Vehicle Model Identification

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Vehicle Model Identification

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Certificate

This is to certify that the work in the thesis entitled "**Vehicle Model Identification**" submitted by Rahul Singh is an original research work carried out by him under my supervision and guidance for partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Computer Science and Engineering during the session 2011-12 in Department of Computer Science and Engineering, NIT Rourkela.

To the best of my knowledge, the matter embodied in this report has not been submitted to any other University/Institute.

Date -15/05/2012

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Abstract

Automobile has become one of the most important modes of transportation. The increasing number of automobiles has facilitated human life but it has also lead to various issues of traffic congestions, parking problems, traffic accidents etc. The objective of this project "Vehicle Model Identification" is to solve some of these problems. Vehicle Identification can be done by recognition of its iconic license plate (LP) but the Automatic License Plate Recognition (ALPR) System is rendered useless in case the license plate is forged, missing or covered. Another important attribute of a vehicle is its logo or emblem which contains important information about the car and as it cannot be tampered with easily, it plays an elemental role in classification and identification of vehicles. Vehicle Model Identification requires segmentation of vehicle logo from the given image followed by its recognition by matching it against a database of logos. The prerequisite for logo detection is the prior information about the License Plate (LP) area. Vehicle logo recognition is done using the feature matching approach provided by a robust image detector and descriptor called Speeded-Up Robust Features (SURF). In this project the experimentation has been confined to Light Motor Vehicles (LMVs) and under certain constrained conditions. Experiments on a number of downloaded as well self-acquired images of car were performed. An average accuracy of 82.5 % was obtained for logo detection using the modified algorithm and 61 % for logo recognition using SURF. The open source software OpenCV configured with CodeBlocks IDE (http://sourceforge.net/projects/opencvlibrary/) has been used for experimentation.

Keywords – Image Segmentation, License Plate Extraction, Logo Localization, Logo Recognition, Speeded-Up Robust Features (SURF)

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Chapter 1

Introduction

With the prosperity of modern transportation, scientific management has become more and more important. Automobile is one of the most important modes of transportation. It has facilitated our life but with the increasing number of automobiles, numerous problems like parking problems, traffic jams, traffic accidents, car thefts etc. have also arisen. The objective of this project - to build a robust Vehicle Model Identification System tries to a give a solution to some of these problems. The classification of vehicles is a basic task of all monitoring systems but Vehicle Model Recognition system is an advanced image processing and pattern recognition system which identifies the model of a vehicle from its captured image. License plate / number plate is one of the information for distinguishing cars. Automatic license plate recognition system is one of the most popular methods and countless number of researches has been done in this field but the problem with number plate is that it can be forged, covered or missing. In that case identification of vehicles through number plate is rendered useless. Another important information of a vehicle is its logo. The iconic vehicle logo is the trademark of a vehicle and a symbol of automobile brands. Vehicle logo is a label of the car and contains important information about the car. Because car logo exchange is very difficult, it provides a crucial basis for classifying and identifying a car.

In this project a Vehicle Model Identification system has been implemented through the use of a vehicle logo. Vehicle logo location is the first and crucial step in vehicle model identification system because the next stage i.e. logo recognition, is directly dependent upon detection. Vehicle logo localization uses the prior information of number plate. The second stage, as mentioned earlier, is the vehicle logo recognition stage in which the model of the vehicle is recognized. In this stage SURF (Speeded-Up Robust Features) [18] is used for the recognition, which basically uses the feature descriptors followed by feature matching approach. Accurate location of the vehicle logo greatly improves the recognition accuracy.

Fig.1 Logos of some of the standard Vehicle Manufacturing companies

1.1 Problem Definition

Vehicle Model Identification can be categorized under the area of Image Segmentation. Image Segmentation refers the decomposition of an acquired scene into components. Segmentation subdivides an image into its constituent objects or regions. In this project we have confined ourselves to the Car Model Identification System. So the basic problem statement is, given the image of a scene in which a car is present such that its license plate and logo are visible, the model or maker of the vehicle has to be identified. We have to keep in mind that the image has to be taken in a controlled environment i.e. car should be in a stationary position, illumination of the image should be optimal because high illumination leads to the formation of sharp edges and low illumination leads to the creation of shadows.

1.2 Overview of the system

Vehicle Model Identification System is composed of two components. The first component extracts the Vehicle Logo and the second part recognizes it. For Logo extraction, prior information of the number plate is required. Then a standard template database of logos is created. Vehicle logo recognition is carried out using SURF (Speeded-Up Robust Features) which compares the test image with each of the gallery templates and calculates the average Euclidean distance. All the distances are stored in a database along with the model names. The model with the least score or difference is the model of our given car image.

