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Traffic Sign Recognition for Autonomous Driving Robot

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ABSTRACT

We introduce a new computer vision based system for robust traffic sign recognition and tracking. Such a system presents a vital support for driver assistance in an intelligent automotive. Firstly, a color based segmentation method is applied to generate traffic sign candidate regions. Secondly, the HoG features are extracted to encode the detected traffic signs and then generating the feature vector. This vector is used as an input to an SVM classifier to identify the traffic sign class. Finally, a tracking method based on optical flow is performed to ensure a continuous capture of the recognized traffic sign while accelerating the execution time. Our method affords high precision rates under different challenging conditions.

Keywords-- HoG, SVM, computer vision

I. INTRODUCTION

The purpose of this paper is to design an intelligent wheel robot, which can recognize and follow a predefined forward sign. By distributing those forward signs, the path of the robot is determined. With this concept, an image based auto pilot system with immunity against electromagnetic interference is constructed. The rotation of the robot for automatic target detecting is achieved by using image processing. The experimental results showed that the robot could successfully detect forward sign and response properly. Simply redistributing the recognizable signs by the robot, a new path for robot is constructed.

The robot will take different signs like left, right, forward, backward, & stop according to an image. Therefore, it has great flexibility for applications. The control system of the robot is integrated with programs of computer vision motion control. The image process program compares with the webcam image inputs with the forward signs features from training program to detect the forward sign. Once a forward sign is detected by image processing program image motion control program will rotate the robot to aim the forward sign and then move toward it. Similarly for remaining signs also the image process program compares with the webcam inputs and the controller will move the robot in different directions (like left, right, backward, stop) based on image. The robot also recognizes an obstacle using IR sensor. The robot is driven with the processor **AT89S52**, where all the instructions are given through coding and emulating in the processor. Zigbee is used as wireless communication device for the robot to act for the instructions given.

