RECOGNISION OF LICENCE PLATE AND DETECTION OF OPTICAL NERVE PATTERN USING HOUGH TRANSFORM

A Thesis Submitted in Partial Fulfilment

of the Requirements for the Award of the Degree of

Master of Technology

In

Electronics and Instrumentation Engineering

By

ABHINAV DEO

Roll No: 211EC3305

Department of Electronics & Communication Engineering

National Institute of Technology, Rourkela

Odisha- 769008, India

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Under the Supervision of

Prof. Umesh Chandra Pati

Department of Electronics & Communication Engineering

National Institute of Technology, Rourkela

Odisha- 769008, India

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National Institute of Technology, Rourkela

CERTIFICATE

This is to certify that the Thesis Report entitled "**Recognition of License Plates and Optical Nerve Pattern Detection Using Hough Transform"** submitted by **ABHINAV DEO** bearing roll no. **211EC3305** in partial fulfilment of the requirements for the award of Master of Technology in Electronics and Communication Engineering with specialization in **"Electronics and Instrumentation Engineering"** during session 2011-2013 at National Institute of Technology, Rourkela is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University / Institute for the award of any Degree or Diploma.

Date:

Prof. Umesh Chandra Pati
Associate Professor
Department of ECE
National Institute of Technology
Rourkela-769008

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Roll number: 211EC3305
Dept. of ECE
National Institute of Technology
Rourkela

Date:

ABSTRACT

The global technique of detection of the features is Hough transform used in image processing, computer vision and image analysis. The detection of prominent line of the object under consideration is the main purpose of the Hough transform which is carried out by the process of voting. Parameter space of the object is used for carrying out the voting. From this parameter space, the local maximum is extracted and thus completing the algorithm of Hough transform.

The first part of this work is the use of Hough transform as feature vector, tested on Indian license plate system, having font of UK standard and UK standard 3D, which has ten slots for characters and numbers. An input image taken is which an RGB image, further the input image is cropped and the significant blocks of information in the number plate are thus obtained. The ten sub images thus obtained from the input image are also RGB and among which 4 are alphabets while the rest are numbers. These sub images are fed to Hough transform and Hough peaks to extract the Hough peaks information. First two Hough peaks are taken into account for the recognition purposes. The edge detection along with image rotation is also used prior to the implementation of Hough transform in order to get the edges of the binary image. Further, the image rotation angle is varied; the superior results are taken under consideration.

The second part of this work makes the use of Hough transform and Hough peaks, for examining the optical nerve patterns of eye. An available database for RIM-one is used to serve the purpose. The optical nerve pattern is unique for every human being and remains almost unchanged throughout the life time. The unique patterns of optical nerves are examined, to obtain there Hough peaks information. The only way of alteration of these patterns are eye diseases. Diseases like Glaucoma makes the patterns of optical nerve which stays constant through the life time change significantly. So the purpose is to detect the change in the pattern report the abnormality, to make automatic system so capable that they can replace the experts of that field. For this detection purpose Hough transform and Hough peaks are used and the fact that these nerve patterns are unique in every sense is confirmed.

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CHAPTER 1

INTRODUCTION TO HOUGH TRANSFORM

1.1 Hough Transform

The global technique of detection of the features is Hough transform used in image processing, computer vision and image analysis. The detection of prominent line of the object under consideration is the main purpose of the Hough transform which is carried out by the process of voting. Parameter space of the object is used for carrying out the voting. From this parameter space, the local maximum is extracted and thus completing the algorithm of Hough transform.

The classical Hough transform was concerned with the identification of lines in the image, but later, extension of Hough transform allows its application for various other parametric curves, like for detection of circle, ellipse and even for arbitrary shape detection.

For finding straight lines hidden in larger amounts of other data, Hough transform is the globally used technique. It is an important technique in image processing. For detecting lines in images, the conversion of image to binary image is done by using some threshold operation and then the positive instances catalogued in an examples dataset. The knowledge of Hough space is must for developing proper understanding about Hough transform. Each point (ρ , θ) in Hough space corresponds to a line at angle θ and distance ρ from the origin in the original data space. The point density along a line in the data space is given by the value of the function in Hough space. Utilization of following method is done by Hough transform, for each point in the original space consider all the lines which go through that point at a particular discrete set of angles, chosen a priority. For each angle θ, calculate the distance to the line through the point at that angle and discretise that distance using an a priori chosen discretisation, giving the value of ρ .

Corresponding discretisation of the Hough space is made, a set of boxes in Hough space are created. These boxes are known as the Hough accumulators. The Hough accumulator is incremented (which is initialized to zero) for each line under consideration. After considering all the lines through all the points, Hough accumulators with the highest value probably correspond to a line of points. Different lines are corresponded by various magnitudes of entries in the Hough space.

Here, equation (1) gives the parametric representation of line

$$x \cos \theta + y \sin \theta = \rho \tag{1}$$

where,θ(theta) is the angle subtended by the normal on line in anticlockwise direction and ρ (rho) is the perpendicular distance between origin and the line.

A transformation between image and its parameter space takes place where the points in picture are sinusoids in parameter space while points in parameter space are lines in picture. Sinusoids corresponding to co-linear points intersect at a unique point. This transformation is shown in Figure 1.1, where sinusoidal curves corresponding to each point is spatial domain are visible.

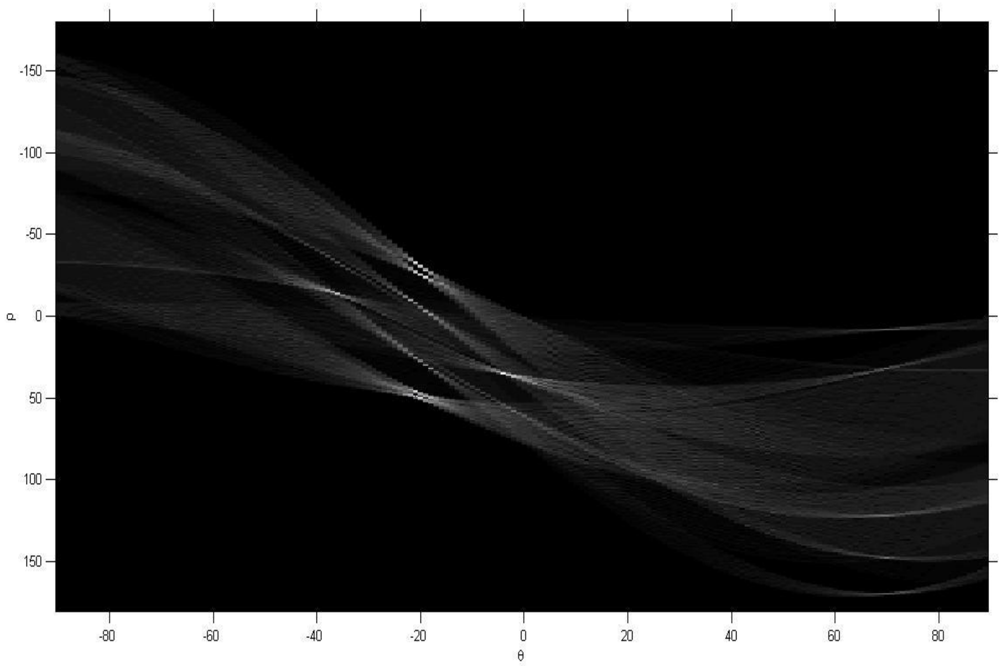


Figure 1.1 Sinusoidal curves for each point in spatial domain

1.2 Hough Transform for Parametric Curve

Detection of lines in image is no more the common use of Hough transform, though that's the purpose for which it was designed. The detection of lines as well as other curves can also be done by Hough transform [1]-[5]. The Hough transform is also well suited for the curves which have fewer parameters under consideration. So, straight lines as well as other curves in the image can also be detected by the use of Hough transform. For example, to find circles, with equation (2):

$$(x-a)^2 + (y-a)^2 = \ r^2 \tag{2}$$

Then, a circle is specified with three parameters the X and Y coordinates of its centre are (a, b) and r, its radius. Three-dimensional accumulator array is needed for the detection of the circle. All the edge elements which lies on the circle are incremented in the Hough space and for the position of center and radius magnitude, 3-D accumulator cell is searched. Only need is a 2-D accumulator, if radius information is available. Then, a surface in (a, b, r) space (vary any two of the parameters a, b and r) is denoted by every point in the spatial domain, the third is determined by the equation of the circle. Thus, the use of 3-D array is done for the detection of circle by basic method. All points in it, which satisfy the equation for a circle, are incremented. The problem is converted to 2-D problem (1-D search) if the gradient information is available. The transformation of conical surface to line for circle detection is shown in Figure 1.2.