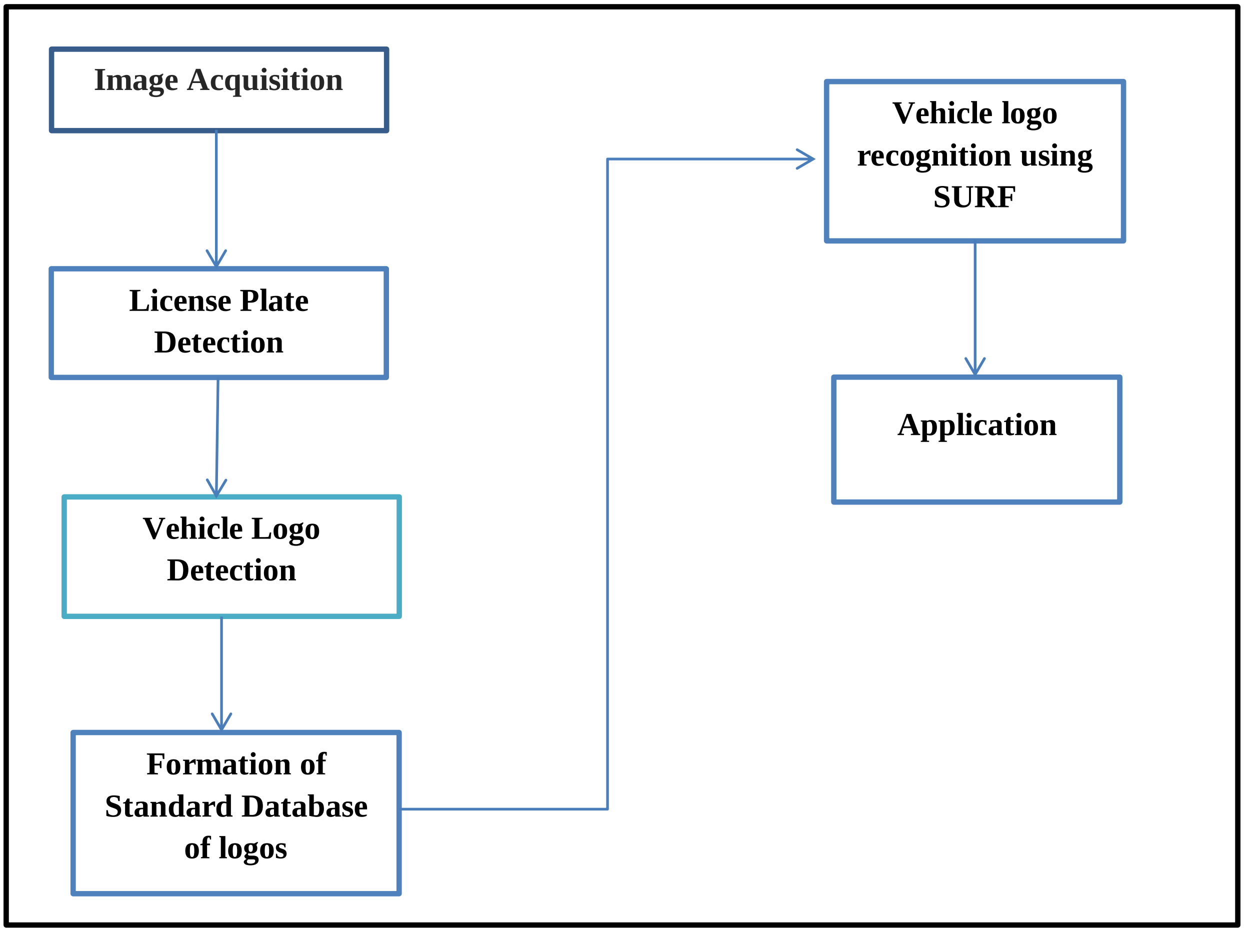

Fig.2 Block Diagram of the Vehicle Model Identification System

1.3 Applications

As stated earlier Vehicle Model Identification system has numerous applications. Some of them are listed below:

Recovery of Stolen Vehicles – Generally when cars are stolen, the thief generally forges the number plate. In that case ALPR is rendered useless. But logo cannot be changed hence through Vehicle Model Identification System the sample space for the suspected cars reduces hence assisting in recovery.

Allotting parking zones – The problem of parking is increasing day by day. Now, some companies are pioneers in Light Motor Vehicle manufacturing (like Honda, Maruti, Hyundai etc.) and some companies manufacture heavy vehicles (like Volvo, Ashok Leyland etc.). Hence by identification of model, LMVs and HVs can be allotted different parking zones hence saving space.

