TYRE MARK IDENTIFICATION FOR CRIME SCENE INVESTIGATION USING IMAGE PROCESSING TECHNIQUES

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ABSTRACT*—The present paper aims to design and develop an android application for identifying tyre marks by applying image processing techniques. An image of tyre mark is fed as an input to the server. In the server image analysis is done so as to extract various features. The extracted features are compared with the database and a comparison is performed. If a match is found then an SMS, with the information corresponding tyre manufacturer and vehicle class of the tyre, is sent to the user's mobile. The developed system is tested with a variety of tyre marks and the results are found to be satisfactory. Such systems find a crucial role in crime investigation and greatly reduce the time involved in the process. The system would also reduce the errors that are caused by Crime Investigators'.*

Keywords—Android mobile; image analysis; tyre mark identification.

I. INTRODUCTION

Although we're not conscious of it all the time, every movement we make -- whether it's on foot or in a vehicle -- leaves some kind of impression. For example, a murderer would also have a hard time entering and exiting his victim's home without stepping on a rug or touching the ground outside. Impression evidence happens when any object or material takes on the form of another object though direct physical contact. There are three main types of impressions: Footprints (or shoe impressions), Tyre treads impression, Tool markings.

Tyre tracks are also important as they reveal a lot about the vehicle used, especially in cases such as hit and run or other road traffic offences. The tracks of tyres are almost as individual as fingerprints and once identified can go as far as determining the make, the model and even the age of the vehicle. Tyres can carry vital clues as to where the vehicle has previously been as there can be sand, glass, soil, grass and other materials in between the treads.

Tyre marks are impressions in surfaces upon which a vehicle has driven on. However, depending on the surface and type of tyres that are involved, it can be determined the type of print that will be made. Some tyres and surfaces will not even leave a print. Surfaces that are "softer," such as snow or mud, will leave an imprint under the weight of the vehicle. On hard surfaces, tyre marks are only made if dust or dirt is present.

II. TYRES AND TYRE MARKS

Tyres are made from a variety of different types of semi- hard rubber. These tyres are classified by both class and individual characteristics. Depending on the surface that the vehicle had driven on, these characteristics will show up when analyzing the tyre marks.

There are two types of tyre prints viz. tow-dimensional (2-D) and three-dimensional (3-D). 2-D tyre tracks occur when the tread surface acquires various residues on or off the road and then deposits those onto a 2-D surface like a piece of paper, clothing, skin, or the road itself. Three-dimensional tyre tracks occur when the tread surface is pressed into a substance like mud.

Tyres come in a wide variety of sizes and tread designs. These tread designs are exclusive to a particular manufacturer like. When we buy tyres, the store typically maintains records of the sale. As we drive our vehicle, tyres gradually wear down from the constant contact with hard road surfaces. These cuts, scrapes, and wear can be found in tyre impressions. These are called individual characteristics because no 2 tyres will have the exact same cuts, scrapes.

In the present work we have considered tyre vendor MRF. Figures 1 through 5 shows the variety of tyre marks of different class of vehicles.

Figure 1: Suzuki Access125 Tyre and Tyre Mark

Figure 2: Honda Activa Tyre and Tyre Mark

Figure 3: Bajaj Avenger Tyre and Tyre Mark

Figure 4: Yamaha Fz-16 Tyre and Tyre Mark

Figure 5: Bajaj XCD 135 Tyre and Tyre Mark

III. MOTIVATION

A. Present scenario

Documenting tyre marks or impressions is essential because there is a significant amount of information that can be derived from doing so. There are several methods for documenting different types of tyre marks. It must be first ascertained whether or not the print is two or three dimensional. The dimension of the impression will tell investigators whether or not to photograph the print or take a dental stone casting of the print.

B. Two-dimensional impressions: Documentation

Two-dimensional tyre marks occur when the tread surface has residue on it which is then transferred to another surface. It is not possible to take a cast of this type of print, therefore photography is used. Photographs of the evidence are taken first before any attempt to collect it. It is a challenge to take good photos of an impression because the photographs should capture every possible detail of the impression. If not, people who look at the photos later won't be able to see those details. First a photo of the general scene is captured and then of each individual impression without a scale and then with a scale. The scale is a two dimensional ruler. The photograph is taken by placing the camera on a tripod with the camera directly over and perpendicular to the impression. The camera height is adjusted so the impression and scale fill the frame.

C. Three-dimensional impressions: Documentation

The three-dimensional impressions occur when the tread surface is pressed into a substance like mud. Commonly, they are found in soil, sand, or snow and the detail within the impression may vary according to the substrate. Casting is an effective method of collecting these types of impressions. A cast is an object made by filling a mold with a liquid that takes the shape of the mold as it changes to a solid. By taking a cast of the impression, the analyst can see more detail such as tread depth, design contours, and expose any uneven tread wear.