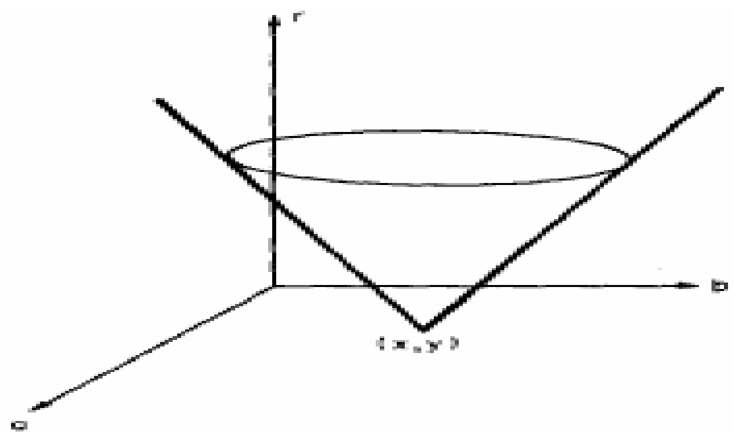


Figure 1.2 Conical surface in the Hough space for detection of circle

1.3 Hough Peaks

After the implementation of Hough transform on a binary gray scale image, a Hough matrix is generated, which can also be called as Hough array, which is generated by voting in parameter domain of the image. This voting in parameter domain gives the information about various lines that can be possible in the image. Even hidden line in the image is also revealed by this voting scheme. Since each point in the parameter domain corresponds to line and each sinusoidal curve represents a point in the original image, which is then reflected by the Hough array. So the highest voted accumulator cell in the accumulator array represents the Hough peak of that particular array. At the same time it also represents the most prominent line in the image. It also is considered that in Hough array, the cell at which maximum number of sinusoidal curves intersects is considered to have highest votes and hence can be considered as Hough peak of that particular Hough matrix. Since there can be many less prominent lines available for which accumulator cell has quite a large value of votes but not the highest can also be displayed. There is provision to show as many Hough peaks of an image. They can also be pointed out in the rho theta plane shown in Figure 1.3.

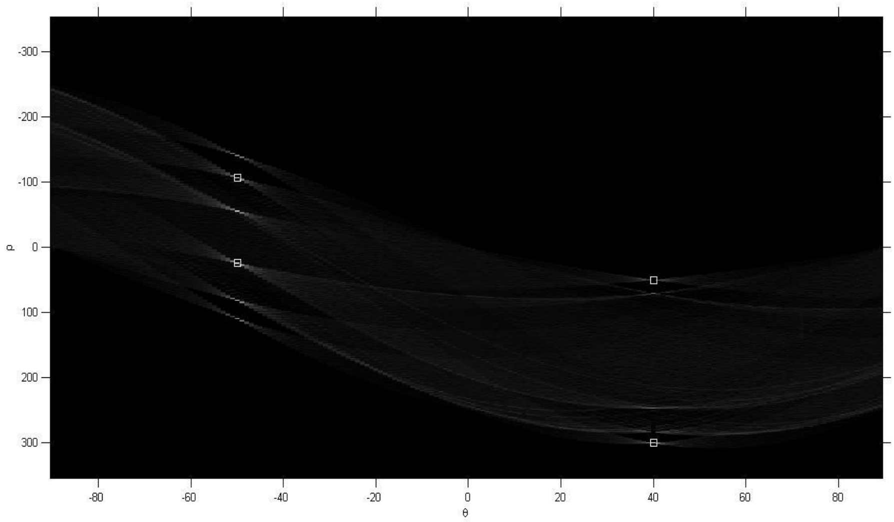


Figure 1.3 Displaying multiple peaks on the rho theta plane

1.4 Real Time Implementation of Hough Transform

In accordance with the present invention, a method and apparatus are disclosed for real-time processing of digitized image data using an implementation of the Hough transform. More specifically, frames of image data are received and stored as pixel arrays in a rectangular coordinate system. Pixels having values above a predetermined intensity are subsequently transformed into polar coordinate space. Maximum meeting points of curves associated with all pixels which have been transformed into polar coordinate space are then identified using a real-time, hardware implementation of a neuro-Hough transform for analyzing windowed portions of the digitized image. The present invention identifies maximum meeting points in polar coordinate space using a neuro-Hough transform implemented as a single chip. The US patent number US 5430810 A is already registered in 1995.

1.5 Motive

Motivation for this work is mainly the result of recent technological advances in the fields of sensing methods and automatic recognition systems. Improved robustness and increased resolution of modern imaging sensors and, more significantly, availability at a lower cost, have made the use of multiple sensors common in a range of imaging applications. In the past decade, medical imaging, night vision, military and civilian avionics, autonomous vehicle navigation, remote sensing, concealed weapons detection and various security and surveillance systems are only some of the applications that have benefited from the technical advancements in the field of image processing and also due to availability and advancements of various image processing tools. Surveillance cameras aren't just the bane of hardcore civil libertarians. Cameras in the sky are the ultimate manifestation of Big Brother a way for the government to watch citizens all the time, everywhere. In addition to normalizing surveillance turning every public place into a venue for criminal investigation, there's also the potential for abuse. Once routine surveillance is done, the government can turn every indiscretion into a criminal matter. Now, in many places around the world, a speed camera will record behaviour and send a ticket in the mail. Combine cameras with facial-recognition technology and license plate recognition technology the crimes can be monitored and can also be prevented. With more and more digitalisation and automation can reduce the irregularity in daily life and in society. Coming on the technical aspect, the use of Hough transform for such automatic recognition system has been very minute. Only face recognition was attempted before. In the market where more and more automatic recognition systems are evolving daily this approach has been left behind. The work gives solid proof that Hough transform can come out of its line and other standard shape detection and can evolve in the real world of automatic recognition systems.

CHAPTER 2

LITRATURE REVIEW

2. 1 Literature Review: Hough Transform

Hough transform is a globally used feature detection algorithm. The basic purpose of Hough transform is line detection, but in recent times it is extended for other purposes also. Some of these applications are discussed below

2.1.1 Generalization of Hough transform

The classical Hough transform was concerned with the identification of lines in the image, but D. H. Ballard in 1981 proposed, a modification of the Hough Transform using the principle of template matching [1]. This modification enables the Hough Transform to be used not only to detect an object described with an analytic equation (e.g. line, circle, etc), but also to detect an arbitrary object described with its model. The problem of finding the object (described with a model) in the image can be solved by finding the model's position in the image. In the Generalized Hough Transform, the problem of finding the model's position is transformed into a problem of finding the transformation parameter that maps the model onto the image. The approach consider not be the use of spatial data but also directional data, thus reducing the variable under consideration. The approach gives explanation about line, circle and also implementation of Hough transform for arbitrary object by introduction of a new concept called as R matrix. The R matrix involves multiple entries about various boundary points distance from a common point and its directional information.

2.1.2 Various Hough transform technique for circle detection.

Comparison of various method used for detection of circle using Hough transform was done by Yuen H.K. *et al*. [2]. Experimental comparison the performance of the methods and illustrates properties such as accuracy, reliability, computational efficiency and storage. Method studied are the Standard Hough Transform (SHT), The Gerig and Klein Hough transform, The GRHT with edge direction (GHTG), The 2-1 Hough Transform, The Fast Hough transform. The Standard Hough transform uses a 3 dimensional matrix and also uses edge information to reduce the number of votes. The Gerig and Klein Hough transform basically solves the storage problem of the standard Hough transform by the use of three, 2 dimensional arrays for voting. The GKHT with edge direction uses the edge direction information, a complete circle has to be incremented at every value of the radius for each edge point. The 2-1 HT is used only when edge direction information is available, it increases the storage efficiency. It was founded that the SHT, the GHTG and The 2-1 HT are close in performance to each other. The GRHT with edge direction (GHTG) is better than the 2-1 HT and the SHT's usage is restricted due to its storage requirements. The usage of GHTG is restricted to non concentric circle operation and also that error susceptibility of the 2-1 HT is more, because it's a two stage operation and the error from first stage gets transported to the next stage.