Traffic Lane Classification – Just like earlier point some companies manufacture fast cars (like Lamborghini, Porsche etc.) who have a high average speed and some companies manufacture normal cars (like Honda, Suzuki etc.) with a normal average speed. Thus by knowing the model of vehicle different lanes can be allotted to them, thus preventing accidents.

One can also use Vehicle Model Identification System for surveying an area to find out which models of vehicles are popular in a particular region.

1.4 Organization of the Thesis

The thesis is organized as follows. In Section 2, a detailed background and literature review of the area has been given. In Section 3, methodology or the proposed work has been described followed by results of 3 different experiments at each stage. In Section 4, the overall statistics and results have been demonstrated by the use of tables and bar charts. Finally we conclude the paper in Section 5 followed by references in the end.

Chapter 2

Background & Literature Review

The area of Vehicle Model Identification was mostly untouched before the 20th century. Researchers' concentration was mostly confined to the development and improvement of Automatic License Plate Recognition (ALPR) systems. But in the recent years (after 2005) significant amount of work has been done by researchers all around the world in this particular area. Research in this area was revolutionized by the work of Wang et al. [1] who presented algorithms for vision based classification of vehicles based on vehicle logo in monocular image of traffic scenes recorded by a stationary camera. Some of the significant works done by researchers have been divided into two subsections: Works on Logo detection and Works on Logo Recognition respectively.

2.1 Works on Logo Detection

Logo detection is a critical step in the vehicle logo recognition system. Accurate logo localization greatly improves the accuracy of logo recognition and classification. Wenju Li et al. [3] in their paper propose a novel approach for vehicle logo location based on edge detection and morphological filter. Two prerequisites for their approach are prior information of number plate location and definition of texture measure for recognition of texture of vehicle logo background. This is one of the base papers for this project. Researchers have presented many other methods to locate vehicle logo, such as segmentation method for car logo based on texture homogeneity measure [13]; method of vehicle logo location using vertical edge energy [14,15].Other methods like vehicle logo location based on PCA and moment invariants [16] and method of logo location from coarseness to fine [17] have also been proposed. Butzke et al. (2008) [2] presented an algorithm for automatic detection of predominant color and logo (trademark) of vehicles. Logo segmentation being obtained from appropriated morphological operators.

2.2 Works on Logo Recognition

Various methods have been proposed to recognize vehicle maker and model from frontal or rear view images of vehicle. Vehicles are identified by extracting features followed by either matching these templates or by a machine learning approach. Iqbal et al. [5] in their paper evaluated in an extensive experimental setting, the strength and weakness of various global and local feature based methods on vehicle images captured under controlled as well as uncontrolled conditions. Travis et al. [7] in their paper compare feature descriptors and shape descriptors methods for recognition and classification of the vehicle logo. Kam-Tong et al. [9] in their paper present a solution for the vehicle logo recognition using Modest AdaBoost machine learning approach combined with radial Tchebichef moments. Psyllos et al. [6] presented a new algorithm for vehicle logo recognition based on an enhanced Scale Invariant Feature Transform (SIFT) feature matching scheme. In this project recognition has been done using a new and better tool called Speeded -Up Robust Features (SURF) [18] which is better than the already existing SIFT.

(a) Test Case 1

(b) Test Case 2

(c) Test Case 3

Fig.3 Three Test cases for demonstration of results

Chapter 3

Methodology

A Vehicle Model Identification System can be compared to a vehicle biometric system. In this system the Vehicle Logo Localization part is comparable to the **Sensor** and **Pre-processing** component, the formation of standard template database is comparable to the **Template Generator** and Stored **Templates** module, the SURF does the **Feature Extractor** and **Matcher** work and finally the last component which recognizes the model and puts it into various applications is the **Application Device**.

