International Journal of
Engineering Research and Science & Technology

IJERST

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Research Paper

DESIGN AND IMPLEMENTATION OF MICROWAVE DOPPLER RADAR SENSOR FOR SPEED SENSING SYSTEM

A Karthiga[1]* and A Ashlin Jeba[2]

Corresponding Author: **A Karthiga ✉ Karthiga2108@gmail.com*

The aim of this paper is to develop a system for speed detection of vehicles and law enforcement using automatic number plate recognition. The image processing has been used for smart traffic surveillance system .Overall work for system comprises of software development and hardware development. Approach uses a microwave Doppler radar mounted on a pole or traffic light which detects the over speeding vehicle and a camera system extracts its number plate. The system works by Doppler principle which Doppler shift is the change in pitch when a car passes - higher in pitch as the car approaches, lower in pitch as it leaves. This algorithm is designed to estimate speed of vehicle on linear and circular path. The algorithm also captures the frame of moving vehicle for its record. On speed violation algorithm detects the number plate information using optical character recognition technique.

Keywords: Background subtraction, Microwave Doppler Radar, Image Processing, Speed detection, Number plate recognition, Optical Character Recognition.

INTRODUCTION

Speed monitoring is required for the enforcement of speed laws and to reduce high rate of road accidents. From past evidences it becomes almost clear that driver always blame bad road condition and equipment failure for the cause of road accidents they never blame over speeding as their mistake. To handle such cases it becomes sole responsibility of traffic management systems to impose speed limits. The system requires two components for speed detection – video camera and a process to control the system. The camera and radar are mounted on a pole, physical distance which this camera covers is already measured. It refers to electronic equipment that detects the presence of objects by using reflected electromagnetic energy. Under some conditions a radar system can measure the direction, height, distance, course and speed of these objects. The frequency of electromagnetic energy used for radar is unaffected by darkness and also penetrates fog and clouds. This permits radar systems to determine the position of airplanes, ships, or other obstacles that are invisible to the naked eye because of distance, darkness, or weather.

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[1] ARJ College of Engineering and Technology, Mannargudi, Thanjavur, India.
[2] Assistant Professor, Department of ECE, A.R.J College of Engineering and Technology, Mannargudi, Thanjavur, India.

Modern radar can extract widely more information from a target's echo signal than its range. But the calculating of the range by measuring the delay time is one of its most important functions.

The speed of the vehicle is then measured within the known distance. If the case of over speeding takes place then system recognizes the number plate automatically. This paper describes the approaches of object detection, object tracking, speed calculation on linear and circular path, capturing image frame, number plate extraction technique—This research uses differencing image concept, background subtraction, labeling, gray scale image and binary image concept, bounding box, dilated and eroded concept and optical character recognition technique. This is easily concluded by using MATLAB. Inexpensive image processing technique is used for this system because it does not require any special hardware. Key features of research work includes the following - Proposed unit is a stationary unit in form of single camera mounted on poles or traffic light or any other suitable location that detects the speed of moving objects, In case of over speeding by vehicles buzzer alarms for intimating interceptor or any other law enforcement unit. LCD display the of moving object. This system focuses on finding speed of vehicles on curved path as well as on linear path, New algorithm developed can measure speed of more than one vehicle at any point of time, System also captures the frame of moving object which provides us with snapshot of moving object at a particular instant, Automated Speed detection technique is integrated with law enforcement using automated number plate recognition. While detecting a vehicle crossing speed limit system by using number plate recognition technique displays the number of

speed violating vehicle, this system may reduce manpower involvement in traffic management systems. This system when used on commercial scale proves to be a helping hand to traffic police in managing traffic as well as maintain law and order by controlling fraud cases.

SYSTEM DESIGN AND IMPLEMENTATION

System design is divided into five phases – moving object detection, object tracking, speed calculation, computation of speed, number plate recognition.