2.1.3 Combining Hough transform and contour algorithm for detecting vehicles license plates

Tran D. D. et al., has proposed a method for detection of licence number plate. Firstly, the image obtained is treated with edge operator like Sobel,Canny operators for edge detection to enrich the edge information of the input image [3]. Now the contour algorithm is generally used for detecting the closed boundaries in the image. More than one candidate is obtained by such an operation. Secondly, the Hough transform which is used for detection of the straight and parallel line in the edge operated image. Here the problem is the amount of image area under consideration is large and hence the process is slow in computation. Proposed method uses both Hough transform and Contour algorithm for the detection purposes. Firstly, Contour algorithm for detection of the closed boundaries in the image and then finally the Hough transform to detect the parallel lines. Even after these operations the number of candidates obtain are more than one in many cases, like head lights, bumpers and off course the required number plate. Two methods are used after this point to finally obtain the number plates. Since, the size of the number plate is generally rectangular so the height and width evaluation is applied to the obtained candidates, as the plates have a standard size. Secondly, a horizontal cross cut method is applied to the image. The process is such that a horizontal cut is made through the centre of the image to calculate the amount of objects crossed by the cut, if the numbers of cut are in proposed range the image is the number plate. The process has worked well even for scratched and poor quality images, but still performance can be enhanced by used better quality cameras.

2.1.4 Automatic number plate recognition using edge filters and window filters.

Various filtering methods for number plate recognition are proposed by Tran Duc Ouan *et al.*. ANPR is a mass surveillance system that captures images of the registration plate of the vehicles and further processes it to obtain the license plate number [4]. It is used for highway purposes, parking places, implementation of traffic rules. The method involves processing an image taken from a digital camera and processed to get the information about the registration number. The two algorithms discussed here are Edge filtering method and filtering by Window method. The Edge filtering method involves taking the variation in contrast level of the number plate since the numbers are on light background, generally white or yellow. The sharp change in contrast gives the probable information about the position of the numbers on the image. By using horizontal and vertical contrast variations, the position of image can be determined roughly. The other method, i.e. the window filtering, a window size is selected accordingly to filter the surrounding and enhance the actual image. Appropriate window size selection is must; a low size selection gives rise to errors, while to larger window size includes unwanted part of the image. The size of the window is generally taken equal to the size in the image for the best results. After filtering operations, binarization and noise removal is done, while keeping the sharpness of the image intact. Character segmentation is done after this; both vertical and horizontal segmentation is done. Finally, Optical Character Recognition is performed (OPR) is performed to complete the detection. The size of the image used is quite small as 15 x 15.

2.1.5 Face recognition using Hough peaks extracted from the significant blocks of the gradient Image

A new approach for face recognition is proposed by Arindam Kar *et al*., by using significant and blocks of a binary gradient image and finally applying Hough transform and further Hough peaks [5]. The face recognition technique should be robust, easily implemented and efficient in performance. The challenges for the face recognition technique is that it has to deal with various illumination levels of input image, various poses of the face, various facial expressions of the face under consideration and should give positive results in all such cases. Here various test images are taken from various facial databases. The method proposed involves three steps primarily, firstly, the input image taken is converted to binary image with bit depth equal to less than 8. Further, the absolute binary gradient of the binary image is calculated followed with various edge operations. The reason for the use of gradient image is that, the variation of intensity in a binary image which is of a face, most variation in the intensity takes place where the important facial information, i.e. features lies. Thus this binary gradient image used has important feature information of the image. Now, after the binary gradient image is obtained, it is fed to the Hough transform and the positions of Hough peaks are taken. By using some similarity measures various obtained results are compared with the database. The obtained results show the efficiency of the method to lie between 75-99% for various databases.

2.1.6 Circle recognition through 2-D Hough transform and radius histogramming.

A two-step algorithm for the recognition of circles is presented by Dimitrios Ioannoua, Walter Hudab and Andrew F. Lainec [9]. The first step uses 2-D Hough Transform for the detection of the center of the circles and the second step validates their existence by radius histogramming. The 2-D Hough Transform technique makes use of the property that every bisector to a chord of a circle passes through its centre. The results of experiments with synthetic data demonstrating that the method is more robust to noise than standard gradient based methods. The normal detection of circle is a three dimensional approach, which is decomposed into a 2-D HT and 1-D histogramming. Instead of 2-D gradient Hough transform, 2-D bisection Hough transform is used, which exploits the property of the chords and its bisector. It is that if a chord of circle is bisected than the bisector will pass through the center. The 1-D radius histogramming involves the plotting of number of votes to a particular radius magnitude and all the radius magnitudes obtained. The use of filters is done ease the voting procedure. Finally, the performance of 2-D bisection based circle detection is found to be better than 2-D gradient based scheme at low levels of SNR.

2.1.7 A two step circle detection algorithm using the intersecting chords

Heung-Soo Kim, Jong Hwan Kim proposed a method for circle detection using the properties of the intersecting chords of the circle [12]. This approach also gives a circle detection method using 2-D Hough transform and 1-D radius histogramming, but instead using bisection approach it uses the properties of two intersecting chords to locate the center followed by radius histogramming. The property involves using a geometric property of the point of intersection of the chords and its distance from the center of the circle. Finally it uses a trigonometric equation of circle to locate the center. The detection of circle using 2-D HT, property of intersecting chords and finally the radius histogramming, circle detection is effectively done.

2.2 Literature Review: Medical Imaging

Medical imaging is the method which involves the use of images of diagnosis purposes. The use of Hough transform for medical imaging is new. Some of these method are discussed below

2.2.1 RIM-ONE: an open retinal image database for optic nerve evaluation.

F. Fumero, S. Alayon *et al.* has produced a database of optical nerve pattern of the eyes. Automatic diagnosis for diseases like glaucoma has been under research for a long time [14]. The Glaucoma is named for group of diseases which involve the change in optical nerve patterns which are uniform throughout the life time for humans. The disease involves the loss of Ganglion cells in the optical nerves and associated with the intraocular pressure in the optical nerves, which are the connection of the eyes to the brain. The automated system for diagnosis involves the use of Retinograph, which takes high resolution images of same orientation of the optical nerve patterns. The idea is to develop a database of optical nerve database for normal pattern and the infected pattern. The database provides 169 images of optical nerve patterns, in which 118 are for normal eyes and rest are of various stages of the disease. The database is used for the detection of the patterns which are unique in nature.

2.2.2 Detection of the optical disc in image of retina using the Hough transform.

Xiaolu Zhu et al. proposed an algorithm of the automatic location of the optical disc in the fundus images of retina [15]. The method involves binary image conversion, edge detection using sobel and canny edge detection algorithm and finally application of Hough transform. Since the original shape of the optical disc is circular, Hough transform for circle detection is used. The standard Hough transform is used, involving a 3-D array. Two databases STARE and DRIVE are used for image input. The proposed method is found out to be showing 92.5% efficiency for sobel edge detector while 80% for canny edge detector. The method is ineffective when the optical disc is not circular in shape. Also, the presence of bright exudates has catastrophic effect on results.

CHAPTER 3

AUTOMATIC NUMBER PLATE RECOGNITION

3.1 Automatic Number Plate Recognition (ANPR)

Automatic number plate recognition (ANPR) is a mass surveillance method that uses character recognition on images to read vehicle registration plates. The use of existing CCTVs or traffic cameras, or task specific equipment is done. The use of ANPR is done by various police department in various areas around the globe, also used for various toll tax collections as a method known as electronic toll collection, also for management of traffic on busy highways and for implementation of traffic rules on them. Storage the images of the site captured by the equipment and verification of the text on the licence plates can also be done by ANPR system [3]. Due to the plate variation from region to region the ANPR is developed as a region specific technology. The violation of privacy act i.e., tracking the movement of the citizens, high error rates, misidentifications and increase spending of tax payer money are the centre of concerns for this technology. At a Police Scientific Development Branch in the UK, the idea of ANPR was put forward in 1976. Prototype systems were working by 1979, and contracts were led to produce industrial systems, first at EMI Electronics, and then at Computer Recognition Systems (CRS) in Wokingham, UK. A1 road and the Dartford Tunnel were the first roads in United Kingdom to get the services of ANPR. In a case of stolen car first arrest was made in 1981. Standard home computer hardware can even implement the aspect of this technology and the link to other applications and database can also be done. It first uses a series of image manipulation techniques to detect, normalize and enhance the image of the number plate, and then the character recognition to extract the alphanumeric and numerals of the license plate. ANPR systems are generally deployed in one of two basic approaches: one allows for the entire process to be performed by transferring the data to a remote computer and where further operations are performed or at the roads only were real time operations are performed. The information captured from the plate like characters, date-time, road identification and any other relevant information required, has to be completed in roughly milliseconds, when ANPR is implemented on the lanes. Transmission of information from roads to a remote computer is done for further processing if necessary and stored at the lane for later retrievals. Large number of PCs acts as a server is used to process the information received from the roads and further processing is done. Often in such systems, large amount of bandwidth is required to send processed information to remote servers. The acquisition, filtering and segmentation of plate are shown in Figure 3.1.

