B.Sc. in Computer Science and Engineering Thesis

Universal Vehicle Identification and Classification System Using Image Processing

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CERTIFICATION

This thesis paper titled **”Universal Vehicle Identification and Classification System Using Image Processing”**, submitted by the group as mentioned below has been accepted as satisfactory in partial fulfillment of the requirements for the degree B.Sc. in Computer Science and Engineering in January 2018.

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CANDIDATES' DECLARATION

This is to certify that the work presented in this thesis paper, titled, **"Universal Vehicle Identification and Classification System Using Image Processing"**,is the outcome of the investigation and research carried out by the following students under the supervision of Lt Cdr Naresh Singh Chauhan, Assistant Professor, CSE Department, Military Institute of Science & Technology.

It is also declared that neither this thesis paper nor any part thereof has been submitted anywhere else for the award of any degree, diploma or other qualifications.

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ABSTRACT

In this new era, the use of vehicles has become very important for human prosperity and development. However, the use of vehicles in various crimes, kidnapping, terrorist activities also have become an unwanted evil for the humanity. The use of vehicle in suicide bombing, vehicle ramming on innocent by the psychopaths and terrorists has been increased drastically. Therefore, there is an urgent requirement of a reliable system that can track and further neutralize the attempt of the vehicles ramming onto the crowd, important building like schools, universities, banks, government institution and high security zones like military establishments. Thus, we have devised a very simple mechanism to identify and classify the vehicles entering or leaving into any establishments as authenticated military and civil vehicles. Our proposed research basically uses the simple image processing method to detect vehicle number plate from a live video captured by a camera installed at the entrance of such buildings or restricted zones. This research could also provide a great assistance to identify the authenticity of a civil vehicle from the database of state or country traffic department.

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LIST OF ABBREVIATION

ULEA : Unwanted Line Elimination Algorithm
VEDA : Vertical Edge Detection Algorithm
HDD : Highlight Desired Details
PRS : Plate Region Selection
CRE : Candidate Region Extraction
OCR : Optical Character Recognition

CHAPTER 1
INTRODUCTION

1.1 Overview

Modern technology has blessed us with many new inventions and one of the most promising inventions is the license plate recognition system by digital image processing. A license plate is used for uniquely identifying a vehicle [1]. In recent years, security has become a major issue worldwide. Vehicle ramming, suicide bombing attacks, terrorist attacks and other illegal activities have become a daily scenario. According to [24] a license plate recognition (LPR) system plays an important role in numerous applications, such as parking accounting systems, traffic law enforcement, road monitoring and security systems. Priti Rajvanshi [25] mentioned that Automated Number Plate Recognition System would greatly enhance the ability of police to detect criminal activity that involves the use of motor vehicles. Thus recognizing license plate can be a vital key to ensure proper security of vehicles, to prevent unauthorized vehicle entry in restricted areas, to identify the traffic rule breakers as well as reduce crimes.

The Azor attack by Palestinian terrorists in 2001 was considered to be the earliest ramming attacks and a new militant tactic which proved to be more difficult to prevent than suicide bombings [44]. Many similar incidents took place such as the Jerusalem truck attack, Edmonton Attack and the Barcelona attack in which a 22 year old drove a van over pedestrians killing 13 people and injuring 130 people. That is why vehicle identification has become a necessity.

The proposed system takes an image as an input, converts color image to grayscale image, binarizes the image and applies Unwanted Line Elimination Algorithm (ULEA) to remove noise and enhance the binarized image. Binarization is performed mainly to highlight characters and to suppress background [26]. Then it separates the vehicle from the background through Vertical Edge Detection Algorithm (VEDA), and afterwards it applies Highlight Desired Details (HDD) to highlight license plate, Candidate Region Extraction (CRE) and finally applies Plate Region Selection (PRS) to extract the actual region of interest.

1.2 Prior Work

There are many researches done in the field of license plate recognition system using image processing. This section briefly mentions some of the related studies in order to provide a clear concept of how the system actually works.

The great impact of license plate recognition and vehicle classification has been discussed by various studies. In 2001, Remus Brad [16] discussed about the endless possibilities that lies in this field. He mentioned that this technology has a wide range of application starting from parking management, traffic control as well as public security.