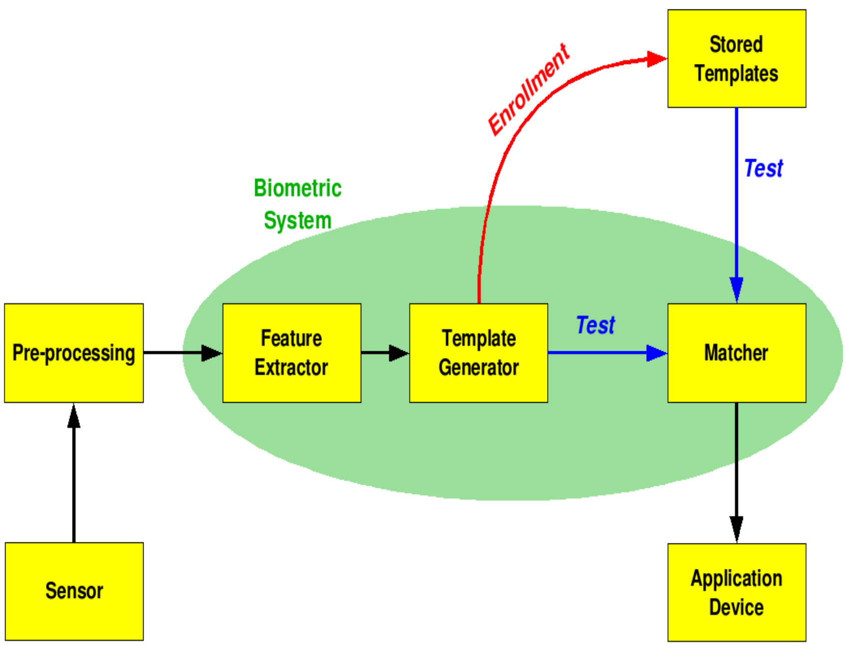

Fig.4 A Vehicle Biometric System [21]

3.1 Vehicle Logo Localization

As mentioned earlier, logo extraction or localization phase is an important component of the Vehicle Recognition System. It was also mentioned that for logo localization, prior information of number plate was needed. For license plate extraction, edge detection and contour finding approach followed by a set of heuristics is used [12]. Once the license plate is obtained coarse logo area is obtained using a set of formulae [1,3]. For removal of background edges or noise, an edge testing operator has been used. In this project edge detection is done using the Sobel operator. Prior information of background texture is necessary on the basis of which either vertical template or horizontal template of Sobel operator is used.

3.1.1 License Plate Extraction

In this stage the license plate region is extracted. Quality of the image plays an important part hence prior to this stage preprocessing of the image is necessary. Preprocessing of the image includes conversion of the colored image into gray scale followed by histogram equalization to enhance the contrast of the image. Now edges are obtained in the image using either Gradient method or Laplacian method. Gradient method finds the maximum and minimum of the derivative of the intensity function to detect edges whereas Laplacian method finds the zero point in the crossing of the second derivative function. In the algorithm followed, the operator used for finding edges in the car image is Canny Edge detection operator which basically follows the gradient method. Now, the Canny Edge image is sent for contour finding and these contours are stored in a sequence. They are approximated to quadrilaterals because generally License plates are rectangular in shape. In order to speed up the process, the concept of bounding boxes is used. Bounding boxes are rectangles with minimum area required to close in the contours. The result obtained, contain a number of candidate bounding boxes for the license plate and these were eliminated to obtain the actual license plate using various heuristics which are enlisted below:

- Generally a license plate is a quadrilateral hence the bounding box must have 4 edges.
- Aspect Ratio: The aspect ratio of the license plate image must lie in the range of 3:1 to 6:1.
- Contrast present in the bounding box, encompassing the license plate, is maximum. Contrast means black to white jump in a span of 1 pixel or vice versa.
- Generally the license plate is present in the lower half of the image hence number of bounding box decreases.

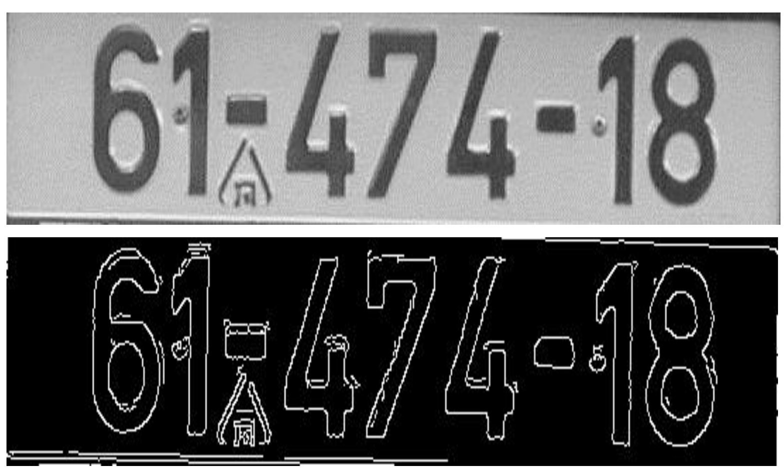

Fig.5 Extracted License Plate for Test Case 1

Fig.6 Extracted License Plate for Test Case 2

Fig.7 Extracted License Plate for Test Case 3

3.1.2 Coarse Location of Vehicle Logo Region

Usually the vehicle logos are on the top of license plate, and it is present with special texture features in its background. After the license plate has been located accurately, we can determine the coarse or rough location of logo region using a set of established formulae [3] which are:

$$Y1 = Ymax - t * h \quad (a)$$

$$Y2 = Ymin - t * h \quad (b)$$

$$X1 = Xmin \quad (c)$$

$$X2 = Xmax \quad (d)$$

Where,

Y1 is the upper boundary of coarse logo area, Ymax is the upper boundary of license plate, Y2 is the lower boundary of coarse logo area, Ymin is the lower boundary of license plate, X1 is the left boundary of coarse logo area, Xmax is the left boundary of license plate, X2 is the right boundary of coarse logo area and Xmin is the right boundary of license plate. Also t is a variable in the range $2.1 <= t <= 3.1$ and h = height of license plate