Figure 3.1 Acquisition, Filtering and Segmentation of plate

There are six primary algorithms that the software requires for identifying a license plate:

1. Plate localization – finding the location of plate and separating from the image.
2. Plate orientation and sizing – compensates for the skew of the plate and adjusts the dimensions to the required size.
3. Normalization – adjustment of contrast and brightness is done.
4. Character segmentation – extraction of individual characters from the number plate
5. Character recognition.
6. Syntactical/Geometrical analysis – examination of character according to the format adopted in the region.

The complexity of each of these subsections of the program determines the accuracy of the system. During the third step of normalization, large amount of pre-processing of image like the use of edge detection techniques, various filters is required for example for reduction of noise in images use of median filter can be done [4].

There are a number of possible difficulties that the software must be able to cope with. These include:

- Poor image resolution, usually because the plate is too far away but sometimes results from the use of a low-quality camera.
- Blurry images, particularly motion blur.
- Poor lighting and low contrast due to overexposure, reflection or shadows.
- An object obscuring (part of) the plate, quite often a tow bar, or dirt on the plate.

- A different font, popular for vanity plates (some countries do not allow such plates, eliminating the problem).
- Circumvention techniques.
- Lack of coordination between countries or states. Two cars from different countries or states can have the same number but different design of the plate.

Meanwhile software part deals with many such corrections; it is primarily the job of the hardware part of the system to solve the related problems. Installation of camera at high altitudes may avoid problems with objects (such as other vehicles) obstructing the plate view but leads to introduction of new problems, such as the task of image segmentation becomes much more complex which involves the extraction of significant part of image. On some cars, tow bars may obscure one or two characters of the license plate. Other problems like vehicles having different plates structures like bike plates needs a total different arrangement for extraction of the character since the bike uses square plate. The error rate should be very low in cases where the ANPR is used for allowing permission for entry in a restricted location. However, any level of inaccuracy is not acceptable for ANPR systems.

ANPR systems may also be used for/by:

- Section control, to measure average vehicle speed over longer distances.
- Border crossings.
- Automobile repossessions.
- Gas stations to log when a motorist drives away without paying for their fuel.
- A marketing tool to log patterns of use.
- Traffic management systems, which determine traffic flow using the time it takes vehicles to pass two ANPR sites.
- Analyses of travel behaviour (route choice, origin-destination etc.) for transport planning purposes.
- Drive through Customer Recognition, to automatically recognize customers based on their license plate and offer them the items they ordered the last time they used the service, improving service to the customer. To assist visitor management systems in recognizing guest vehicles.
- Police and auxiliary Police.

3.2 Proposed Method for Number Plate Recognition

A new approach for character recognition based on matching measures using Hough peak as the matching vector has been proposed [5]. The method gives fair results and produces good results even when about 4-5% of original RGB image is under consideration. The method involves an input RGB image of the license plate of vehicle. There are three main contribution of this research. Firstly, extraction of the significant parts of image to get various characters of the RGB license plate input image by using image cropping. Secondly, converting the cropped images to binary image up to bit depth 8, anything above bit depth 8 is not acceptable. Thirdly, application of the Hough transform and Hough peaks on the binary images only to make the computing fast. After this the position of the first two Hough peaks are taken under consideration while ignoring all others. A database for similar dimension binary images is maintained and the comparison leads to the recognition of the characters on the RGB license plate. The detection is susceptible to image scaling and image rotation. The proposed algorithm is shown in Figure 3.2.

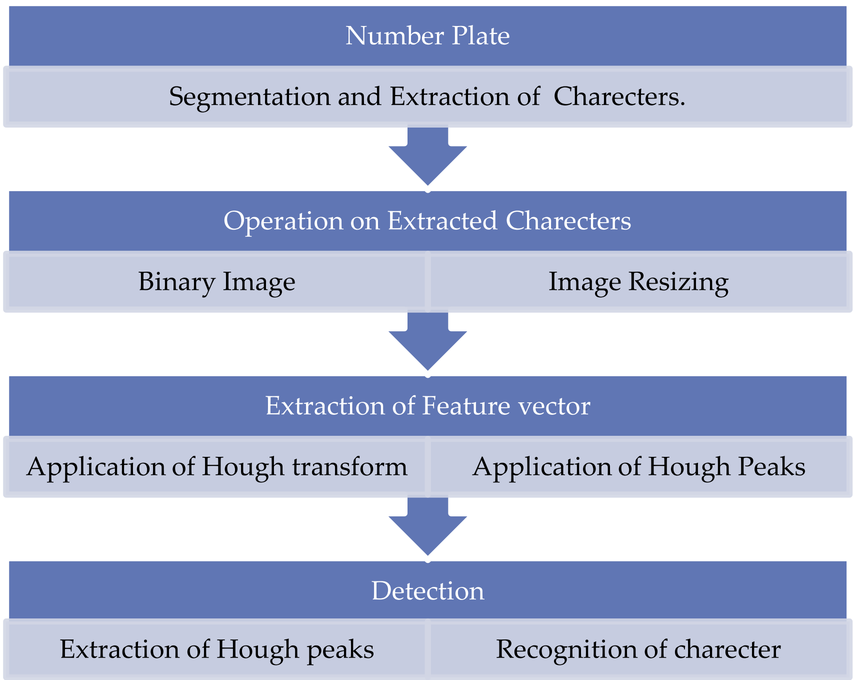


Figure 3.2 Proposed detection algorithm

3.3 Acquisition of License Plate Images

Since the quality of detection result dominantly depend on the quality of the acquisition process, the choice of acquisition system must be done carefully. Normally image acquisition by means of 2-D sensors needs image processing technique. In this experimental work, online facility of generation of any license plate of standard font and size is used. The font used is standard UK, with actual plate size of 520mm. x 111mm. (20.5 in. x 4.375 in.). The size of the image used is 2018 x 503 pixels. The segmented RGB images of the characters are sized as 160 x 325 pixels and the binary images which are fed to Hough Transform and Hough Peaks operations are resized to 250 x 250 pixels. The Indian license plates are shown in Figure 3.3.

(a)

(b)

Figure 3.3 Indian license plates (a) Standard UK font (b) standard UK 3D font

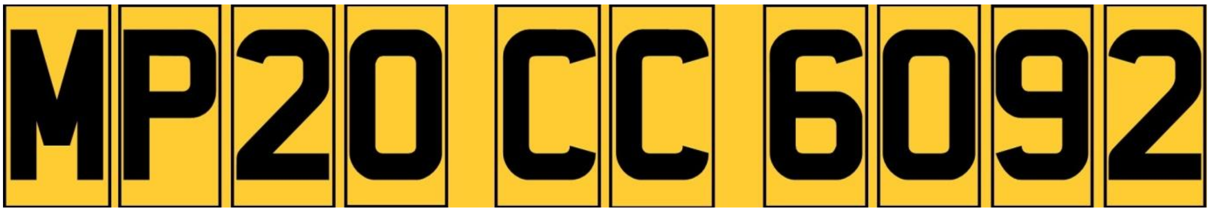
3.4 Extraction of Characters by Segmentation

The input License plate according to the Indian convention has 10 slots to convey the information regarding the details of the registration [6]. The current format of the registration index consists of 3 parts. They are

a. The first two letters which are alphabets gives the information about the state to which the vehicle is registered.
b. The next two slots are numbers and are sequential number of a district. Due to increase in the vehicle registration, the numbers were given to the RTO offices of registration as well.
c. The third part is a 4 digit number unique to each plate. A letter(s) is prefixed when the 4 digit number runs out of sequence.

The input image is a RGB image, with ten slots for the character and alphanumeric characters. Now the input image is then cropped to get these characters and numbers which are considered to be significant blocks of the image. The format of the characters and numbers used in license plate are standard UK format, database is maintained accordingly. Since the proposed method is basically feature dependent, same database for different font is not acceptable, hence for other formats the database should be upgraded accordingly.

Thus, the license plate input image is cropped to extract the alphabets and numbers. Image cropping algorithm is used to fulfill the intend. Ten sub images having information of license plate are cropped. Accordingly, four sub images of alphabets and six sub images of numbers are obtained. These sub images are cropped to a size of 160 x 325 each; the cropping pattern should be uniform for all sub images as non uniformity has bad effects on the final output. The cropping size of the image should be such that uniform size characters can be cropped out without any problem. Figure 3.4 shows the segmentation and cropping operations.