According to Nikolaos and Ioannis [17] extraction, segmentation and recognition of characters are three main steps of any license plate recognition algorithm. They mentioned these tasks to be very challenging as various vehicles have various license plate formats. [18] mentioned that these tasks become more complex when license plate images are of various angles and the images consist of noise. Thus they suggested that an accurate and fast processing system is required.

[19] used three techniques which are morphological operation, histogram manipulation and edge detection. All these three techniques help in license plate localization and segmentation of characters. In this paper they used Artificial Neural Network for recognizing and classifying the characters. The limitation of this paper is that it works with standard Egyptian license plates only.

Robert F.K and Surendra Gupte [20] used segmentation, region tracking, vehicle identification, vehicle tracking and vehicle classification. Region is tracked by observing multiple images of the vehicle. Various parameters like height, width, length are obtained by applying 2D projection.

[21] and [46] followed the similar approach like [19]. The first paper modified the morphological operation by modi- fication of Hough Transformation. They used feed-forward back propagation Artificial Neural Network. The second paper printed the extracted characters in a text file with the help of MATLAB. They also proposed and algorithm for Parking Management System besides the license plate recognition.

Ragini and Bijender [39] used Sobel Edge Detection and Morphologicl operation. They used bounding box method for segmentation.

The paper [22] developed algorithm for vehicle color detection and trademark(logo). They did color classification using fuzzy sets and morphological operation was used for logo segmentation. The Results for correct color classification for this system is just 32.71 percent.

[23] conducted experiments using image data collected in Thailand. Histogram of Oriented

Gradient (HOG-based BOF) and linear support vector machine (SVM) were adopted for a detector. They mentioned that robustness against illumination or environmental change can be achieved with HOG, and robustness against various types of fonts can be achieved with BOF. There are certain limitations in this system. In some cases the license plate is not detected from vehicle image.

By going through the depth of the prior works we can find that though several studies have been done in the field of license plate recognition but there is no paper that has done successful classification of vehicles that are of various formats and languages all together

1.3 Thesis Organization

In order to go through the depth of this research work we need to study on image processing, license Plate recognition and various license plate recognition techniques. A brief description of evaluation and application of image processing, various noise removal techniques and stages of license plate recognition is given in chapter 2. Chapter 3 describes the methodology. The Experiment results of our thesis work is given in chapter 4. Chapter 5 describes limitations and future work.

CHAPTER 2
LITERATURE REVIEW

2.1 Image

An image is a visual representation of something which is created or copied and stored in electronic form.

1. Images may be 2D, such as a photograph or screen display, or three-dimensional, such as a statue or hologram.

2. It has to terms,vector graphics and raster graphics.A vector graphic file describes a series of points to be connected. A raster is a grid of x and y or even z coordinates on a display space. A raster image file identifies which of these coordinates to illuminate in monochrome or color values

3. Examples of raster image file types are BMP, TIFF, GIF, and JPEG files.They are difficult to modify without loss of information.

4. Portable Network Graphics(png) is lossless.

5. SVG is Scalable Vector Graphics: Scalability means that the file can be viewed on a computer display of any size and resolution, whether the small screen of a smartphone or a large widescreen display in a PC. Files usually have .svg extension.

2.2 Pixel

In digital imaging, a pixel, dots, or picture element is a physical point in a raster image.It is the smallest portion of an image or display that a computer is capable of printing or displaying.

A pixel is represented by a dot or square on a computer monitor display screen.They are the basic building blocks of a digital image or display and are created using geometric coordinates.

Depending on the graphics card and display monitor, the quantity, size and color combination of pixels varies and is measured in terms of the display resolution.

Each pixel is a sample of an original image; more samples typically provide more accurate representations of the original. The intensity of each pixel is variable.

2.3 Binary Image

A binary image is a digital image that has only two possible values for each pixel. Typically, the two colors used for a binary image are black and white.

Figure 2.1: Binary Image

2.4 Grayscale Image

A grayscale or grayscale digital image is an image in which the value of each pixel is a single sample, that is, it carries only intensity information.

The intensity of a pixel is expressed within a given range between a minimum and a maximum, inclusive. This range is represented in an abstract way as a range from 0 (total absence, black) and 1 (total presence, white) with any fractional values in between.