Fig.8 Coarse logo area after application of Established Algorithm for Test Case 1

Fig.9 Coarse logo area after application of Established Algorithm for Test Case 2

Fig.10 Coarse logo area after application of Established Algorithm for Test Case 3

3.1.3 Modification in established algorithm

After conducting many experiments, it was concluded that the position of the vehicle logo in the coarse logo area does not show any horizontal displacement but it only has vertical variations. Hence, the original formula was modified a bit so that accuracy of logo detection increases and since logo recognition is directly dependent upon detection thus its accuracy will also increase. So the new formula for calculating the horizontal boundaries of the logo region is:

$$X1 = Xmin + w/3 \qquad (e)$$

$$X2 = Xmax - w/3 \qquad (f)$$

Where,

w is the width of the license plate

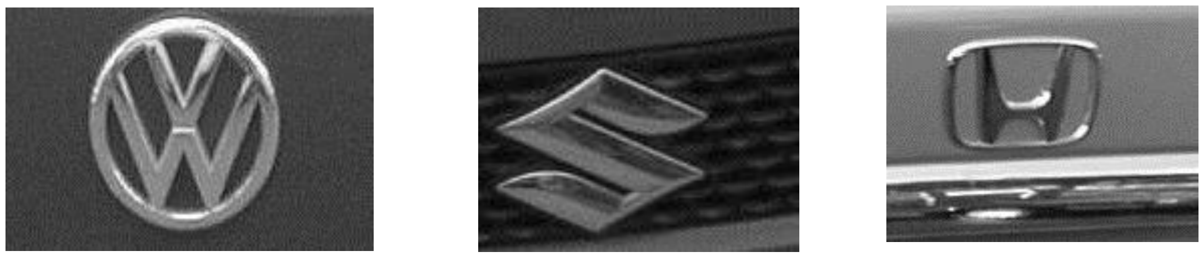

Fig.11 Extracted Coarse Logo area for the three cases with modified algorithm

3.1.4 Background Suppression

Texture of the background of the vehicle logo can be categorized into three: horizontal, vertical or meshy. The background acts as a negative factor during logo recognition hence it has to be removed. Now, to remove or suppress background noise we use an Edge testing operator which is the first step of all border based division methods. Commonly used edge testing operators are Sobel operator, Laplacian-Gaussian differential operator, Roberts operator, Perwitt operator etc. In the present case Sobel operator is used. Sobel operator basically measures the gradient of intensity at a pixel in an image. The edge testing operation of a Sobel operator is completed by using a neighborhood convolution method of two direction templates and image in image space [4]. Before the background suppression, texture recognition is carried out of the vehicle logo background. The background texture is equivalent to noise so we must suppress it. Hence for vertical texture we use Vertical template of Sobel operator which does horizontal edge detection and for horizontal texture we use Horizontal template of Sobel operator which does vertical edge detection. This bates the background and highlights the vehicle logo.

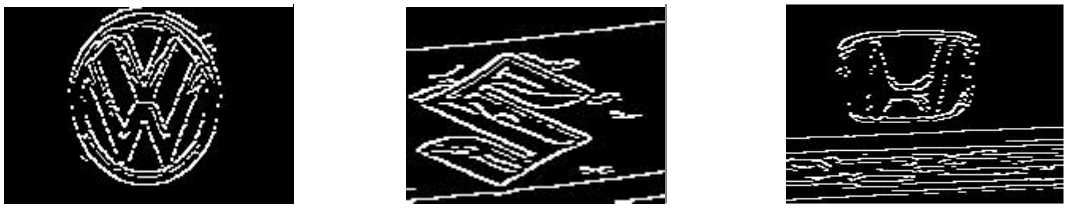

Fig.12 Background suppressed images for the three test cases

3.2 Vehicle Logo Recognition

Vehicle Logo recognition is the second stage of Vehicle Model Identification system. Image matching is a fundamental problem in image processing. A common approach is to locate the characteristics image features (or interest points) from the images and compare them through descriptors made around those features [6].

3.2.1 Formation of Standard Template Database

A standard database of 21 images of the most popular automobile companies is created. It is first resized and then converted into grayscale i.e. single channel image. Grayscale image is a type of image in which the value of each pixel carries only intensity information. These images act as gallery image and they are provided as input image along with test image to SURF which then applies its algorithm and finds out the best possible match for the given test logo.