(a)

(b)

Figure 3.4 (a) Segmented image (b) Cropped images

3.5 Image Resizing and Binary Conversion

The scaling of an image is known as Image resizing. It's a non-trivial process and trade-off between efficiency, smoothness and sharpness is done. With bitmap graphics, as the size of an image is reduced or enlarged, the pixels which comprises the image become increasingly visible, making the image appear "soft" if pixels are averaged, or jagged if not. With vector graphics the trade-off may be in processing power for re-rendering the image, which may be noticeable as slow re-rendering with still graphics, or slower frame rate and frame skipping in computer animation.

Apart from fitting a smaller display area, image size is most commonly decreased (or sub sampled or down sampled) in order to produce thumbnails. Enlarging an image (up sampling or interpolating) is generally common for making smaller imagery fit a bigger screen in full screen mode, for example, in "zooming" a bitmap image, it is not possible to discover any more information in the image than already exists, and image quality inevitably suffers. However, there are several methods of increasing the number of pixels that an image contains, which evens out the appearance of the original pixels. The use of image resizing in the proposed method is to increase the number of pixels under consideration. If the size of the image is considerably low than the variation in position of Hough peaks of different input is considerably low and in some cases exactly identical. So an optimal image size is chosen, so that image size on disk doesn't increase too much and variations in the results are also achieved. A bitmap binary image, such as a monochrome bitmap, is created in a way that assigns a number of different bits of data to each pixel in the image; this is referred to as the "bits per pixel" (BPP). The number of colours that can be displayed on a bitmap image is equal to two raised to the power of the BPP number for that particular file. An image that can be displayed in "256 colours," which means up to 256 different colours can be used, is an 8-bit image; eight bits are used to determine the colour of each pixel which means that 2^8 or 256 colours are available.

Only a single bit of data is used for each pixel of a monochrome bitmap, meaning that these images have only 1 BPP. This means that such images can have 2^1 colours, or only two colours available. While technically it may be possible to set these colours differently, a monochrome bitmap is typically created with one colour being black, and the other is transparent. Since this transparent area is usually appears on computer screens and paper as white, these images are considered black and white.

Each bit used to create a monochrome bitmap is a piece of binary information, meaning that it is represented by either a one or zero. A pixel with a value of zero is usually displayed as transparent or white, while pixels with a value of one are black. These images have no possibility of other colours or values, so a monochrome bitmap displays crisp, straight horizontal and vertical lines, but curves and diagonal lines can appear jagged. Finally, the cropped images were resized to 250 X 250 and further converted to monochrome bitmap format to obtain the bit depth of "1". The resized and binary images are shown in Figure 3.5 [5].

Figure 3.5 Resized and converted binary image (bit depth 1 and monochrome bmp format)

3.6 Application of Hough Transform

Now the resized binary images are ready to be applied to the Hough transform. Before for the Hough transform application the image are fed to edge detector. Various edge detectors are used for serving this purpose. Primarily, the aim is to find edges from binary images. Some primary edge detectors are

3.6.1 Canny operator based edge detection

A good detection, good localization, and minimal response are the three criteria are taken under consideration by Canny edge detection. The technique is basically known as feature synthesis. Using Gaussian convolution accompanied by 2-D first derivative operator the image smoothening operation is done. Using two values of thresholds the application of non-maximal technique is performed. The value of upper threshold is kept as high as possible and for lower threshold as low as possible to ensure good results. A wide Gaussian kernel reduces the sensitivity of detector. Canny operator for edge detection due its high smoothness is more tolerant to noise.

3.6.2 Sobel operator based edge detector

Another edge detection operation performed in image processing is Sobel edge detector. Technically, it is a discrete differentiation operator, the gradient value of the image intensity function is computed. The result of the Sobel edge detection operation is either the normal or gradient value of the vector at each point in the image. The Sobel operator involves convolution of the image with a small and integer valued filter in both horizontal and vertical direction and this is the reason why, the amount of computation for Sobel operation is more. For high frequency variation of intensity in the image particularly gives relatively crude output.

3.6.3 Prewitt operator based edge detector

Another edge detection operation performed in image processing is Prewitt edge detector. Technically, it is a discrete differentiation operator, the gradient value of the image intensity function is computed. The result of the Prewitt edge detection operation is either the normal or gradient value of the vector at each point in the image. The Prewitt operator involves convolution of the image with a small and integer valued filter in both horizontal and vertical direction and this is the reason why, the amount of computation for Prewitt operation is more. For high frequency variation of intensity in the image particularly gives relatively crude output.

3.6.4 Laplacian of gaussian operator based edge detector

In Laplacian of Gaussian function, first, a Gaussian function is used and is convolved around the image, which blurs the image. The degree of blurring depends on the standard deviation of the Gaussian function. After that, Laplacian function is used over this smoothened image. Because Laplacian is a linear operator it convolves with the Gaussian function, which is same as convolving the image with smoothing function first and followed by computation of the Laplacian result.

3.7 Results & Discussion

The effectiveness of the proposed method is tested on Indian license plate system, having fonts of UK standard and UK standard 3-D [6], which has ten slots for characters and numbers. The size of the input image taken is 2018 x 503 pixels, which is an RGB image, further the input image is cropped and the significant blocks of information in the number plate are thus obtained. The ten sub images thus obtained from the input image are also RGB and among which 4 are alphabets while the rest are numbers. The size of the sub images obtained is 162 x 325 pixels. These sub images are resized to a size of 250 x 250 pixels, in order to increase the number of pixel under consideration and avoiding the possibility of getting same peak positions of different characters. First two Hough peaks are taken into account for the recognition purposes. The edge detection operation along with image rotation operation are also used prior to the implementation of Hough transform in order to get the edges of the binary image. The local maximum for the intensity gradient of image is looked upon by the Canny edge detector. The derivative of a Gaussian filter is used to calculate the gradient of intensity for the image. The method uses two thresholds, to detect strong and weak edges, and only if the weaker edges are connected to the strong edges, the detection of weak edges is done. This method is therefore less likely than the others to be fooled by noise, and more likely to detect true weak edges. Further, the image rotation angle is varied to 0, 20 and 50 degrees respectively. The performance for image rotation angle 20 degree is found out to be differentiating all the alphabets and numbers. Table 3.1, 3.2 and 3.3 comprises position of first four peaks for some alphabets in the Hough matrix.

Table 3.1
Position of peaks for rotation angle 0 degree

SAMPLE	peak 1	peak 2	peak 3	peak 4
A	133,001	493,067	455,115	164,001
B	322,001	134,001	384,091	600,091
C	321,001	357,091	134,001	423,091
D	321,001	134,001	591,091	443,091
E	321,001	134,001	360,091	168,001
F	321,001	357,091	288,001	244,001
G	365,091	321,001	134,001	430,091
H	360,091	598,091	533,091	321,001
J	601,091	536,091	134,001	
K	366,091	318,001	431,091	138,001
L	138,001	366,091	169,001	431,091
M	362,091	592,091	317,001	138,001
N	362,091	592,091	318,001	138,001
O	318,001	363,091	592,091	138,001
P	318,001	363,091	212,001	428,091
Q	318,001	363,091	144,001	531,091
R	317,001	365,091	138,001	429,091
T	317,001	285,001	443,091	507,091
U	595,091	360,091	426,091	530,091
V	321,001	589,116	345,066	406,066
W	321,001	134,001	600.97	354,085
X	322,001	134,001	379,046	505,136
Y	321,001	446,091	511,091	559,134
Z	321,001	134,001	168,001	288,001

Table 3.2
Position of peaks for rotation angle 20 degree

SAMPLE	peak 1	peak 2	peak 3	peak 4
A	426,096	433,047	303,071	553,071
B	608,161	420,161	333,071	303,071
C	303,071	608,161	553,071	373,071
D	608,161	393,071	541,071	421,161
E	421,161	608,161	454,161	309,071
F	421,161	303,071	454,161	373,071
G	314,071	380,071	303,071	608,161
H	482,071	548,071	309,071	376,071
J	485,071	554,071	608,161	303,071
K	315,071	381,071	265,025	321,026
L	604,161	381,071	315,071	573,161
M	542,071	311,071	553,071	496,102
N	321,027	542,071	269,027	311,071
O	542,071	477,071	312,071	303,071
P	312,071	424,161	378,071	303,071
Q	303,071	553,071	542,070	597,162
R	314,071	425,161	379,071	285,071
T	425,161	457,071	392,071	457,161
U	376,071	479,071	545,071	608,161
V	558,096	497,096	284,046	303,071
W	553,077	300,065	303,071	553,071
X	495,116	267,026	547,116	319,026
Y	546,115	303,071	553,071	268,026
Z	549,124	421,161	608,161	499,123