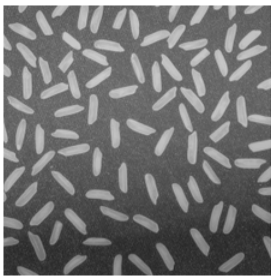


Figure 2.2: Grayscale Image

2.5 Color Image

A color image is usually stored in memory as a raster map, a two-dimensional array of small integer triplets; or (rarely) as three separate raster maps, one for each channel.

In color imaging systems, a color is typically represented by three or four component intensities such as red, green and blue or cyan, magenta, yellow and black

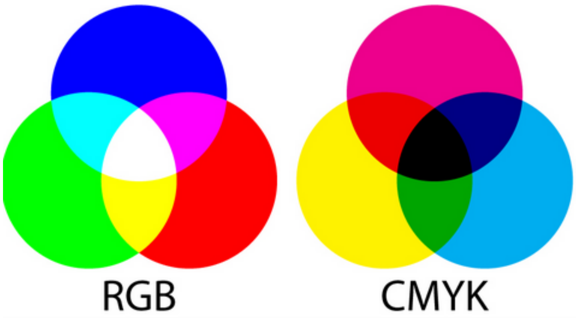


Figure 2.3: Color Image

2.6 Image Processing

Image processing is a method to perform some operations on an image, in order to get an enhanced image or to extract some useful information from it. It is a type of signal processing in which input is an image and output may be image or characteristics/features associated with that image.

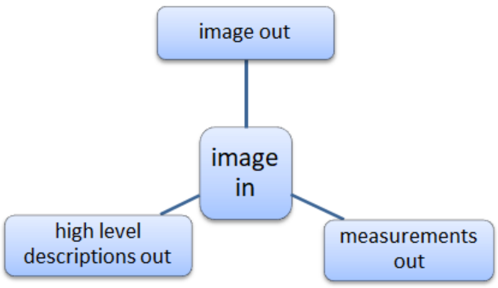


Figure 2.4: Image Processing

Image processing usually refers to digital image processing, but optical and analog image processing also are possible

2.7 Digital image processing

It the use of computer algorithms to create, process, communicate, and display digital images.

Digital image processing algorithms can be used to:

1. Convert signals from an image sensor into digital images
2. Improve clarity, and remove noise and other artifacts
3. Extract the size, scale, or number of objects in a scene
4. Prepare images for display or printing
5. Compress images for communication across a network

2.8 Image Analysis

Involves extracting meaningful information from an image, image segmentation, image matching and comparison and medical diagnosis from an image

2.9 Computer Vision Image Analysis

1. Object detection
2. Object recognition
3. Object shape analysis
4. Object racking
5. Use of Artificial Intelligence and Machine Learning.

2.10 History of Digital Image Processing

2.10.1 Early 1920s

One of the first applications of digital imaging was in the newspaper industry

Figure 2.5: Digital picture produced in 1921 from a coded tape by a telegraph printer with special type faces (McFarlane)

1. The Bartlane cable picture transmission service

2. Images were transferred by submarine cable between London and New York

3. Pictures were coded for cable transfer and reconstructed at the receiving end on a telegraph printer

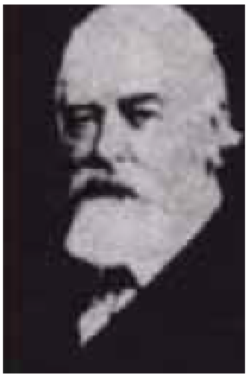


Figure 2.6: Digital picture made in 1922 from a tape punched after the signal had crossed the Atlantic twice. Here some errors are visible(McFarlane)

2.10.2 Mid to late 1920s

Improvements to the Bartlane system resulted in higher quality images

1. New reproduction processes based on photographic techniques

2. Increased number of tones in reproduced images

2.10.3 1960s

Many of the techniques of digital image processing, or digital picture processing as it often was called, were developed in the 1960s at the Jet Propulsion Laboratory, Massachusetts Institute of Technology, Bell Laboratories, University of Maryland, and a few other research facilities, with application to satellite imagery, wire-photo standards conversion, medical imaging, videophone, character recognition, and photograph enhancement. Robert Nathan led the development of digital image processing in its early stages, and with the technical help of other JPL scientists, won for it a featured place on the planetary missions of the late 1960s and beyond. Of the early resistance, he later said that he ”had to prove to project management each time what they needed” to get the most out of the first American pictures coming from space. When he saw the Russian pictures of the far side of the moon, he thought he could do better and began developing digital techniques for image.