A. Object Detection

Hybrid algorithm for detecting moving vehicles is used. The algorithm is based on combination of adaptive background subtraction technique with three-frame differencing algorithm. The combination overcomes the major drawback of using adaptive background subtraction alone. It makes no references for the stationary objects which tends to start moving in the target region. Although when such objects are detected they tend to leave Holes behind where newly exposed background image differs from the existing background model. When the background model adapts to such Holes false alarm is generated for short period of time. It is not an effective method to find entire shape of moving object. To overcome this in this paper we suggest two methods-a) Constructing motion matrix- It construct a matrix that corresponds to the current frame. This step is done to decide what pixels of the object are moving and which pixels are stationary. Here the probability that moving pixel will represent foreground pixel and stationary pixel will represent background pixel is high; (b) Background subtraction -A three frame differencing is used to
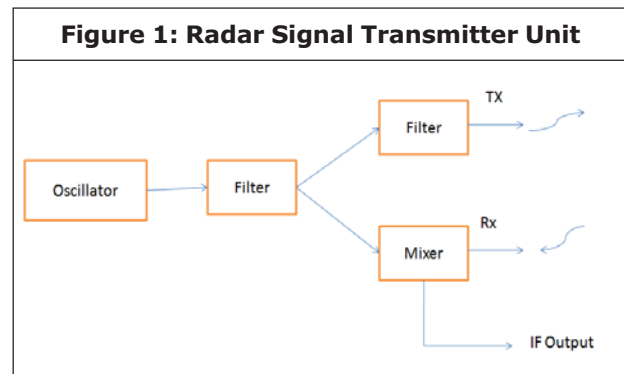
construct motion matrix and it is followed by background subtraction. Let us consider a video stream available from a stationary mounted camera. Let Is*(x,y)* represents the intensity value of pixel position *(x,y)* at any time t=n. According to three differencing rule a pixel is legitimately moving if its intensity is changed significantly between both the current image frame (Is) and the last frame (Is-1) and the current image (Is) and the next-to-last frame (Is-2) significant intensity change at a pixel position (*x,y*).

B. Object Tracking

Moving object can be traced by using object segmentation, object labeling, and center extraction. (a) Object segmentation- it works on connectivity of objects in order to segment foreground image it must be seen that every object is connected as single component. Else segmentation will leads to many several objects. Since there are no connected objects our goal is to detect the area that surrounds the objects. This area can be treated as excellent representation to non-connected moving objects in simple words the operation aims to map the object into a rectangular box representing it. This method comprises of successive iterations and in each iteration there are two main parts- horizontal scanning and vertical scanning. Horizontal scanning initiate from the top left most pixel at the foreground image it then scans the foreground image horizontally. In case of no foreground pixel also called white pixel is found it will mark the whole line scanned. The same process is followed by vertical scanning.

C. Speed Calculation Using Radar

Non-contact speed measurement using the Delta speed sensor is achieved through the use of Doppler radar. The Doppler principle explains the

Figure 1: Radar Signal Transmitter Unit

frequency shift associated with energy waves reflected by or emanated from a moving body. A familiar example of a Doppler shift is the change in pitch when a car passes - higher in pitch as the car approaches, lower in pitch as it leaves. In the case of the Delta speed sensor, a Ka band radar signal is transmitted at a specific frequency by the sensor, reflects off of a target (or targets) and returns to the sensor (see Figure 1). If either the sensor or the target is moving relative to one another, the signal will be shifted in frequency when it returns to the sensor.

In the present work, we use a miniature Doppler RADAR which has dimensions of only 46 x 40 mm. It operates on a + 5 V power supply. It emits microwave signals of 10.525 GHz frequencies. The waves can hit any moving object within a distance of 20 m. It reflects back some portion of the transmitted signal with a shift in the frequency. When the target is moving toward the RADAR receiver, the signal frequency increases by fd and when it is moving away from the receiver the frequency decreases by fd, where fd is the Doppler shift. This signal is band limited and amplified from micro volts to volts with the help of an amplifier circuit. The output of the amplifier is a sine wave which cannot be fed directly to a microcontroller. Therefore it is converted to a square wave by using a Zero Crossing Detector. The output of the ZCD a

square wave is fed to the arduino development board to performs the tasks of calculation of frequency, calculation of speed and display.

D. Computation of Speed

One of the important applications of the wind profiling is the computation of wind speed. By using the Doppler profiles of the radar returns, wind speed can be calculated at different heights. For computing the wind speed, wind profiles for six directions is a must. The wind profiles in North, South, East and West directions with an oblique angle θ are obtained using the algorithms discussed.[13]. The wind profiles in the remaining two Zenith beams are also obtained. If there is a relative motion between the source of the waves and an object encountering the waves, the frequency is measured at the object will be different from that at the source. This is called the Doppler Effect. If the object is approaching the source, the frequency will be higher, if it receding, the frequency will be lower.

The amount of frequency change is called the Doppler shift which is directly proportional to the relative radial velocity between the source and the object and inversely proportional to the wavelength. In the case of wind profiling, the source is the wind profiler and the object is the refractive irregularity that scatters the waves. A double Doppler shift is encountered here: one shift as the pulse impinges upon the scattering volume and other as the pulse is scattered back towards the wind profiler.

