Development Board

B. Microwave sensor module Doppler radar module

HB100 is a miniature microwave radar based motion sensor. It is used for vehicle detection and speed measurement. It can work in all environment conditions such as fog, nigh conditions etc. It works in X-band. Its basic advantage is that it has long range. It has following specifications:

Frequency: 10.525 GHz
Range: 1 m to 100 m
Antenna Beam width: Azimuth-80, Elevation-40
Supply Voltage: 5 V

Figure 3 depicts the block diagram of the radar module. It contains various parts namely transmitter, receiver, mixer andoscillator.

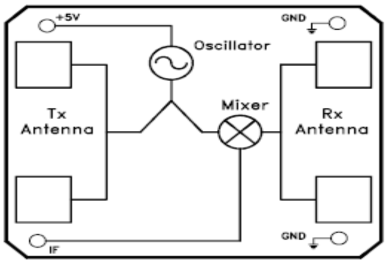

Fig 3: Block diagram of Radar Module

C. Camera

A digital camera is a camera that encodes digital images and videos digitally and stores them for later reproduction. Most camera sold today are digital and digital cameras are incorporated into many devices ranging from PDAs and mobile phones to vehicles. In this proposed work, camera is used as an input sensor to capture the real time video. The INTEX IT-306WC Camera is used for capturing input images of real-time road scenario.

Fig 4: INTEX IT-306WC camera

Specifications of INTEX IT-306WC Camera

Operation:	**Plug and play**
Image sensor:	High Quality CMOS sensor
Image Resolution:	30megapixels(3280x2460)
Angle of view:	58 degree
Image format:	RGB 24
Interface:	USB 2.0
Frame rate:	30 fps
Maximum:	1W
Focus range:	4cm to100 m
Power consumption:	160mW typical

D. LCD display

LCD display is used to continuously show the monitored level of the fume inside the cabinet. It shows the continuous volume of carbon monoxide gas inside the cabinet. A Liquid Crystal Display (LCD) is a thin, flat electronic visual display that uses the light modulating properties of liquid crystals (LCs). It is a low cost, low power device capable of displaying text and images. LCDs are extremely common in embedded systems. They are usually more compact, lightweight, portable, less expensive, more reliable, and easier on the eyes. Only alphanumeric characters are displayed on LCD for which ASCII numbers are sent on data pins of LCD by the microcontroller.

IV. SOFTWARE DESCRIPTION

A. Arduino 1.0.6

Arduino is a cross-platform that works in conjunction with an Arduino controller in order to write, compile and upload code to the board. The universal languages for Arduino are C and C++. The program includes a rich array of built-in libraries such as EEPROM, Firmata, GSM, Servo, TFT, WiFI, etc, but adding your own is also feasible.

The Arduino Mega2560 provides a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega2560 have four hardware UARTs for the purpose of TTL (5V) serial communication. This module provides on the board channels, one of these over USB and other a virtual com port to burn software from the computer (Windows operating system will need a .inf file, while OSX and Linux machines recognizes the board as a COM port automatically). The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the board. The RX and TX LEDs on the board will flash when data is being transmitted via the ATmega8U2 chip(microcontroller) and USB connection to the computer (but not for serial communication on pins 0 and 1). A Software Serial library allows for serial communication on any of the Mega2560's digital pins.

To design PCB a software OrCAD is used. Once testing of all the possible modules has been completed using a general purpose PCB, the final hardware for the product was it invdeveloped. To ensure a reliable system, professional prototype was developed. It involves mainly two steps schematic design and PCB layout. The first step in process of PCB designing is Schematic design. The schematic gives a visual demonstration of the connections of the electronic components used. Schematic is made very easily by using OrCAD software in just few steps. There is just a need to select component, place them and then connect them with wires. Next step is to layout the print circuit board. The net list contains the information about what are components in circuit and how are they connected with each other so there is no need to re enter the information manually. Net list also includes information about component sizes and the packages for use in creating the PCB artwork.

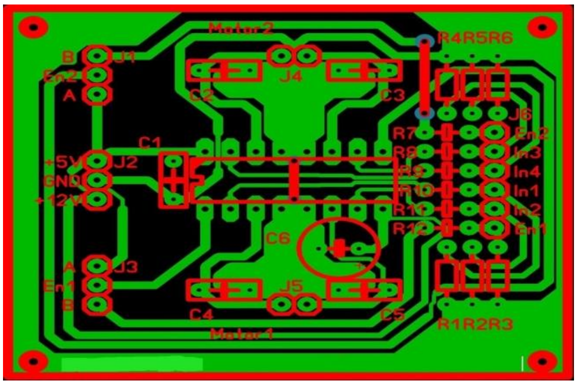

Fig 5: Final Printed Circuit Board

Figure 5 depicts the final PCB of the developed prototype system.