Before an image can be processed, it must be put into digital form. Frederick Billingsley and Roger Brandt of JPL devised a Video Film Converter (VFC) that could transform analog

Figure 2.7: The first picture of the moon by a U.S. spacecraft. Ranger 7 took this image on July, 1964, about 17 minutes before impacting the lunar surface (courtesy of NASA).

video signals, such as those sent back by Ranger spacecraft, into digital data. The spacecraft, Mariner Mars had a camera capable of recording frames of 700 lines by 832 pixels, or 580,000 individual dots.

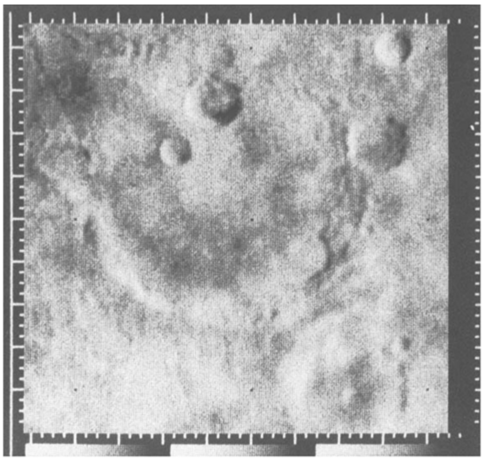


Figure 2.8: Mariner Mars 1964 returns the first closeup of Mars

2.10.4 1970s

The cost of processing was fairly high, however, with the computing equipment of that era. That changed in the 1970s, when digital image processing proliferated as cheaper computers and dedicated hardware became available. Images then could be processed in real time, for some dedicated problems such as television standards conversion. As general-purpose computers became faster, they started to take over the role of dedicated hardware for all but the most specialized and computer-intensive operations.

2.10.5 Late 1970s till now

the fast computers and signal processors available in the 2000s, digital image processing has become the most common form of image processing and generally, is used because it is not only the most versatile method, but also the cheapest.

The Field of image processing is continually evolving. During the past few years, there has been a significant increase in the level of interest in image morphology, neural networks, full-color image processing, image data compression, image recognition, and knowledge-based image analysis systems.

2.11 Applications of image processing

1. Medical field
2. Security Systems
3. Document Processing
4. Law enforcement and forensics
5. Pattern Recognition
6. Video Processing
7. Microscopic imaging
8. Machine/Robot vision
9. Photography
10. GIS
11. Space exploration and astronomy

2.12 Steps of Digital Image Processing

1. Acquisition
2. Enhancement
3. Restoration
4. Color image restoration
5. Wavelets

6. Morphological processing

7. Segmentation

8. Representation

9. Recognition

2.12.1 Image Acquisition

Image acquisition is the first process. Generally, the image acquisition stage involves pre-processing, such as scaling.

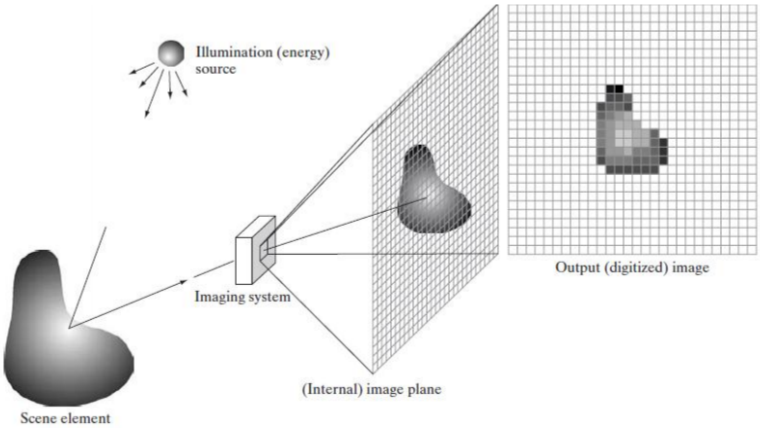


Figure 2.9: Image Acquisition

2.12.2 Image Enhancement

It is the process of manipulating an image so that the result is more suitable than the original for a specific application.