II. HARDWARE ANALYSIS

2.1 BLOCK DIAGRAM:
2.1.1 TRANSMITTER SECTION:

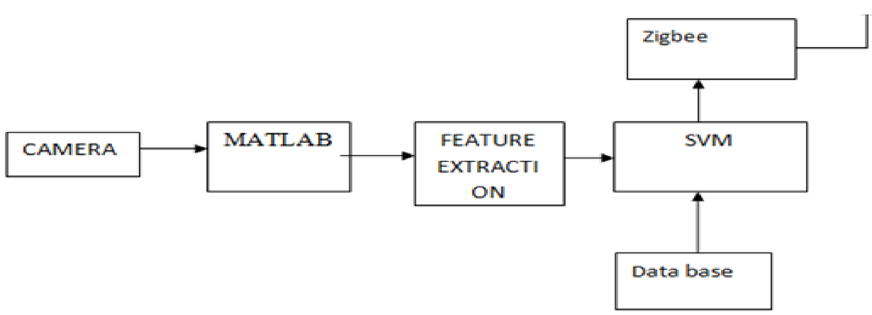


Fig 2.1.1: block diagram of transmitter section

2.1.2 RECEIVER SECTION:

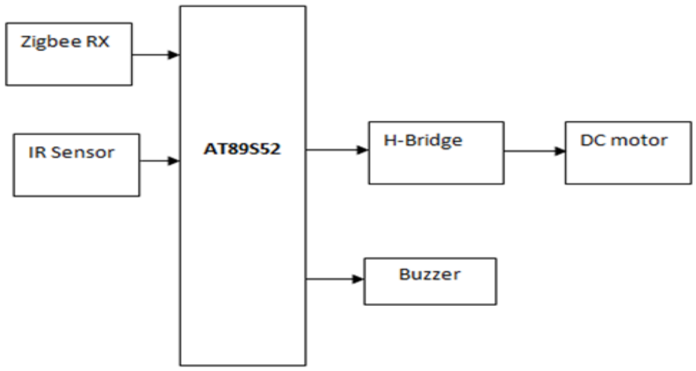


Fig 2.1.2: Block diagram of receiver section

2.2 SCHEMATIC DIAGRAM:

2.2.1 SCHEMATIC DIAGRAM OF TRANSMITTER SECTION:

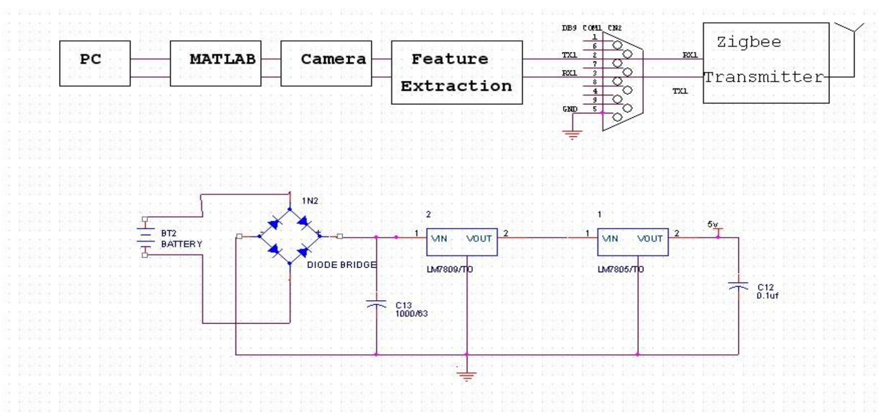


Fig 2.2.1: Schematic diagram of transmitter section

2.2.2 SCHEMATIC DIAGRAM OF RECEIVER SECTION:

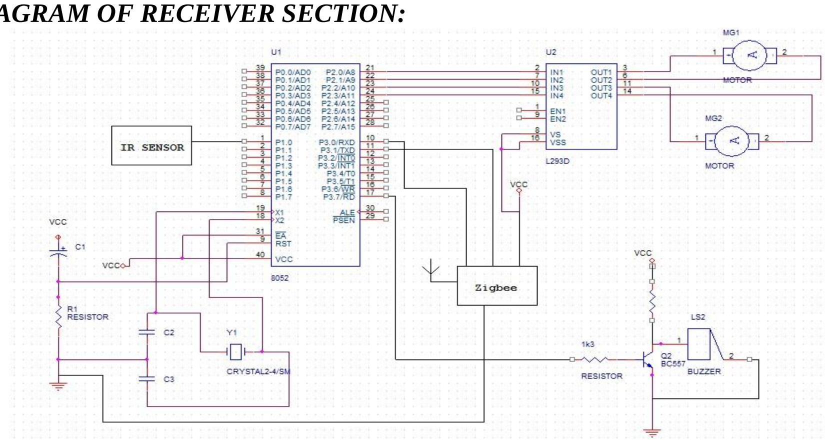


Fig 2.2.2: Schematic diagram of receiver section

2.3 ZIGBEE:

The explosion in wireless technology has seen the emergence of many standards, especially in the industrial, scientific and medical (ISM) radio band. There have been a multitude of proprietary protocols for control applications, which bottlenecked interfacing. Need for a widely accepted standard for communication between sensors in low data rate wireless networks was felt. As an answer to this dilemma, many companies forged an alliance to create a standard which would be accepted worldwide. It was this Zigbee Alliance that created **Zigbee**. Bluetooth and Wi-Fi should not be confused with Zibgee. Both Bluetooth and Wi-Fi have been developed for communication of large amount of data with complex structure like the media files, software etc. Zigbee on the other hand has been developed looking into the needs of communication of data with simple structure like the data from the sensors.

Fig 2.3.1: Zigbee module

Zigbee is a low power spin off of WiFi. It is a specification for small, low power radios based on IEEE 802.15.4 – 2003 Wireless Personal Area Networks standard. The specification was accepted and ratified by the Zigbee alliance in December 2004. Zigbee Alliance is a group of more than 300 companies including industry majors like Philips, Mitsubishi Electric, Epson, Atmel, Texas Instruments etc. which are committed towards developing and promoting this standard. The alliance is responsible for publishing and maintaining the ZIgbee specification and has updated it time and again after making it public for the first time in 2005. Most of the recent devices conform to the Zigbee 2007 specifications has two feature sets– Zigbee and Zigbee Pro. The manufacturers which are members of the Alliance provide software, hardware and reference designs to anyone who wants to build applications using Zigbee**.** ZigBee Device Objects (ZDO) provides an interface between the application objects, the device profiles, and the APS layer in Zigbee devices. It is located between the Application Profiles and the application support sub-layer. The ZDO are responsible for initializing the APS, the network layer, and the Security Service Provider, and also forming the configuration information from applications to implement discovery, security, network and binding management.

III. STEPS IN TRAFFIC SIGN RECOGNITION

The identification of the road signs is achieved through two main stages:

- Detection
- Recognition.

In the detection phase, the image is pre-processed, enhanced, and segmented according to the sign properties such as color or shape or both. The output is a segmented image containing potential regions which could be recognized as possible road signs. The efficiency and speed of the detection are important factors because they reduce the search space and indicate only potential regions.