B. MATLAB

MATLAB provides a powerful simulation environment for image processing, calibration of camera and computer vision module. MATLAB includes the following add-on options: Image processing Toolbox, Image Acquisition Toolbox, Calibration Toolbox, and Control System Toolbox, Fuzzy logic Toolbox, Filter Design Toolbox, Instrument Control Toolbox, and Mapping Toolbox etc. Image Acquisition Toolbox enables us to acquire images and video from cameras and frame grabbers directly into MATLAB. Support to number of hardware is provided by MATLAB. Imaging devices, ranging from inexpensive web cameras to high-end scientific and industrial devices that meet low-light, high-speed, and various other challenging requirements, are used. In the proposed work, MATLAB R2013a is used.

1) Developed GUI for real time video

Figure 6 descript the flow diagram of the software implementation of the proposed system. Longitudinal distance is provided to the GUI with the help of active sensor. Further, series of the software implementation are described in the sections below.

The camera is connected to the PC with the USB cable. First of all, the properties of the connected imaging device are acquired. If the resolution of the video is lesser than the highest supported formats, then selected the maximum video input format so as to acquire maximum. Moderate level of camera exposure is selected in the camera configuration. It avoids the saturation of images at high exposure and capturing of only high intensity images at low exposure. The assumption is made without considering the side view, multiple cars or at the point of turning of vehicle. Figure 7 shows that the captured image..

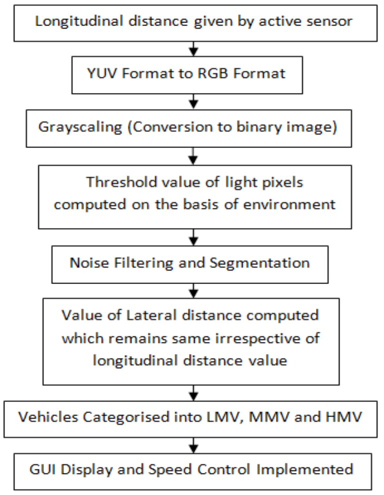

Fig 6: Flow diagram of software implementation

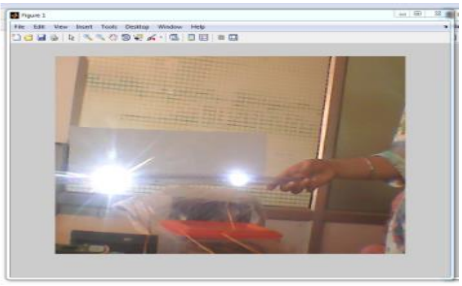

Fig 7: Captured image.

The vehicle detection algorithm is proposed on the basis of two conditions. First, distance between prototype and other vehicle. This particular distance is computed by the ultrasonic sensor. This value is given continuously by the controller to the MATLAB software with the help of serial to USB converter interface chip. Further, video input from camera is taken in the form of YUV format. For the purpose of detection of colour pixel detection in the obtained video, YUV format is converted to RGB format. Then these RGB pixels are segregated into individual red, green and blue colours. For conversion of this data into binary format, average of red, green and blue pixels is taken. Out of these, the maximum intensity pixels are classified as headlights. Figure 8 shows the morphological image.

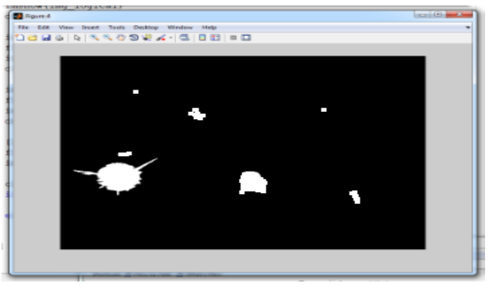

Fig 8: Binary image.

Further, the unwanted pixels and extra noise is removed by thresholding and background subtraction. This binary image is formed by increasing seed regions in the objects. Figure 9 the removed noise from the binary image.

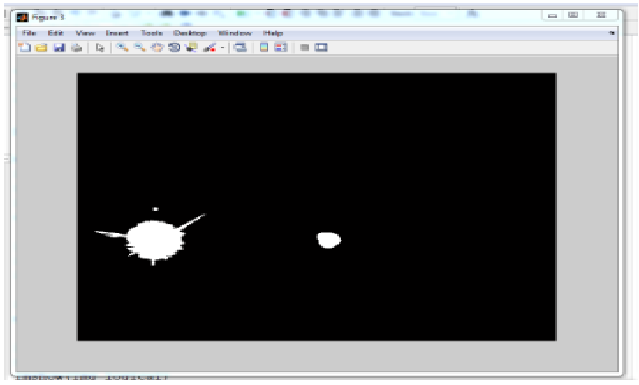

Fig 9: Image obtained after noise removal.

This morphological Figure 10 is categorised as different objects and sorted in the ascending order. The cross-correlation is applied and circle is surrounded around symmetrical objects.