Cast impressions are usually made from dental stone. The steps that a crime scene analysts follow when taking a cast impression are: First, they block the area were the cast is located and place a form around the impression. They will then add 10 ounces of water to 2 pounds of dental stone in the 8" x 12" zip lock bag and mix it thoroughly. The thickness resembles pancake batter. The bag is then opened at ground level and carefully the mixture is poured into the impression, allowing it to gently flow into it. When the cast is firm but still soft,

identifying marks are scratched on the exposed surface, this helps with identification purposes. The cast is allowed to dry for approximately 20 minutes, depending upon the weather. Carefully the cast is lifted. Then the cast is packaged in a large brown paper bag and is allowed to dry for an additional 48 hours. The cast is then sent to the crime laboratory. In the crime laboratory, to compare tyre prints, examiners use data supplied by companies that make tyres like MRF. This data may be part of an online database or it may be in a reference book. Using this system, an impression from a crime scene is then compared to a reference database to find out what type of tyre caused the imprint. When a suspect is apprehended, the tyre from the vehicle in question is then compared to the data gathered by the analyst.

D. Motivation

The primary disadvantage to the existing technique which uses premeasured bags of dental stone for tyre mark identification is the convenience they offer. By limiting the amount of dental stone available, the amount of casting to be performed is also inappropriately limited. While mixing in the bag is convenient, it does not lend itself in determining the consistency of the mixture before pouring. Special care needs to be taken to ensure that all of the dry material is thoroughly mixed, paying specific attention to the corners of the bag. Variances resulting from the mixing of premeasured dental stone can be attributed to several factors such as: amount of water added, the temperature of the water, how the water was added, how the bag was kneaded, the amount of time taken to knead the mixture and the environmental conditions. The existing system also consumes considerable amount of time for the identification of tyre marks in crime investigation. Therefore this leads to a delay in reconstruction of crime scene. All these factors led to the need of a system which can reduce the time required for identification of tyre mark obtained on roads/grounds. As a result of this, the police sleuths can determine the vehicle class in less than 2 minutes. This practice can lead to reduced time in crime investigation and hence, decrease the overall crime rate in the country.

IV. RELATED WORK

Ying-Wei Wang [1] investigated a scheme the ways to identify tyre mark of the suspected vehicle in hit and run accident. The system employs Visual dBASE to establish a systematic tyre-marks matching database. This database includes tyre manufactures, vehicle type/model, and tyre specifications. In addition, it encompasses a tyre-marks matching function. It proposes a way to identify the tyre pattern and catch tyre-treads by inputting the actual widths of light and heavy streaks on the tyre-marks. From this system, it is possible to find out the information pertaining to the tyre-marks' belonging based on tyre size and vehicle geometric properties and front/rear track and wheelbase. Authors have validated that the system does increase the operational effectiveness of tyre-marks identification and reduce the scope of investigation, especially in hit and run accidents.

The paper titled "A Non-contact Method for Sensing Tyre Contact Patch Deformation using a Monocular Vision System and Speckled Image Tracking" [2] proves that digital image processing can measure tyre deformation accurately. It proposes a full-field, non-contact deformation sensing system with an application for tyres. It makes use of an image tracking algorithm, to calculate in-plane displacements and their gradients. Furthermore, it also focuses on the effects of blurring from out-of-plane displacement and illumination variation thus providing more accurate in-plane information. The paper proposes to place an imaging system inside a tyre that was compressed by approximate normal loadings. Images of the compressed inner liner were recorded and processed.

V. SYSTEM ARCHITECTURE

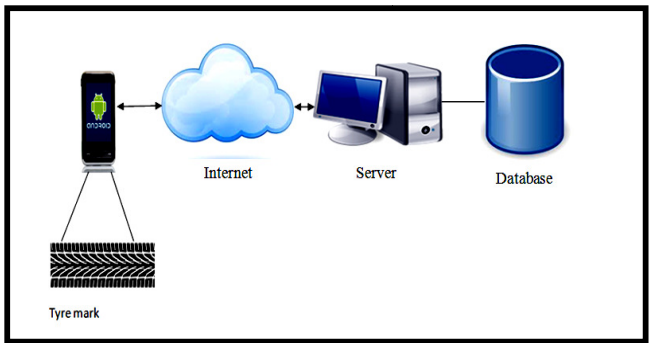

Figure 6: System architecture of Tyre Mark Identification System

Figure 6 shows the conceptual architecture of the proposed system. An Android app is developed to provide an easy interface to the investigator. Initially, the image of the tyre mark on road/mud/sand is captured. The captured images will be saved in gallery of the Android phone and also sent to the server through the

communication module. The communication module is used to make a entry in the database regarding the image. The information about the image like image path, image name, status is stored in the database.
In the server, the image is made to undergo various image processing steps. After the pre-processing various texture properties of the image are extracted and stored in the database. These extracted values are then sent to the Pattern Matching Module. This module performs two functions: (1) It compares the extracted features of the image against values stored in database. (2) If the match is successful, information about the manufacturer and class of the corresponding tyre mark will be sent to the communication module which inturn sends it as an SMS to the Android phone. If the match is not successful, the same will be communicated to the communication module.

VI. Results and Discussions

In the present work Android application has been developed in .NET framework. Image processing and feature extraction is implemented using MATLAB. Server side scripting is developed using PHP. Figure 7 shows the main GUI of the Android app. The investigator can either click the photograph of a tyre mark or can upload a tyre mark image.