In the recognition stage, each of the candidates is tested against a certain set of features (a pattern) to decide whether it is in the group of road signs or not, and then according to these features they are classified into different groups. These features are chosen so as to emphasize the differences among the classes. The shape of the sign plays a central role in this stage and the signs are classified into different classes such as triangles, circles, octagons. Pictogram analysis allows a further stage of classification. By analyzing pictogram shapes together with the text available in the interior of the sign, it is easy to decide the individual class of the sign under consideration. A prototype of road sign detection and recognition system is shown in Figure. The system can be implemented by either color information, shape information, or both. Combining color and shape may give better results if the two features are available, but many studies have shown that detection and recognition can be achieved even if one component, color or shape, is missing.

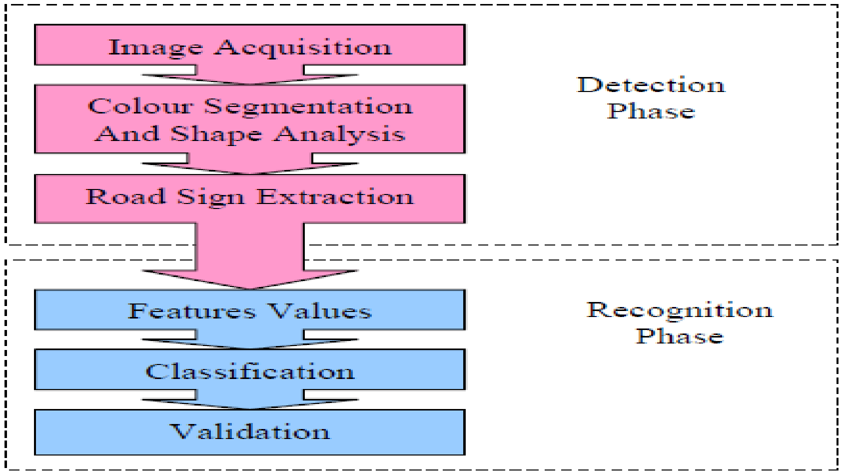


Fig:3.1.1 Block diagram of the road sign recognition and classification.

The recognition of TSs is mainly performed using three steps: detection, classification and tracking .The detection step seeks to reduce the search space and indicate only potential regions which could be recognized as possible TSs. In the classification step, each of the already detected candidates regions is filtered to decide whether it is a traffic sign or not. As for tracking step, it helps to reduce the time processing of traffic sign while keeping a continuous focus on the classified traffic sign.

3.1.2 IMAGE ACQUISITION:

Image acquisition is nothing but bringing an image into the MATLAB environment. Image must be firs brought and read in the MATLAB before processing it. Acquiring the required image, reading the image falls under image acquisition category. MATLAB software has inbuilt image acquisition tool box. The Image Acquisition Toolbox is a collection of functions that extend the capability of the MATLAB® numeric computing environment. The toolbox supports a wide range of image acquisition operations, including

• Acquiring images through many types of image acquisition devices, from professional grade frame grabbers to USB-based Webcams.
• Viewing a preview of the live video stream.
• Triggering acquisitions (includes external hardware triggers).
• Configuring callback functions that execute when certain events occur.
• Bringing the image data into the MATLAB workspace.

2.1.3 IMAGE SEGMENTATION:

The main goal of image segmentation is domain independent partitioning of an image into a set of disjoint regions that are visually different, homogeneous and meaningful with respect to some characteristics or computed property(ies), such as grey level, texture or color to enable easy image analysis (object identification, classification and processing).

Discontinuity and similarity/homogeneity are two basic properties of the pixels in relation to their local neighborhood used in many segmentation methods. The segmentation methods that are based on discontinuity property of pixels are considered as boundary or edges based techniques and that are based on similarity or homogeneity are region based techniques. Unfortunately, both techniques often fail to produce accurate segmentation results. Image segmentation is used in various applications. For all the applications, a single method cannot produce the desired result. It is all due to that the images have different property and some other factors also like noise, brightness etc. put impact on the images, and it is not possible to apply a single segmentation method and also a single evaluation technique for all types of imagery.Segmentation can be done based on colour, texture, depth or motion of an image.