Table 3.3
Position of peaks for rotation angle 50 degree

SAMPLE	peak 1	peak 2	peak 3	peak 4
A	345,017	351,066	654,131	404,131
B	624,131	436,131	654,131	404,131
C	624,131	437,131	654,131	404,131
D	624,131	437,131	654,131	404,131
E	590,131	470,131	470,131	624,131
F	437,131	470,131	547,131	514,131
G	624,137	470,131	547,131	514,131
H	514,131	548,131	392,041	654,131
J	624,131	464,041	395,041	654,131
K	462,176	456,098	654,131	404,131
L	620,131	589,131	654,131	404,131
M	251,010	654,131	404,131	452,041
N	462,177	515,177	654,131	404,131
O	620,131	440,131	654,131	404,131
P	440,131	546,131	654,131	404,131
Q	440,131	654,131	404,131	614,131
R	441,131	654,131	404,131	473,131
T	441,131	473,131	654,131	367,041
U	624,131	654,131	404,131	389,041
V	196,016	484,066	422,066	654,131
W	654,131	404,131	209,035	624,131
X	443,086	515,176	494,086	463,176
Y	514,177	654,131	404,131	491,084
Z	437,131	624,131	457,093	470,131

3.8 Summary

The proposed technique hereby uses image cropping and image resizing on the original input RGB image and thus, obtaining the significant blocks of the input image needed for detection. As instead of whole image, significant blocks are used, the database management becomes compact and the technique becomes flexible, until same font is used. Further, conversions of these RGB sub images to binary images is done and then are fed to the Hough transform algorithm followed by Hough peaks algorithm to give the Hough peak positions on ρ , θ plane. Here selection of first two Hough peaks gives unique result for almost every alphabet and number used in the license plates. Non uniform cropping and resizing of image has catastrophic effects on the detection, thus uniform cropping and resizing algorithm should be followed to ensure proper and efficient detection.

CHAPTER 4

USE OF HOUGH TRANSFORM ON RETINAL IMAGE FOR OPTICAL NERVE EVALUATION

4.1 Introduction

A shift from film to electronic images is undergoing in Medical imaging. The STARE (structured analysis of the retina) system is a sophisticated setup that automatically performs diagnosis of images, comparison images, measurement of key features in images, annotate image contents, and search for such image in database is done. Concentration is on automated diagnosis. The objects of interest are annotated by the process of segmentation, the extraction of objects and reasoning about the contents of the image is done. The use of Hough transform in medical imaging is not new [8]-[9]. It's expected that ophthalmologists and physicians in other fields also that rely in images for their diagnosis, also use a system like STARE (structured analysis of the retina) to increase the efficiency of work, in case of difficult diagnoses or the case of unfamiliar diseases the assistance is provided to the physician, and for maintenance of the image database. Automated diagnosis of glaucoma disease has been studied for years [9]-[10]. A great amount of research work in this field has been focused on the analysis of retinal images to localize, detect and evaluate the optic disc [11]. An open funds image database with accurate gold standards of the optic nerve head has been implemented. A variability measurement by zones of the optic disc is also proposed. The relevance of this work is to provide accurate ONH (Optical nerve head) segmentations and a segmentation assessment procedure to allow the design of computerized methods for glaucoma detection.

Ophthalmologists rely heavily on images of the eye in patient care and research. The most common method of acquisition and storage of color and fluoresce in angiogram images of the retina and optic nerve is film-based. Today, inexpensive computers are able to handle electronic images large enough to contain important details. The user can manipulate electronic images in ways that is superior to film-based images. For example, the user is able to obtain automated diagnosis from images, compare sequential images, measure important structures in an image, and aggregate images similar in content. The physician can thereby receive decision support, be relieved of repetitive actions and routinely obtain useful measurements currently too difficult or arduous to obtain. The retina is a forward extension of the brain and its blood vessels. Images of the retina tell about retinal, ophthalmic, and even systemic diseases. The ophthalmologist uses images to aid in diagnoses, to make measurements, to look for change in lesions or severity of disease, and as a medical record. For example, while screening images of the ocular fundus, the physician may suspect the presence of diabetes from a pattern of hemorrhages, exudates, (yellow deposits in the retina), and cotton-wool spots (microscopic loss of circulation). It is a natural human desire to find ways to avoid repetitive or routine work and be left with interesting and challenging work. Also it is advantageous to make use of outside expertise at the moment if it is needed. There is a need for an imaging system to provide physician assistance at any time and to relieve the physician of drudgery or repetitive work.

4.2 Database used for Purpose

An online database with retinal fundus images has been developed in order to be a reference for the design of optic nerve head segmentation algorithms. The main differences among all the databases cited in the previously and the proposed RIM-ONE (retinal image method) [12] are the following: RIM-ONE is exclusively focused on ONH (Optical nerve head) segmentation; it has a relatively large amount of high-resolution images (169) and manual reference segmentations of each one. This enables the creation of reliable gold standards, thus decreasing the variability among expert segmentations, and the development of highly accurate segmentation algorithms.

The designed database is composed of 169 ONH (Optical nerve head) images obtained from 169 full fundus images of different subjects. The ONH (Optical nerve head) is a clearly identifiable part of the retina so these images has been manually cropped to this region of interest. These retinographs has been captured in the three hospitals cited before which are located in different Spanish regions. All the retinographs are non mydriatic retinal photographs captured with specific flash intensities, avoiding the saturation. The camera used to capture these images is a fundus camera Nidek AFC-210 with a body of a Canon EOS 5D Mark II of 21.1 megapixels. Some images of this database are shown in Figure 4.1. The images are classified in different subsets, as domain experts have indicated:

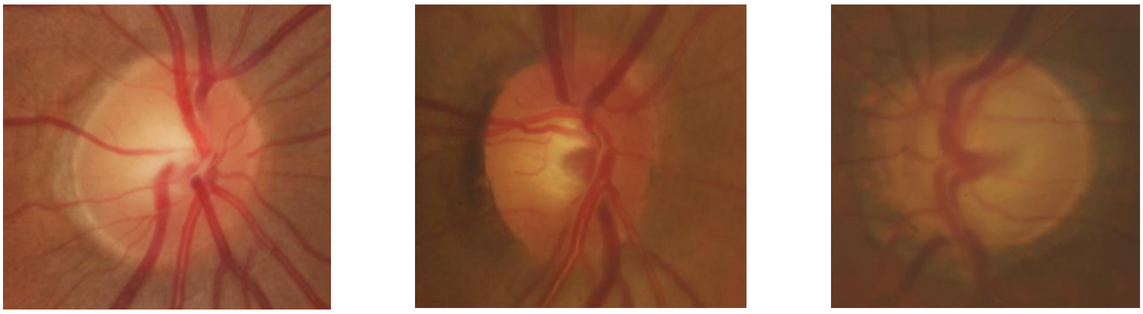
• Normal eye (non-glaucomatous): 118 images.

• Early glaucoma: 12 images.

• Moderate glaucoma: 14 images.

• Deep glaucoma: 14 images.

• Ocular hypertension (OHT): 11 images.



(a) normal (b) early (c) deep

Figure 4.1 RIM-ONE optical nerve images (a) normal eye (b) early stage Glaucoma (c) deep stage Glaucoma

4.3 Proposed Method using Hough Transform

The proposed approach for optical nerves pattern detector based on matching measures using Hough peak as the matching vector has been proposed. The method is able to distinguish between various patterns even when about 3.5-4% of original RGB image of RIM-ONE (retinal image method) database is under consideration [15]. There are three main contribution of this method. Firstly, the images of the RIM-ONE database are resized to a fixed size as the available database has different sized images in it but the orientation is same. Secondly, conversion of the resized images to binary image up to bit depth 8, anything above bit depth 8 is not acceptable. Thirdly, application of the Hough transform and Hough peaks on the binary images is done only to make the computing fast. After this the position of the first two Hough peaks are taken under consideration while ignoring all others. The detection is susceptible to image scaling and image rotation. The proposed algorithm is shown in Figure 4.2.