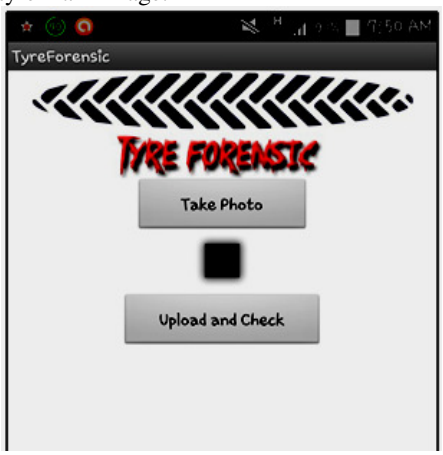

Figure 7: Main GUI of the Android App

Figure 8 shows the next step where the captured image can be saved or discarded. If the image is not clear the image can be retaken and saved.
Figure 9 shows the next step where the user can upload the image onto the server.

Figure 8: Screenshot of saving/ discarding the captured image

Figure 9: Image can be uploaded onto server for checking

Figure 10 shows the screenshot of the server side. This module is developed using is the VB .NET language to process the image. This module keeps monitoring the database for any new image uploads after every 20 seconds. If there is no new image to process, it displays the message 'No Image to process'.

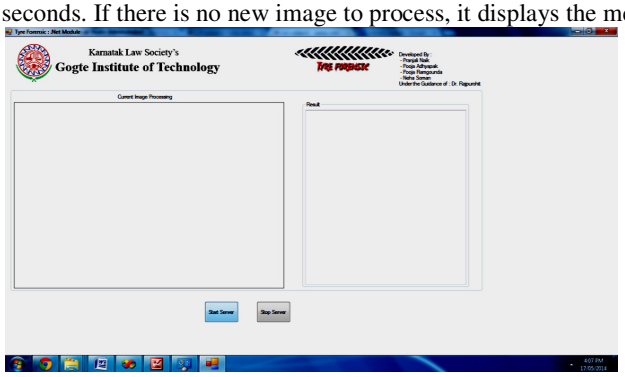

Figure 10: Server side screenshot 1

Figure 11 shows the image being uploaded, which need to be processed and checked against the database.

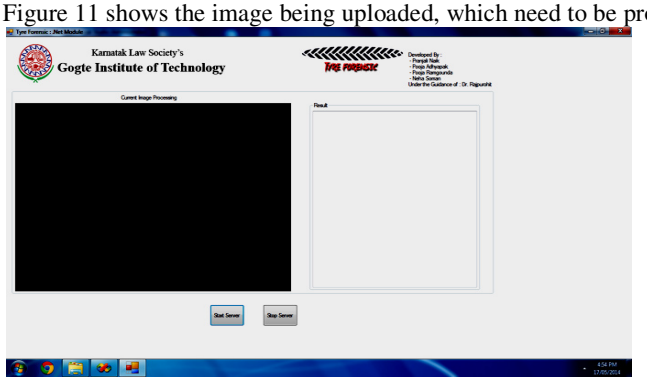

Figure 11: Server side screen shot 2

Figure 12 shows the screenshot of the results of analysis. The information comprising the class of vehicle and company name of the tyre is displayed.

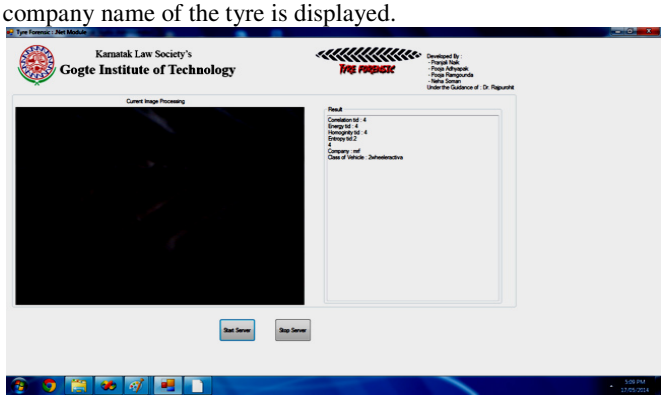

Figure 12: Server side screenshot 3 – results of analysis

Once the processing and analysis is done at the server side, the results are sent as SMS to the user's mobile. Figure 13 shows the SMS being received on the Android phone.

Figure 13: SMS received on the phone

VII. CONCLUSION

In the present paper a novel system has been developed which can analyze the tyre marks and do the basic investigation of identifying the class of vehicle. This application will help the police sleuths in identifying the vehicles used for crimes through the images of the tyre mark traces obtained from remote places through mobile phones. The developed application is based on the image processing techniques to identify vehicle class from the tyre mark traces observed on roads/grounds for the purpose of crime investigation. The system has been tested with several tyre marks and the results are proved to be satisfactory. As part of future work, larger set of tyre mark values need to be added to extend the database. The system can be enhanced by making use of sensors to adjust the distance and orientation of the mobile to particular angle.

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