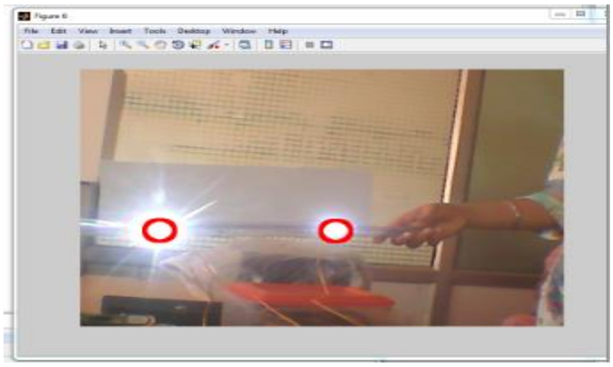

Fig 10: Image obtained after cross correlation

The distance between the lights is obtained by the Euclidean distance relation. The relation between x and y in the coordinate axis is obtained with the help of curve fitting tool. This equation is used in the algorithm for the computation of type of vehicle.

V. TEST RESULT AND DISCUSSION

A custom GUI has been developed for manual arrangement of video processing results and collection of performance statistics. Figure 11 shows the developed GUI. Value entered by the user with the keypad is being displayed in the first column, Vehicle distance detected by ultrasonic sensor is being displayed in the second column (Longitudinal distance), distance between light is being displayed in third column (Lateral Distance), and vehicle type is displayed in the fourth column i.e., LMV, MMV and HMV.

Fig 11: Developed GUI showing user counter, vehicle distance, light distance (a) LMV (b) MMV (c) HMV

The values of distance between host vehicle and obstacle in front is being displayed in cm. Distance between headlights is shown in terms of mm. The accuracy of ultrasonic sensor remains up to 400 cm. After that vehicle distance start giving errors. This Euclidean based algorithm can be applied on the road scenario by using radar sensor in place of ultrasonic sensor. The false positives are well removed till the range of 30-40 meter. After this range error start coming in the video obtained by the camera.

Table I: Rear- light and head light detection performance evaluation of different cameras

Camera	5m	10m	15m	20m	25m	30m	35m
1	*	*	*	*	*	*	*
2	*	*	*	*	*	*	-
3	*	*	*	*	*	-	-

Test images were at the interval of 5 m for testing the accuracy of images taken by different camera. Test images were taken up to the distance of 35 m. The results of these tests are presented in Table 1The range of camera 1 extends to the 50 m, while that of camera 2 and 3 is limited to 30 m and 25 m.

In order to test the validity of the proposed algorithm, two videos has been tested for the vehicle detection by using the global detection algorithm, Kalman filtering algorithm and Euclidean based proposed method. The first video is taken on the highway, with street lamps, having one-way traffic. The second video is captured on the street roads, with street lights as well as various other light sources such as traffic lights, home lights etc. In Table 2, minimum false positive rate is achieved with the proposed algorithm.

Table II: Table of comparison between different algorithms

Scene	Method	Detected Vehicle	Correct Detection	Detection Rate (%)	False Negative	False Negative Rate (%)	False Positive	False Positive Rate (%)
1(High Way)	M1	25	17	68.0%	4	16.0%	3	12.0%
1	M2	30	25	83.3%	2	6.62%	3	10.12%
1	M3	32	30	93.75%	1	3.125%	1	3.125%
2(Street Roads)	M1	21	16	76.13%	3	14.28%	2	9.25%
2	M2	29	23	79.3%	5	17.3%	2	6.8%
2	M3	27	25	92.59%	1	3.7%	1	3.7%

From the above table it can be concluded that objects having insufficient pixels in the developed algorithm have been rejected. Robust detection of targets is achieved by the system, with fewer occurrences of false targets such as street light and single head light detection that of two wheeler vehicle.

VI. CONCLUSION

ADAS system has been developed to ensure the safety of driver as well as pedestrians taking into consideration increasing number of vehicles on the road. In the previous developed system thermal imaging sensor has been employed which makes the system quite costly. In this system, a low cost CMOS sensor is employed. Noise filtering and background subtraction is used in image processing. It leads to robust detection of targets with fewer occurrences of false targets such as street lights. CMOS sensor usage leads to development of low cost system. Human machine interface keypad usage for setting user-defined safe distance value makes the system user-friendly. State of the art Euclidean distance based algorithm is developed using MATLAB image processing technique. It measures the distance between the head lights/ tail lights i.e., lateral distance and further categorise the vehicle into Light Motor Vehicle like cars, Medium Motor Vehicle like cabs and Heavy Motor Vehicles like trucks, buses. Further, tracking of the vehicle is performed by the GUI. If the vehicle in front is very close to the host vehicle then a smaller vehicle may appear to be bigger one. In Euclidean based algorithm, pixels of whole image are taken as a constant parameter and pixels between head lights is taken as variable parameter. In the previous systems, Kalman filtering, global detection algorithm has been employed for vehicle detection and tracking. The comparison between previous algorithms and proposed algorithm is done in two road scenarios i.e., high way and street roads. The developed algorithm is better than previous algorithm as it categorises vehicle accurately irrespective of the longitudinal distance. Further, this algorithm leads to minimum false positive rate vehicle detection.

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