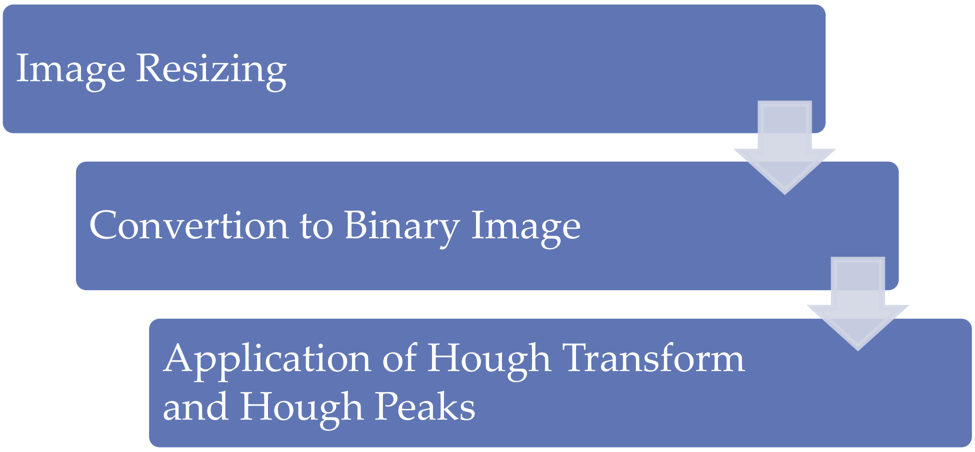


Figure 4.2 Flowchart for optical pattern detector

4.4 Image Scaling and Conversion to Binary Image

Image scaling is the process of resizing a digital image. Scaling is a non-trivial process that involves a trade-off between efficiency, smoothness and sharpness. With bitmap graphics, as the size of an image is reduced or enlarged, the pixels which comprise the image become increasingly visible, making the image appear "soft" if pixels are averaged, or jagged if not. With vector graphics the trade-off may be in processing power for re-rendering the image, which may be noticeable as slow re-rendering with still graphics, or slower frame rate and frame skipping in computer animation.

Apart from fitting a smaller display area, image size is most commonly decreased (or sub sampled or down sampled) in order to produce thumbnails. Enlarging an image (up sampling or interpolating) is generally common for making smaller imagery fit a bigger screen in full screen mode, for example. In "zooming" a bitmap image, it is not possible to discover any more information in the image than already exists, and image quality inevitably suffers. However, there are several methods of increasing the number of pixels that an image contains, which evens out the appearance of the original pixels. The use of image resizing in the proposed method is to increase the number of pixels under consideration. If the size of the image is considerably low than the variation in position of Hough peaks of different input is considerably low and in some cases exactly identical. So an optimal image size is chosen, so that image size on disk doesn't increase too much and variations in the results are also achieved.

A bitmap binary image, such as a monochrome bitmap, is created in a way that assigns a number of different bits of data to each pixel in the image; this is referred to as the “bits per pixel” (BPP). The number of colours that can be displayed on a bitmap image is equal to two raised to the power of the BPP number for that particular file. An image that can be displayed in “256 colours,” which means up to 256 different colours can be used, is an 8-bit image; eight bits are used to determine the colour of each pixel which means that 2^8 or 256 colours are available.

Only a single bit of data is used for each pixel of a monochrome bitmap, meaning that these images have only 1 BPP. This means that such images can have 2^1 colours, or only two colours available. While technically it may be possible for someone to set these colours differently, a monochrome bitmap is typically created with one colour being black, and the other is transparent. Since this transparent area is usually appears on computer screens and paper as white, these images are considered black and white.

Each bit used to create a monochrome bitmap is a piece of binary information, meaning that it is represented by either a one or zero. A pixel with a value of zero is usually displayed as transparent or white, while pixels with a value of one are black. These images have no possibility of other colours or values, so a monochrome bitmap displays crisp, straight horizontal and vertical lines, but curves and diagonal lines can appear jagged. The input database images are random in size. They are resized to a common scale of 500 x 500. These resized images are converted to binary images to have the bit depth of “1”. The RGB images from database, resized binary images are shown in Figure 4.3 and Figure 4.4. Now the binary images are ready to be fed to Hough transform and Hough peaks. Since the database has already provided the images of optical nerves, the image segmentation and image cropping are not used.

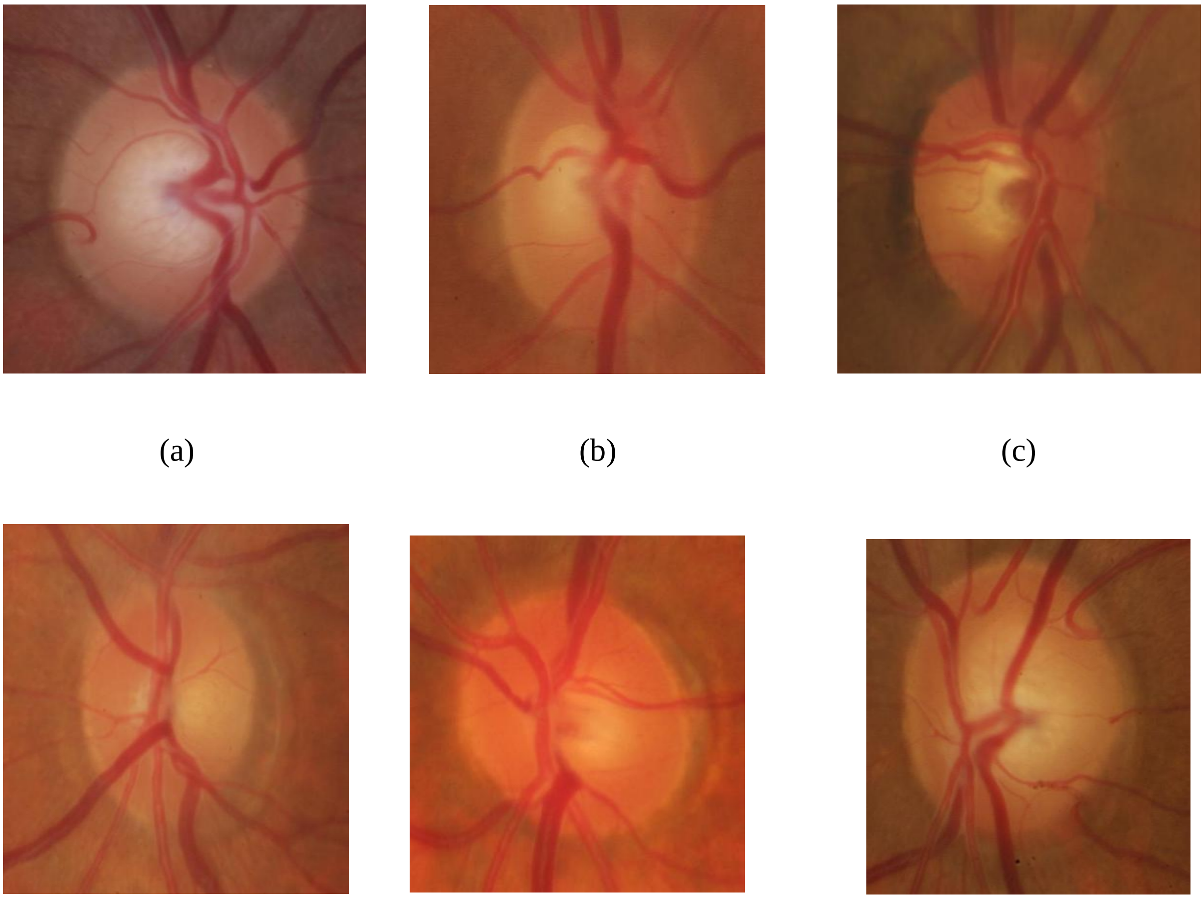
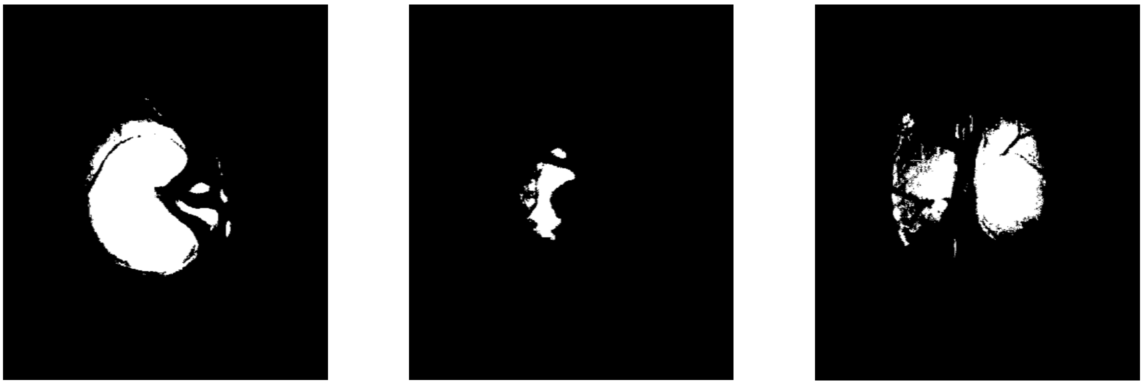
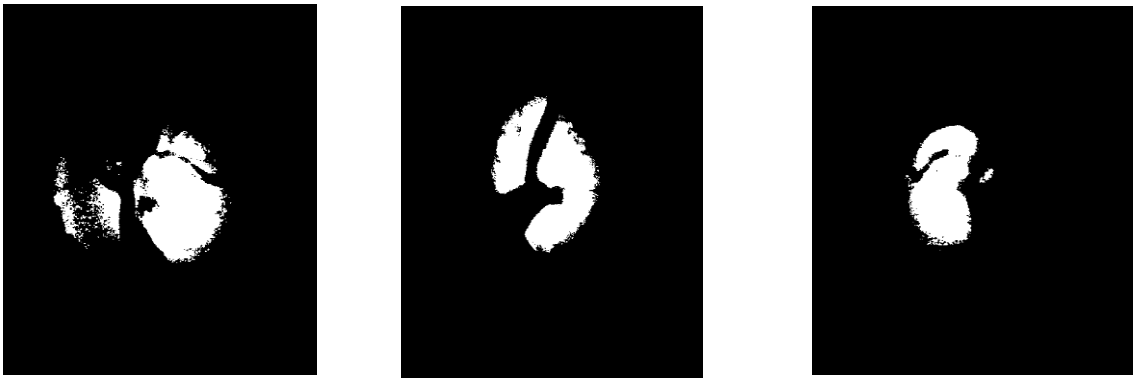