Figure 2.10: Image Enhancement

There is no general theory of image enhancement.When an image is processed for visual interpretation, the viewer is the ultimate judge of how well a particular method works.

2.12.3 Image Restoration

Image Restoration is the operation of taking a corrupt/noisy image and estimating the clean, original image. Corruption may come in many forms such as motion blur, noise and camera mis-focus.

It is an area that also deals with improving the appearance of an image.However, unlike enhancement, which is subjective, image restoration is objective, in the sense that restoration techniques tend to be based on mathematical or probabilistic models of image degradation.

Image restoration is performed by reversing the process that blurred the image and such is performed by imaging a point source and use the point source image, which is called the Point Spread Function (PSF) to restore the image information lost to the blurring process.

Figure 2.11: Image Restoration

2.12.4 Color Image Processing

It is an area that has been gaining in importance because of the significant increase in the use of digital images over the Internet.

2.12.5 Wavelets

Wavelets are the foundation for representing images in various degrees of resolution.

2.12.6 Compression

As the name implies, deals with techniques for reducing the storage required to save an image, or the bandwidth required to transmit it. This is true particularly in uses of the Internet.

2.12.7 Morphological processing

Morphological processing deals with tools for extracting image components that are useful in the representation and description of shape

2.12.8 Segmentation

Segmentation procedures partition an image into its constituent parts or objects. A segmentation procedure brings the process a long way toward successful solution of imaging problems that require objects to be identified individually. In general, the more accurate the segmentation, the more likely recognition is to succeed.

2.12.9 Representation and description

Almost always follow the output of a segmentation stage, which usually is raw pixel data. 1. Boundary representation is appropriate when the focus is on external shape characteristics, such as corners and inflections. 2. Regional representation is appropriate when the focus is on internal properties, such as texture or skeletal shape.

Description, also called feature selection, deals with extracting attributes that result in some quantitative information of interest or are basic for differentiating one class of objects from another.

2.12.10 Recognition

It is the process that assigns a label (e.g., vehicle) an object based on its descriptors. Digital image processing with the development of methods for recognition of individual objects.

2.13 Noise

The images sent from sender end may not be the same at the receiving end it is often corrupted with noise.

Image noise is random variation of brightness or color information in images.It is unwanted electrical fluctuations in signals.It also means, the pixels in the image show different intensity values instead of true pixel values.It may arise in the image as effects of basic physics-like photon nature of light or thermal energy of heat inside the image sensors.

Noise can degrade the images at the time of capturing or transmission of the image

2.13.1 Principal sources of noise

The principal sources of noise in the digital image are:

1. The imaging sensor may be affected by environmental conditions during image acquisition.

2. Insufficient Light levels and sensor temperature may introduce the noise in the image.

3. Interference in the transmission channel may also corrupt the image.

4. If dust particles are present on the scanner screen, they can also introduce noise in the image.

2.13.2 Various types of noise

Salt and Pepper Noise

It is caused by sharp and sudden disturbances in the image.Black and white dots appear in the image as a result of this noise and hence salt and pepper noise.

This noise arises in the image because of sharp and sudden changes of image signal. Dust particles in the image acquisition source or over heated faulty components can cause this type of noise. Image is corrupted to a small extent due to noise.

Figure 2.12: Salt and Pepper Noise

Gaussian Noise

It is caused by random fluctuations in the signal. It can be idealized form of white noise.

The term normal noise model is the synonym of Gaussian noise. This noise model is additive in nature and follow Gaussian distribution. Meaning that each pixel in the noisy image is the sum of the true pixel value and a random, Gaussian distributed noise value. The noise is independent of intensity of pixel value at each point.

Shot Noise

The dominant noise in the darker parts of an image from an image sensor is typically that caused by statistical quantum fluctuations, that is, variation in the number of photons sensed at a given exposure level. This noise is known as photon shot noise.

Shot noise has a root-mean-square value proportional to the square root of the image intensity, and the noises at different pixels are independent of one another.

Shot noise follows a Poisson distribution, which except at very low intensity levels approximates a Gaussian distribution.