The Doppler shift is given as:

$fD = (-2Vr/\lambda) \sin \theta$ where

Vr= radial velocity of the scatters along the beam

θ = angle deviated from the vertical direction

The –ve sign arises from the fact that positive radial velocities refer to motion away from the radar, which causes the frequency to be lower. From Doppler shift, the radial velocity is given as:

$Vr = -fD\lambda/2 \sin \theta$

For the directions of Zenith-X and Zenith-Y the radar is operated in vertical direction. So the related equation for Doppler frequency is

$fD = -2Vr/\theta$ After computing the radial velocity for different beam positions, the absolute velocity can be calculated.

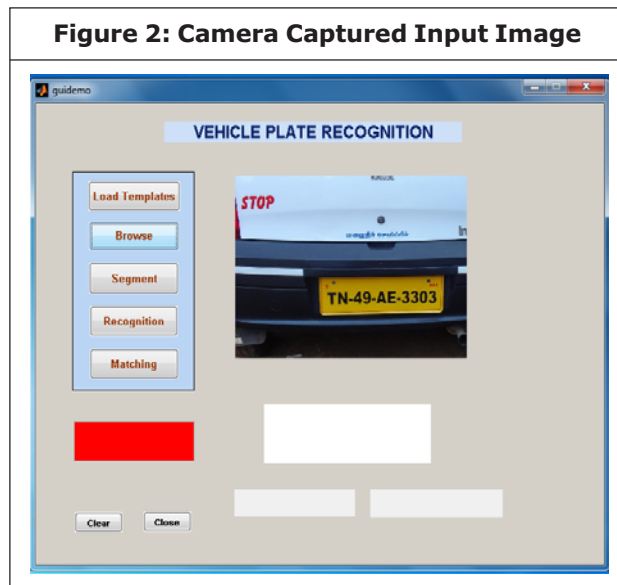## E. Automatic Number Plate Recognition

Automated number plate recognition is unique characteristic of optical character recognition. License plate recognition allows user to read automatically the registration no. of vehicles. LPR is image-processing technique used to identify number of vehicles. This technology has its advantage in various security and traffic applications. LPR units are works on images of the front or rear number plates. The information contained in the image is read by the LPR unit and is analysed automatically. The image given below is taken from the front side of the car is made up of 256 grey levels ranging from black to white. A typical format comprises of 768 X 288 pixels or about 0.2 million elements. Such large information is processed by the number plate recognition software in order to read number plate automatically.

The computer processor needs to work on entire image for detecting the number plate, zooms into the data to handle the minute details and finally extract the registration number plate. The result of the recognition process is contained in a string.

ALGORITHM FOR PROPOSED METHODOLOGY

A. Input Image

This is the first phase deals with acquiring an image. In the proposed system, digital camera of 3.2 megapixel camera is used. The input image is 120 x160 or 1200 x 1600.

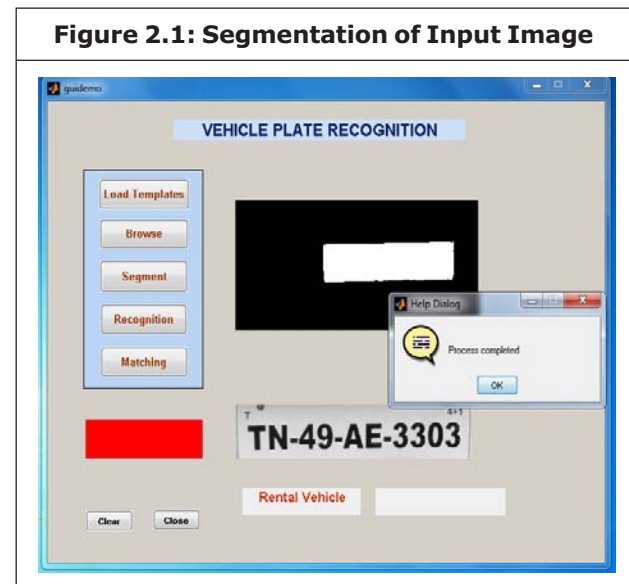**Figure 2: Camera Captured Input Image**

B. Extraction of Number Plate Location

The inputs to the system were the images of vehicles captured by a camera. RGB to gray-scale conversion is adopted, in order to facilitate the plate extraction, and increase the processing speed. Color image (RGB) acquired by a digital camera is converted to gray-scale image using Equation (1).

Gray = 0.114*R+0.587*G+0.299*B　　　...(1)

The basic step in recognition of vehicle number plate is to detect the plate size. In general number plates are in rectangular shape; hence it is necessary to detect the edges of the rectangular plate. Mathematical morphology is used to detect the region of interest and Sobel operator are used to calculate the threshold value, that detect high light regions with high edge magnitude and high edge variance. The binary gradient mask shows lines of high contrast in the image. These lines do not quite delineate the outline of the object of interest. Compared to the original image, gaps in the lines are observed that surrounds the object in the gradient mask. This linear gap disappears if the Sobel image is dilated using linear structuring elements. Structuring element is represented as matrices, which is a characteristic of certain structure and features to measure the shape of an image which is used to carry out other image processing operations. The binary gradient mask is dilated using the vertical structuring element followed by the horizontal structuring element.