Figure 4.3 RIM-ONE data base for optical nerves patterns for normal eyes



(a) (b) (c)



(e) (f) (g)

Figure 4.4 Binary images for optical nerves patterns

4.5 Application of Hough Transform

As the binary images of optical nerve patterns are obtained, similar as in character recognition, the images are ready to be fed to the Hough transform. The image size used for this purpose is 500x500 pixels. The reason for bigger sized image to be used this time is to make sure that each pattern which is different in shape should be seen by Hough transform as different, not even single visual information about the pattern can't be skipped. Similar to previous method Canny edge detection is used for detection of edges.

Image rotation angle is taken as 20 degrees. All 118 images of optical nerve system provided by RIM-ONE database are tested and the results are found out to be unique. The rho theta plane here varies from -600 to +600 for rho and -80 to +80 for theta. Unique peaks positions obtained for every image taken as input.

4.6 Results and Discussion

A new method is proposed here in order to detect the variation in the optical nerve patterns. The size of the input image taken is form a database called as RIM-ONE. The idea of the database is to provide a collection of images of optical nerves for normal eyes and for various stages of the disease. The input images, which were RGB image, taken by camera named as Nidek AFC-210 with a body of a Canon EOS 5D Mark II of 21.1 megapixels [15]. The images in the database are different in size but the orientation of images was uniform. These sub images are resized to size 500 x 500 pixels, in order to increase the number of pixel under consideration and avoiding skipping of any information about the nerve pattern, hence avoiding the possibility of getting same peak positions of patterns. First two Hough peaks are taken into account for serving the purposes. The edge detection along with image rotation is also used prior to the implementation of Hough transform in order to get the edges of the binary images. Further, the image rotation angle is varied to 0, 20 and 50 degrees respectively. Here diseases like glaucoma makes the patterns of optical nerve which stays constant through the life time, change significantly. So the purpose is to detect the change in the pattern and report the abnormality. The position for the first two Hough Peaks for first 24 images of the RIM-one database is shown in Table 4.1.

Table 4.1

Position of peaks on rho theta plane for optical nerve patterns of RIM-one database

IMAGE	PEAK I	PEAK II
IM 01	4,213	246,84
IM03	10,286	-259,-89
IM04	8,220	247,9
IM08	-45,-139	303,32
IM12	10,266	250,21
IM11	45,284	225,49
IM22	7,341	-215,-76
IM24	55,353	294,89
IM25	55,360	355,58
IM20	4,155	275,89
IM23	-31,182	120,-45
IM27	-12,221	-158,-77
IM28	-10,176	396,78
IM29	45,264	261,38
IM31	68,351	313,79
IM32	-88,-234	109,-5
IM33	80,281	198,-32
IM36	-35,105	266,0
IM37	-26,101	283,87
IM40	0,281	381,73
IM41	-37,60	41,-52
IM42	-87,-203	-214,-67
IM70	-66,-64	,-120,-76
IM71	-5,287	-87,-67

4.7 Summary

Optical nerves are the connection from eyes to brain. They are the part of the nervous system. The pattern of optical nerve are unique and are not time bounded, even when a person is old the optical nerve pattern remains almost unchanged. Even twins don't share the same pattern. The only way of alteration of these patterns are eye diseases. Diseases like glaucoma makes the patterns of optical nerve which stays constant through the life time change significantly. So the aim is to detect the change in the pattern and report the abnormality, to make automatic system so capable that they can assist the experts of that field. For this detection purpose Hough transform and Hough peaks are used and the fact that these nerve patterns are unique in every sense is confirmed.

Further, since the optical nerve patterns are unique. They also comes in class of various biometrics like fingerprints, retina etc. The method can also be used for serving this purpose also, i.e. to acts as a biometric variable detector.

CHAPTER 5

CONCLUSIONS AND FUTURE WORK

5.1 Conclusion

The first work is about detection of characters using Hough transform and further using it for recognition of license plates of the vehicles. The proposed technique hereby uses image cropping and image resizing on the original input RGB image and thus, obtaining the significant blocks of the input image needed for detection. The common font for the character is used. Instead of whole image, significant blocks are used the database management becomes compact and the technique becomes flexible, until same font is used. Further, conversion of these RGB sub images to binary images is done and then is fed to the Hough transform algorithm followed by Hough peaks algorithm to give the Hough peak positions on ρ , θ plane. Here selection of first two Hough peaks gives unique result for almost every alphabet and number used in the license plates. Non uniform cropping and resizing of image has catastrophic effects on the detection, thus uniform cropping and resizing algorithm should be followed to ensure proper and efficient detection.

Optical nerves are the connection from eyes to brain. They are the part of the nervous system. The pattern of optical nerve are unique and are not time bounded, even when a person is old the optical nerve pattern remains almost unchanged. Even twins don't share the same pattern. The only way of alteration of these patterns are eye diseases. Diseases like Glaucoma makes the patterns of optical nerve which stays constant through the life time change significantly. So the proposed method is used to detect the change in the pattern report the abnormality, to make automatic system so capable that they can replace the experts of the field. For this detection purpose Hough transform and Hough peaks are used and the fact that these nerve patterns are unique in every sense is confirmed.

Further, since the optical nerve patterns are unique. They also comes in class of various biometrics like fingerprints, retina etc. The method can also be used for serving this purpose also i.e. to acts as a biometric variable.

5.2 Future Work

Hough transform has significant contribution towards the detection lines and even other parametric shapes. Hough transform is considered to be the best pattern detecting tool available in image processing. A combination of Hough transform and Hough peaks has been incorporated in this work. By the Implementation of suitable images Hough transform based approach has given fair results for both character and optical nerve detection.

Some other Hough transform approaches like fast Hough transform and circular Hough transform can be used to further improve the processing. One major shortcoming of the proposed method is that the variation in results is drastic if the orientation of the image is changed. Tilting and non uniform position of image affects the result. Hence, further work is required to modify these shortcomings. One approach can be normalisation of the rho theta plan after the position of Hough peaks are located, this will allow us to use different size images for the purpose. But even by this the problem of orientation is not rectified. Further research is needed to rectify this problem. The images with high noise are not incorporated but since Hough transform is used, the handling of noise is not supposed to be a problem. Non availability of a database is also a problem faced, some work is needed to establish one.

As far as optical nerve detection is concerned, the database has images of normal and effected optical nerve patterns, but pre and post disease patterns were not available. But since the disease has quite an effect on the nerve pattern and the sensitivity show by the method, it can take care of such variations. On the use of other biometric variables as finger prints, the conversion of RGB image into binary image almost looses all significant features necessary for detection and every fingerprint almost gives the same position of Hough peaks. To implement and further increase the use of this technique, some image pre-processing is required, in order to save the differtiating data from being overlooked by the monochrome bitmap format, i.e. binary images. The method like further extracting sub images from RGB input images or looking for gradient, as done in case of face recognition can be used.

The use of Hough transform in Automatic recognition systems is new, but as explained in previously large amount of pre-processing of the images are needed before to be fed to Hough transform. A lot of work more is needed to make detection more robust and immune to minute changes in image orientation. The technique has a long way to go until it is implemented to the real world.

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