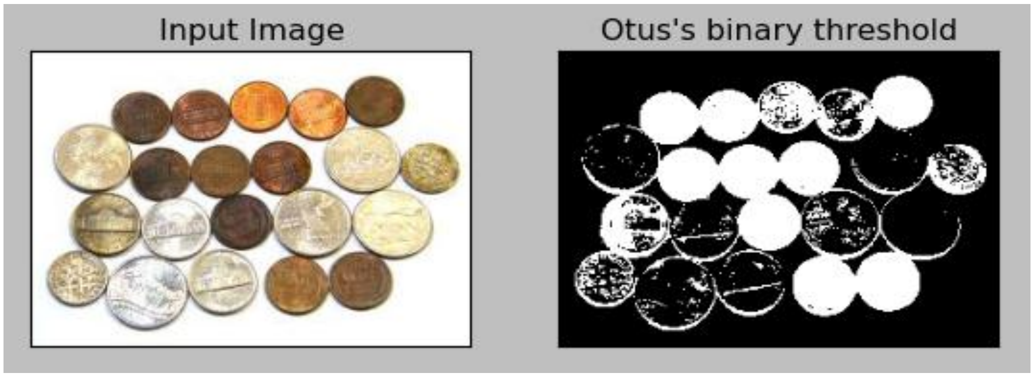


Fig 3.1.3: Segmented Image

3.1.4 OBJECT RECOGNITION:

Object recognition includes the process of determining the object's identity or location in space. The problem of object or target recognition starts with the sensing of data with the help of sensors, such as video cameras and thermal sensors, and then interpreting these data in order to recognize an object or objects. We can divide the object-recognition problem into two categories: the modeling problem and the recognition problem. In our context of study, we are interested to recognize and track danger and prohibitory traffic signs since they constitute the important cause of accident-prone situations.

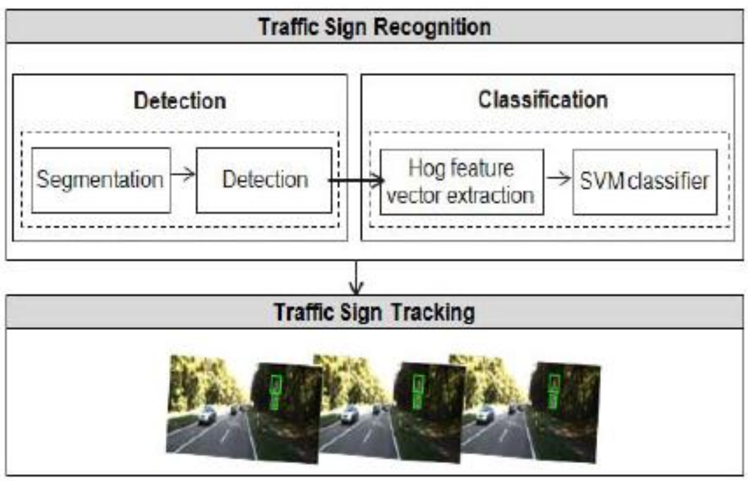


Fig 3.1.4: The proposed traffic sign recognition and tracking process.

3.1.5 TRAFFIC SIGN RECOGNITION:

A. TRAFFIC SIGN DETECTION:

In the detection step, the image is segmented relying on the visual key of traffic signs features such as color and shape. In fact, traffic signs colors represent basic information as the TSs contain bright primary colors that contrast strongly with background environments. Therefore, many methods proceed with a segmentation stage within a specific color space. Typically, the output of a mounted camera is an RGB image. Whereas, the RGB color space is not suitable for the detection of signs' colors due to its sensitiveness to the illumination variations. Therefore, some authors used a color ratio between the intensity components of RGB, while others used only one RGB component as a reference to detect the sign colors in the image. To reduce the dependency on illumination variation, the Hue Saturation Intensity (HSI) system and HSV has been frequently used.

In contrast, there are methods based on the TS shape which totally ignore color information and focus on shape information from gray scale images. For instance, the technique of local radial symmetry was implemented to detect the points of interest in the TS image. This technique is applied on the gradient of a gray scale image and used a center point votes for circular signs and a line votes for regular polygons. Authors in used the Hough transforms techniques to detect the rectangles, triangle and circles shapes of traffic signs.

B. TRAFFIC SIGN CLASSIFICATION:

Once the candidate traffic sign regions have been detected, a classifying step is performed to make the decision to keep or reject a candidate region of traffic sign. To ensure a prominent classification, there are training based methods and model-based methods. The training based methods rely on a training phase wherein different artificial techniques, such as Neural Network and Support Vector Machine, can be applied. They perceive TSs as a global entity whose characteristics and deformations are learned. Indeed, they require some prior knowledge about the TS structure. The training-based methods using the neural networks with their different topologies have been widely exploited.