Figure 2.13: Shot Noise

Speckle Noise

Speckle noise is multiplicative noise unlike the Gaussian and salt pepper noise. This noise can be modeled by random vale multiplications with pixel values of the image and can be expressed as P = I +n * I.

Speckle noise is commonly observed in radar sensing system, although it may appear in any type of remotely sensed image utilizing coherent radiation.

Like the light from a laser, the waves emitted by active sensors travel in phase and interact minimally on their way to the target area.

Reducing the effect of speckle noise permits both better discrimination of scene targets and easier automatic image segmentation.

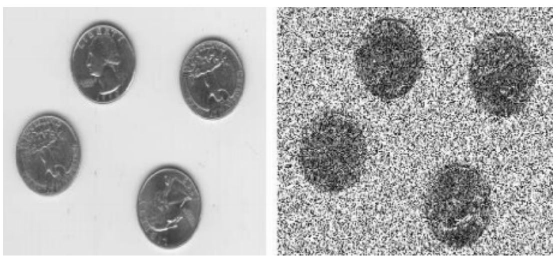


Figure 2.14: Speckle Noise

2.13.3 Factors in selecting various noise removal algorithms

1. Available computer power and time available: a digital camera must apply noise reduction in a fraction of a second using a tiny onboard CPU, while a desktop computer has much more power and time.

2. Whether sacrificing some real detail is acceptable if it allows more noise to be removed (how aggressively to decide whether variations in the image are noise or not).

3. The characteristics of the noise and the detail in the image, to better make those decisions

2.13.4 Different types of linear and non-linear filters

Mean Filter

The mean filter is a simple sliding window spatial filter that replaces the center value in the window with the average of all the neighboring pixel values including itself.

This process is repeated for all pixel values in the image. By doing this, it replaces pixels that are unrepresentative of their surroundings.The window is usually square but it can be of any shape.

8	4	7
2	1	9
5	3	6

Figure 2.15: Mean Filter

Median filter

12 4	125	127	13 1	14 1
12 3	125	127	12 8	13 6
11 9	121	**154**	12 6	13 5
12 0	116	120	12 4	13 4

Figure 2.16: Median Filter

In this filter, we do not replace the pixel value of the image with the mean of all neighboring pixel values; we replace it with the median value. Median filtering is done by, first sorting all the pixel values from the surrounding neighborhood into numerical order and then replacing the pixel being considered with the middle pixel value.

Adaptive Filter

These filters change their behavior on the basis of statistical characteristics of the image region, encompassed by the filter region.BM3D is an adaptive filter. It is a nonlocal image modeling technique based on adaptive, high order group-wise models. This de-noising algorithm can be divided in three steps :

1. **Analysis**: Firstly similar image blocks are collected in groups. Blocks in each group are stacked together to form 3-D data arrays, which are de-correlated using an invertible 3D transform.

2. **Processing**: The obtained 3-D group spectra are filtered by hard thresholding.

3. **Synthesis**: The filtered spectra are inverted, providing estimates for each block in the group. These block-wise estimates are returned to their original positions and the final image reconstruction is calculated as a weighted average of all the obtained block-wise estimates.

Max and Min Filter

It is a morphological filters that work by considering a neighborhood around each pixel. From the list of neighbor pixels, the minimum or maximum value is found and stored as the corresponding resulting value.

Finally, each pixel in the image is replaced by the resulting value generated for its associated neighborhood. If we apply max and min filters alternately they can remove certain kind of noise, such as salt-and-pepper noise very efficiently

Midpoint Filter

The midpoint filter simply computes the midpoint between the maximum and minimum values in the area encompassed by the filter.

Alpha- trimmed mean Filter

Alpha-trimmed mean filter algorithm:

1. Place a window over element.

2. Pick up elements.

3. Order elements.

4. Discard elements at the beginning and at the end of the got ordered set.

5. Take an average sum up the remaining elements and divide the sum by their number.

2.14 Image Reconstruction

Image reconstruction is the creation of a two- or three-dimensional image from scattered or incomplete data.

For some imaging techniques, it is necessary to apply a mathematical formula to generate a readable and usable image or to sharpen an image to make it useful.

These reconstruction techniques form the basis for common imaging modalities such as CT, MRI, and PET, and they are useful in medicine, biology, earth science, archaeology, materials science, and nondestructive testing.