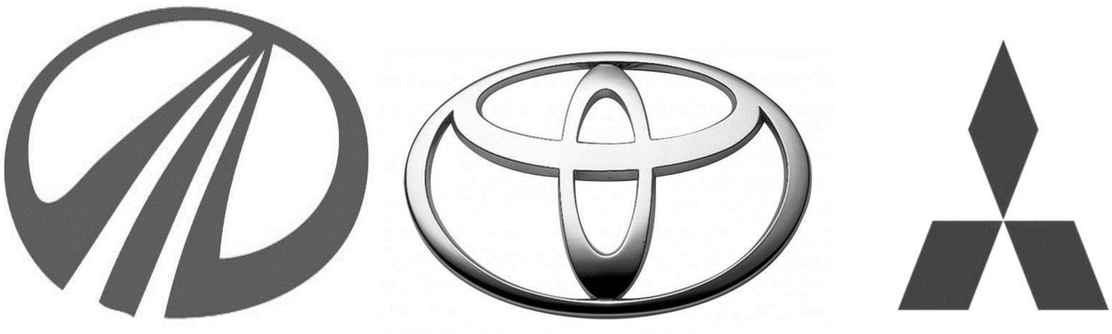

Fig.13 Some of the logos of standard template database

3.2.2 Application of SURF

SURF stands for Speeded Up Robust Features which basically is a robust image detector and descriptor [19] and it is used for object recognition and 3D reconstruction. It is the advanced version of Scale Invariant Feature Transform (SIFT) and several times faster and also much faster. SURF is scale invariant, translation invariant and rotation invariant. It works in three stages namely Interest Point Detection, Interest Point Description and Feature Matching [22]. Interest points are points of maximum variance which is calculated by finding the local maxima of Hessian determinant operator applied to the scale space environment followed by application of a given threshold. Once the interest points are obtained SURF creates descriptors of (16*4) dimensional vector around each interest points to store the features. Once features are stored, the last stage matches the descriptors of both the images performing exhaustive comparisons by calculating Euclidean distance of all potential matching pairs. For this project the SURF algorithm was modified a bit to suit my purpose of comparison with a set of template images in the database of standard logos [20]. The algorithm for recognition is briefed below.

3.2.3 Algorithm for Recognition

[1] Choose a descriptor of the probe image.

[2] Compare this with all the descriptors of the gallery image.

[3] Find the nearest descriptor which is the one with the lowest distance to our descriptor compared to all the other descriptors.

[4] The nearest descriptor distance is stored.

[5] Take a descriptor other than the one's already taken from probe image and go to step-2.

[6] Now all the nearest descriptor distances are added, and the sum is divided with the total number of probe descriptors. This gives us the average distance.

[7] This average distance, along with the name of the gallery image we just matched, can be outputted to a file.

[8] For every gallery image, go to step-1.

[9] When all the gallery images get over, sort the distances in the outputted file and the one with the lowest distance is the best match for our probe image.