In fact, some authors used a convolutional neural network while others applied the radial-based neural networks. The SVM classifier has also been widely employed to identify the corresponding TS class. In addition, the Ad boost algorithm has been also used to classify TSs using a set of week classifiers. Another group of works have based their identification process on TSs models. In fact, the TS region is compared to a set of TSs Template exemplars (models) labeled with discrete class in order to find out the most similar TS class. To perform TSs matching, some comparison metrics are used like the normalized correlation between the templates stored in the database and the potential TS regions.

3.1.6 TRAFFIC SIGN TRACKING:

Different methods were proposed to carry out the tracking step. These methods can be classified into two classes, namely points-based methods and model based methods. The points-based methods represent the traffic sign in consecutive frames through a point or a set of points. They perform the tracking throw the matching of a set of interest points extracted from the detected traffic sign. They are generally robust to illumination changes and affine transformations. The model-based methods represent the traffic sign appearance by modeling their shape or/and color. The problem is that this shape may not include certain parts of the traffic sign and may include parts of the background. Hence, it highly depends on the traffic signs detection accuracy.

Based on the aforementioned advantages of existing approaches, we have defined the appropriate methods to use in our proposed solution for traffic sign detection, classification and tracking. For the detection step, we opted for a color based methods since it provides a faster focusing on the potential areas of traffic signs. In fact, similar objects to the traffic signs shapes may coexist in the background like windows, mail boxes and cars. Besides, methods based on shapes require robust edge detection algorithm which is not an easy task with a not head-on viewing angle or with low resolution traffic sign capture. For classification step, we used a SVM classifier thanks to its performance in statistical learning theory and robustness already proved in TRS topic. Concerning the tracking step, we performed with a points-based method thanks to its invariance to illumination changes and affine transformations.

3.1.7 SVM (Support Vector Machine):

The classification problem can be restricted to consideration of the two-class problem without loss of generality. In this problem, the goal is to separate the two classes by a function which is induced from available examples. The goal is to produce a classifier that will work well on unseen examples, i.e. it generalizes well. Consider the example in Figure. Here there are many possible linear classifiers that can separate the data, but there is only one that maximizes the margin (maximizes the distance between it and the nearest data point of each class). This linear classifier is termed the optimal separating hyperplane. Intuitively, we would expect this boundary to generalize well as opposed to the other possible boundaries.

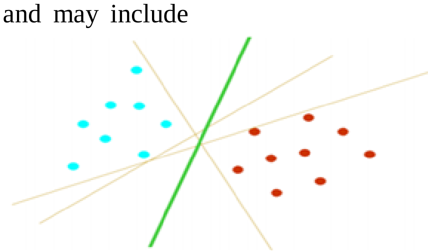


Fig 3.1.7(a): Optimal Separating Hyperplane

Given linearly separable data **x**i labelled into two categories yi = {-1,1}, find a weight vector **w** such that the discriminant function

$$f(\mathbf{x}_i) = \mathbf{w}^\top \mathbf{x}_i + b$$

separates the categories for i = 1, .., N

Write classifier as

$$f(\mathbf{x}_i) = \tilde{\mathbf{w}}^\top \tilde{\mathbf{x}}_i + w_0 = \mathbf{w}^\top \mathbf{x}_i$$

Where

$$\mathbf{w} = (\tilde{\mathbf{w}}, w_0), \mathbf{x}_i = (\tilde{\mathbf{x}}_i, 1)$$

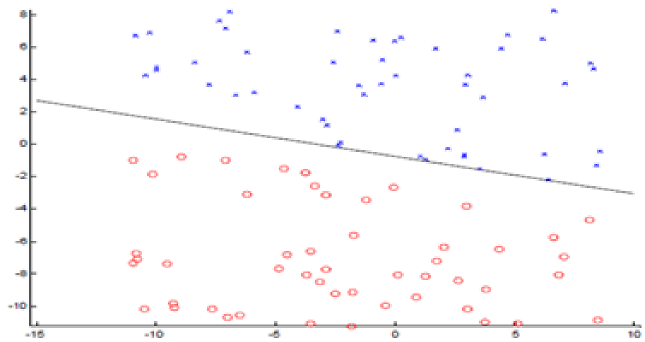
Initialize **w** = 0

• Cycle though the data points { **x**i, yi }

$$\mathbf{w} \leftarrow \mathbf{w} + \alpha\, \mathrm{sign}(f(\mathbf{x}_i))\, \mathbf{x}_i$$

• if **x**i is misclassified then

• Until all the data is correctly classified.