2.15 Vehicle Identification and Classification

Vehicle identification and classification is the process of identifying a specific vehicle based on its unique identity which is the number plate and classifying the vehicle based on various parameters

2.15.1 Vehicle Identification

Vehicle identification helps to identify a vehicle by its number plate or vehicle identification number.

2.15.2 Vehicle Number Plate

A plate or tag, usually of metal, bearing evidence of official registration and permission, as for the use of a motor vehicle.

2.15.3 Vehicle Identification Number

A vehicle identification number (VIN) is a unique code, including a serial number, used by the automotive industry to identify individual motor vehicles, towed vehicles, motorcycles, scooters and mopeds.VINs were first used in 1954 in the United States.

2.16 License-plate recognition

License Plate Recognition (LPR) also known as Automatic Number-Plate Recognition (ANPR) is a technology that uses optical character recognition on images to read vehicle registration plates.

Automatic number plate recognition can be used to store the images captured by the cameras as well as the text from the license plate.

2.16.1 Algorithms for License Plate Recognition

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

1. **Plate localization**: Responsible for finding and isolating the plate on the picture.

2. **Plate orientation and sizing**: Compensates for the skew of the plate and adjusts the dimensions to the required size.

3. **Normalization**: Adjusts the brightness and contrast of the image.

4. **Character segmentation**: Finds the individual characters on the plates.

5. **Optical character recognition**

6. **Syntactical/Geometrical analysis**: Check characters and positions against country-specific rules.

7. The averaging of the recognised value over multiple fields/images to produce a more reliable or confident result. Especially since any single image may contain a reflected light flare, be partially obscured or other temporary effect.

The complexity of each of these subsections of the program determines the accuracy of the system. During the third phase (normalization), some systems use edge detection techniques to increase the picture difference between the letters and the plate backing. A median filter may also be used to reduce the visual noise on the image.

2.16.2 License Plate Recognition Applications

There are several applications where automatic license plate recognition can be used. The two major values license plate recognition adds to systems are automation and security.

After integrating a License Plate Recognition Software Engine into intelligent transportation systems, it becomes possible to automate motorway toll collection, analyse traffic, improve law enforcement, etc.

Intelligent Transportation System equipped with LPR

An Intelligent Transportation System equipped with LPR can provide

1. Flexible and automatic highway toll collection systems

2. Analysis of city traffic during peak periods

3. Automation of weigh-in-motion systems

4. Enhanced vehicle theft prevention

5. Effective law enforcement

6. Effective enforcement of traffic rules

7. Highest efficiency for border control systems, etc.

Other possible applications include:

1. Building a comprehensive database of traffic movement

2. Automation and simplicity of airport and harbour logistics

3. Security monitoring of roads, checkpoints, etc.

4. Vehicle surveillance Prevention of non-payment at gas stations, drive-in restaurants, etc.

Integrating License Plate Recognition Software Engine into parking management systems

After integrating License Plate Recognition Software Engine into parking management systems, controlled and automatic vehicle entry and exit in car parks or secure zones becomes possible. Furthermore, the ability to recognise registration number is a significant added value for comprehensive parking solutions or inventory management.

A parking lot equipped with LPR can provide:

1. Flexible and automatic vehicle entry to and exit from a car park

2. Management information about car park usage 3. Improved security for both car park operators and car park users

4. Improved traffic flow during peak periods

Other possible applications include:

1. Vehicle recognition through date and time stamping as well as exact location

2. Inventory management Comprehensive database of traffic movement

Figure 2.17: License Plate Recognition in Parking Management System

At last but not least state **border control** is one of the most important applications of automatic license plate recognition

2.16.3 Difficulties

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

1. Poor file resolution, usually because the plate is too far away but sometimes resulting from the use of a low-quality camera.

2.Blurry images, particularly motion blur.

3. Poor lighting and low contrast due to overexposure, reflection or shadows.

4. An object obscuring (part of) the plate, quite often a tow bar, or dirt on the plate.

5. Read license plates that are different at the front and the back because of towed trailers, campers, etc.

6. Vehicle lane change in the camera's angle of view during license plate reading.

7. A different font, popular for vanity plates (some countries do not allow such plates, eliminating the problem).

8. Circumvention techniques.

9. 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.