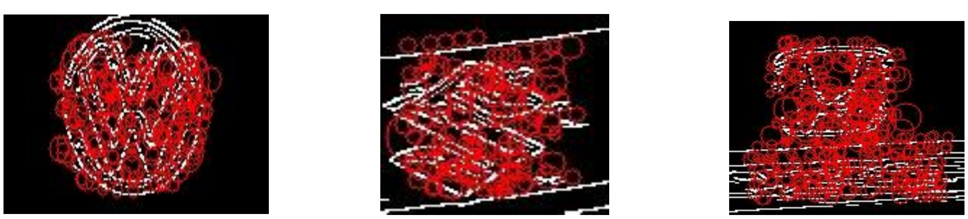

Fig.14 Logo images of each test case showing feature descriptors

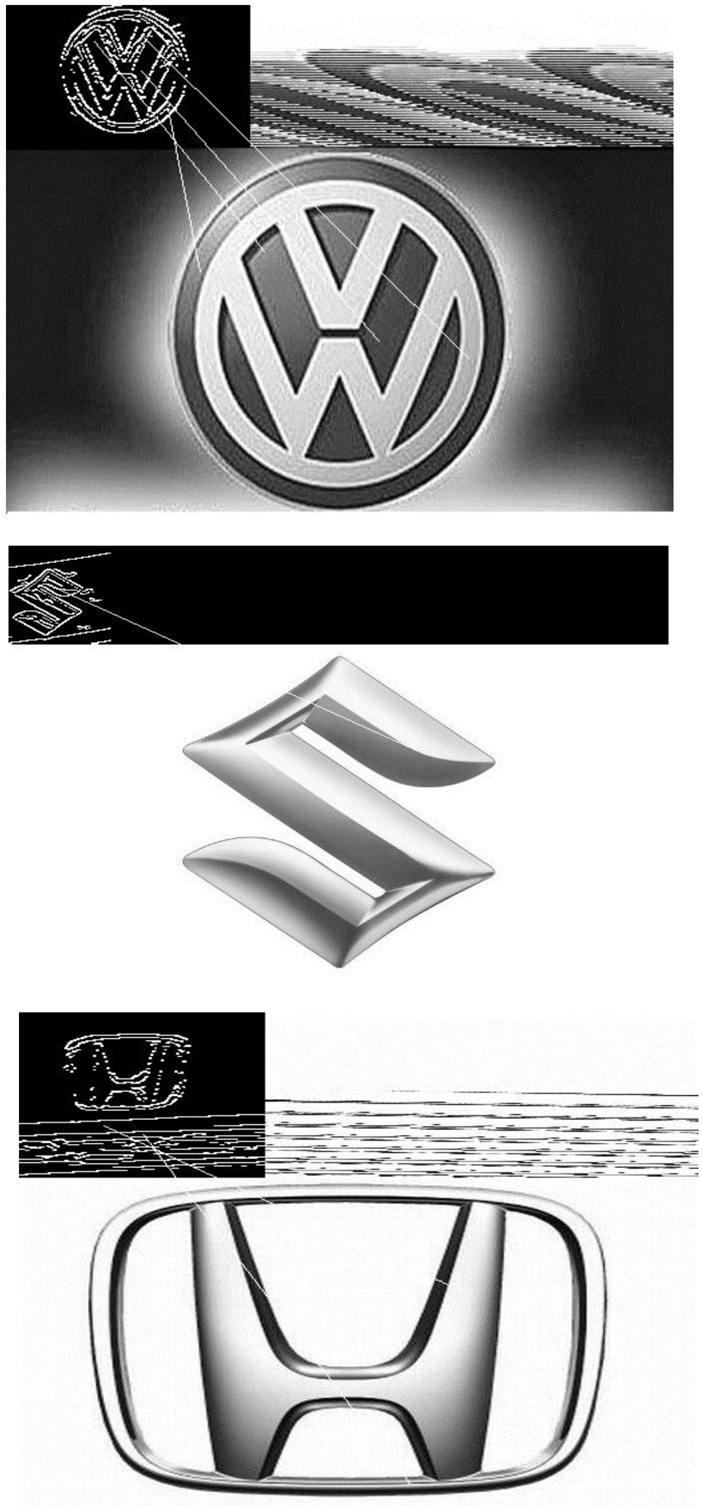

Fig.15 Feature Matching done by SURF for each of the Test Cases

3.2.4 Final Recognition of Model

All the average differences or the Euclidean distances for each of the 21 cases are stored in a file against the name of each model. This list is then sorted using bubble sort and the least distance or score is concluded as the model of the vehicle in the given test image.

Model	Score / Minimum Distance
Volkswagen	0.250184
Ford	a0.258722
Fiat	0.285490
Porsche	0.290691
BMW	0.295704
Land Rover	0.300941
Toyota	0.318085
Skoda	0.348925
Volvo	0.381872
Nissan	0.383430
Honda	0.385683
Chevrolet	0.385912
Mercedes	0.387814
Audi	0.396099
Suzuki	0.439982
Mahindra	0.446701
Tata	0.467839
Hindustan Motors	0.487730
Chery	0.559841
Hyundai	0.615699
Mistibushi	0.781301

Table 1 Minimum distance of all gallery images against test image for Test Case 1

The above table gives a description of the table of average distances which is stored after the last program is run. In the above scenario Test Case 1 has been taken, where as we can clearly see that Volkswagen has the least distance from the test image hence our model is Volkswagen. The same method is followed for Test cases 2 and 3 where the models are Suzuki and Honda respectively.