Figure 2.1: Segmentation of Input Image
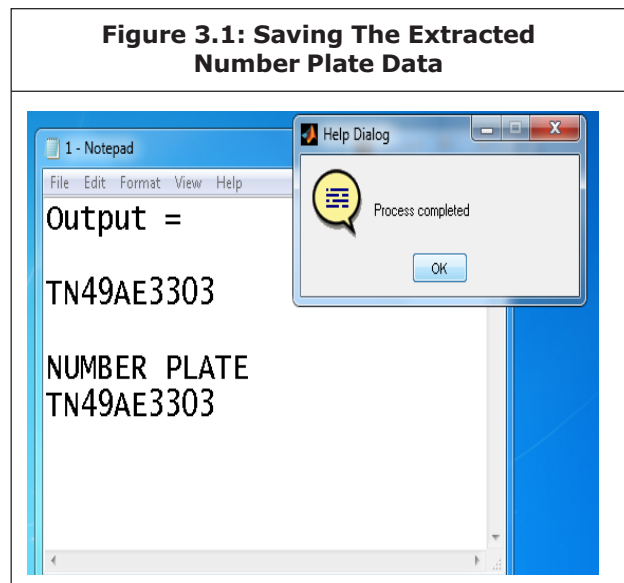

C. Feature Extraction

Generally, the description of an image region is based on its internal and external representation. The internal representation of an image is based on its regional properties, such as color or texture. The external representation is chosen when the primary focus is on shape characteristics. The description of normalized characters is based on its external characteristics because we deal only with properties such as character shape. Then, the vector of descriptors includes characteristics

such as number of lines, bays, lakes, the amount of horizontal, vertical and diagonal or diagonal edges, and etc. The feature extraction is a process of transformation of data from a bitmap representation into a form of descriptors, which are more suitable for computers. If we associate similar instances of the same character into the classes, then the descriptors of characters from the same class should be geometrically closed to each other in the vector space. This is a basic assumption for successfulness of the pattern recognition process. This section deals with various methods of feature extraction, and explains which method is the most suitable for a specific type of character bitmap. For example, the "edge detection" method should not be used in combination with a blurred bitmap.

RESULT

The new algorithm for speed detection focuses on determining speed of vehicle on circular and linear track. It uses a single mounted high resolution camera for this purpose. Firstly current frame from video stream is obtained from which differencing image is obtained. For this purpose three frame differencing and masked subtraction technique of image processing is used. Binary image is generated and all connected components are labeled using bounding box method. Out of all labeled objects center of each object is extracted. Using some MATLAB functions speed is calculated at this moment if vehicle is found over speeding the system calls for automatic number plate recognition. Number plate recognition uses OCR technology to read license plate. Algorithm takes input image, resize it and converts to grey scale image after that eroded and dilated images of input image are obtained. After filling holes applying thinning

operation high pixel area image is obtained. All these operations used above improves the quality of image and make it ready for further processing. By applying OCR characters from number plate are displayed below.

Figure 3: Number Plate Extraction Using Optical Character Recognition

Figure 3.1: Saving The Extracted Number Plate Data

CONCLUSION

The research uses various concept of image processing and tools of MATLAB to detect a vehicle under the range of high resolution camera to retrieve its number plate. The use of high

resolution camera has overcome traditional sensor based system for speed detection. This research work is outcome of an integrated system that integrates video surveillance system for speed Detection and its law enforcement using automatic number plate recognition. The system detects moving objects on the road, derive its other parameters, label all its connected components which helped in obtaining the centroid of the moving object. Finally, the vehicle speed is calculated using various MATLAB functions and is based on the imaging geometry and camera pose of the image. The system works in a fine way for speed determination of local as well as highway traffic. The system uses various techniques of image processing such as background subtraction, binary image formation, grey scale image formation, etc. For license plate detection it uses OCR technique. The research work is proven with implementation on hardware set up which makes it a real time solution for commercial traffic control system.

FUTURE WORK

There can be several advancements to the present project using the output of the Doppler sensor. A. Use of DF100 which has a range of 100m as compared to hb100's range of 20 m. B. Over speeding can trigger a camera to capture an image of the over speeding vehicle. Speed limit can be preset on the device, which when exceeded can trigger a camera to capture the image of the vehicle in question, thus helping in policing. C.Can be used as traffic counters to count the number of vehicles plying on an highway. Using the number of disturbances on the sensor, number of vehicles in a particular lane can be estimated.

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International Journal of Engineering Research and Science & Technology

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