If the data is linearly separable, then the algorithm will converge convergence can be slow separating line close to training data we would prefer a larger margin for generalization.

Fig 3.1.7(b): Classified traffic signs by using SVM classifier.

IV. RESULTS

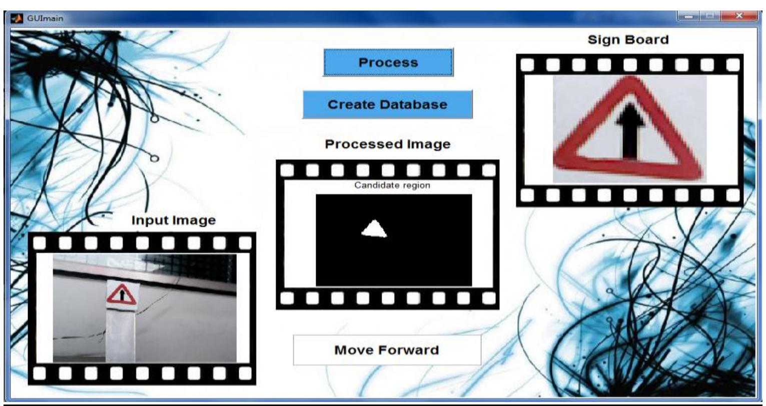


Fig 4(a):Moving forward

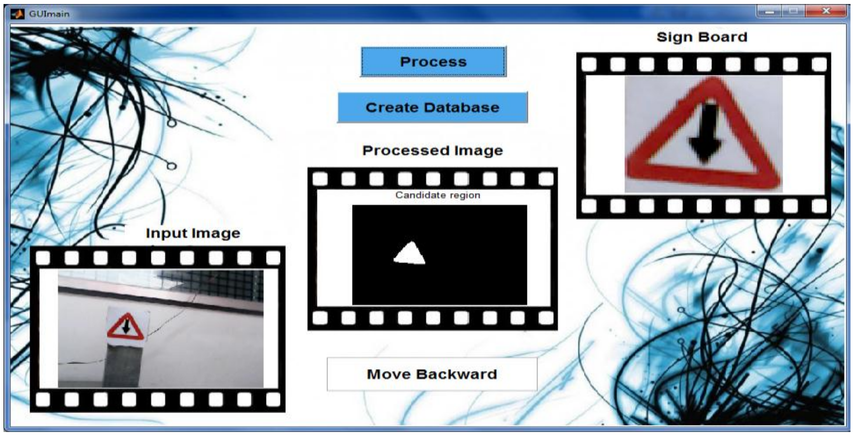


Fig 4(b): Moving backward

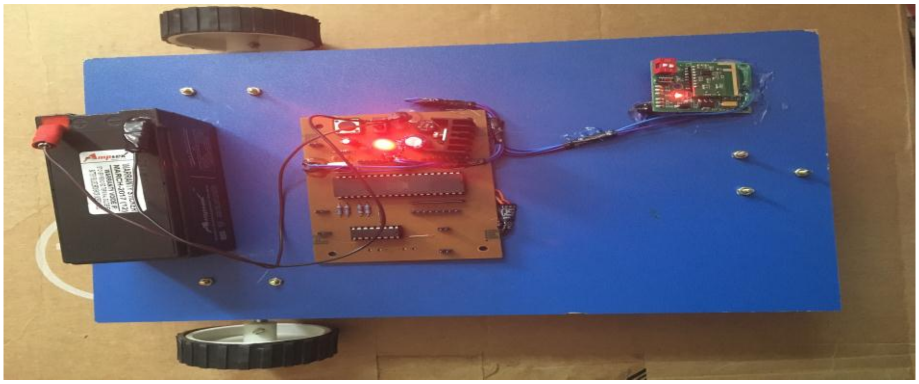


Figure 4(c): Autonomous driving robot

V. CONCLUSION AND FUTURE SCOPE

This paper presents a robot, whose control has been designed and implemented with Atmel 89S52 Matlab. The direction of X-axis, Y-axis, Z-axis has been found by acceleration sensor and according to that the robot with the help of dc motor in the desired direction. Experimental work has been carried out carefully. The result shows that higher efficiency is indeed achieved using the embedded system. The proposed method is verified to be highly beneficial for the Domestic purpose. We may use GSM in place of RF module to improve the range of the system.

REFERENCES

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