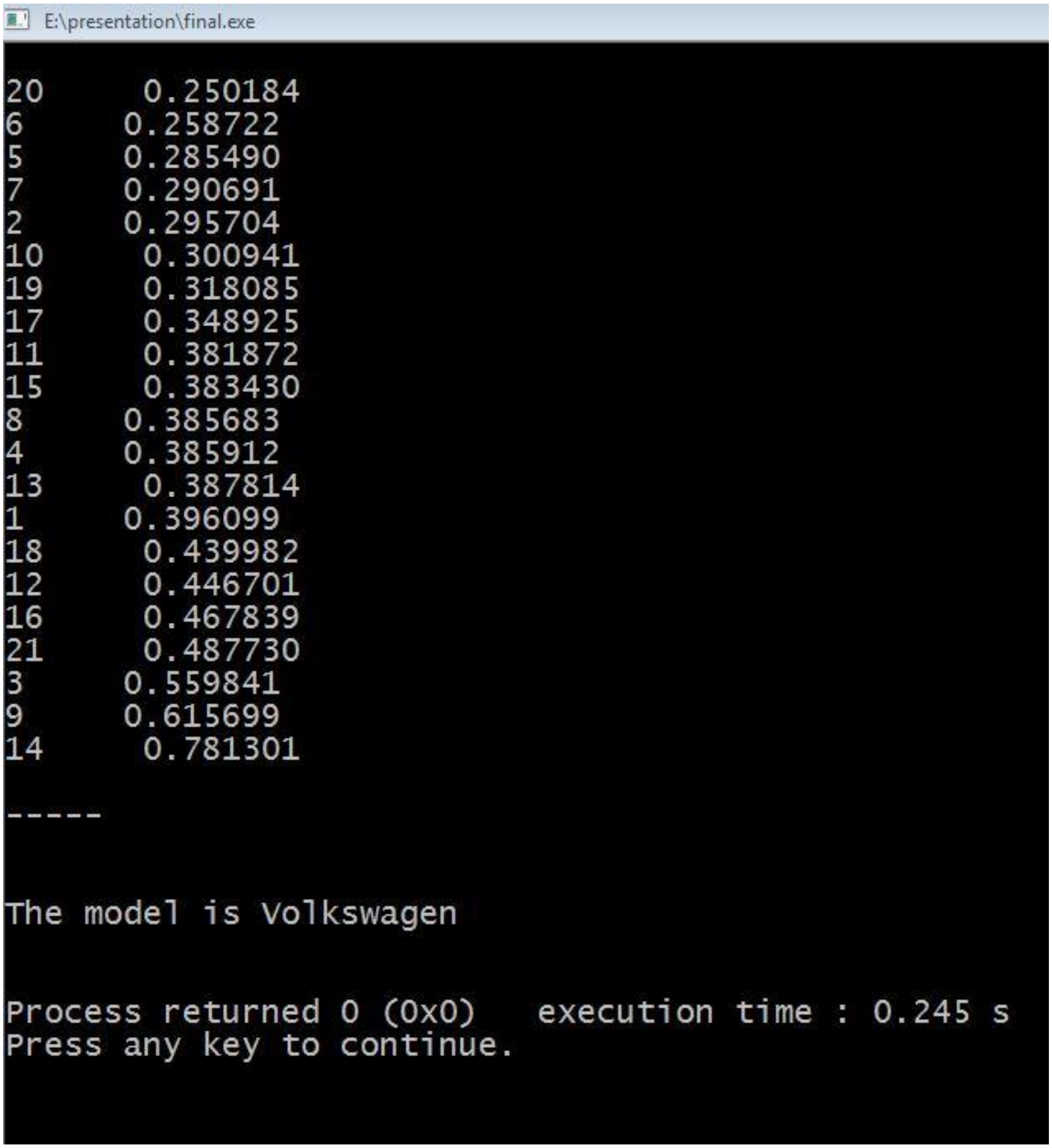

Fig. 16 Snapshot of the final screen which appears after vehicle model is identified (Test Case 1)

Chapter 4

Results

Experimentation was done on a number of sample images which were either downloaded from the internet or self-acquired. The sample space consisted of 30 car images downloaded from the internet and around 60 self-acquired images of Indian cars. The extracted logos from these test images were matched against a Standard Template Database which consisted of logos of 21 models which are popular in India. Experiments were done using both established as well modified algorithms and results were compared. The average execution time for the experiments was 3.06 seconds.

Table 2 Percentage Accuracy for Vehicle Model Identification System

	Accuracy for Vehicle logo detection	Accuracy for Logo Recognition (Using base paper Algorithm)	Accuracy for Logo Recognition (Using Modified Algorithm)
Images downloaded from the internet (30)	85%	65%	62%
Self-Acquired Images (60)	80%	58%	60%

Chapter 5

Conclusion

After concluding all the experiments, finally an 85% and 80% accuracy for logo detection of downloaded images and self-acquired images respectively was obtained. The accuracy of logo recognition by SURF on internet downloaded images and self-acquired image were 62% and 60% respectively which is slightly better than the original paper followed which showed a recognition accuracy rate of 58% and 65%. Some of the constraints for the experiments were that image was not of a complex scene i.e. image was not blurred. High illumination, sharp edges and shadows were as low as possible. Variation in light, size and color of the logo significantly reduces the robustness of feature detection.

Future works in these areas could be done to increase the accuracy rate upto 95%. This is possible through Machine Learning Approaches like Adaboost Learning Approach which trains a machine to better identify objects. With the machine learning approach the accuracy rate of logo detection increases and it is detected more precisely. And since logo recognition is subsequent process to detection, its recognition undoubtedly increases.

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