CHAPTER 3
METHODOLOGY

The overall scenario of how the system works is represented with the flowchart in the Figure 3.1 and the block diagram in the Figure 3.2.

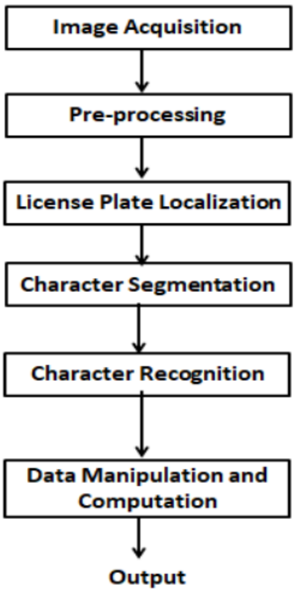


Figure 3.1: Flowchart

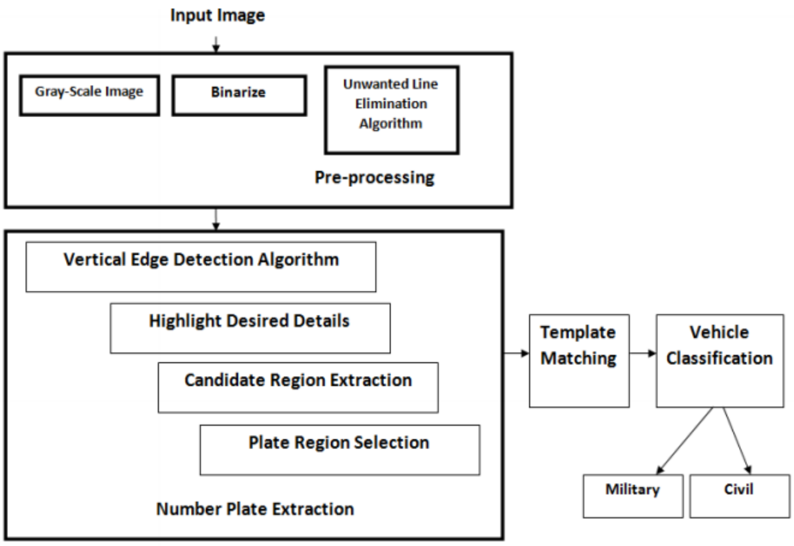


Figure 3.2: Block Diagram

3.1 Pre-processing

At first a color image of a vehicle, captured from the camera installed at the entrance of any building or establishment, is taken as input. Color images can be represented by three or four component for each pixel such as red, green, blue, cyan, magenta, etc. This color image is converted to grey-scale image which is shown in Figure 3.3. In the grey-scale image the intensity of a pixel is represented as a range starting from 0 for black to 1 for white. Then the picture is binarized so that it contains only two value that is 0s and 1s.

The unwanted line elimination algorithm then enhances the binarized image. The entire process starting from color image input to ULEA image is known as Pre-processing stage.

Figure 3.3: Color Image to Gray Scale Image

3.2 Edge Detection

The edge information is quite helpful to obtain shape information. At first the edges are detected and after that the sharpness is increased to make the image more clear.

The process of classifying and placing sharp discontinuities in an image is called the edge detection [37].

The Vertical Edge Detection Algorithm differentiates the number plate details from the background. It basically reduces the amount of data to be manipulated and thus makes the further process faster. Each character has two edges, one is the starting edge consisting of two pixel and another is the ending edge which is of one pixel.

3.3 Highlight Desired Details

It takes the VEDA output and highlights the desired details such as the number plate.

3.4 Candidate Region Extraction

There are multiple candidate regions. This method gives regions that have larger darkness ratio. The candidate regions are separated from each other with upper and lower lines. [38] studied that morphological filtering is used as a tool for extracting image components and so representing and describing region shapes such as boundaries. Candidate region is extracted in this method.

Figure 3.4: Input Image

Figure 3.5: Dilated Image

3.5 Plate Region Selection

It extracts the actual region of interest such as the license plate region. It relies on the output of candidate region extraction. The region with maximum black pixel is considered to be the desired license plate region. The process described is shown in the figures 3.4, 3.5, 3.6 and 3.7.

Figure 3.6: Plate Region Selection

Figure 3.7: Segmented Image

3.6 Template Matching

Template Matching is a technique through which image is compared with predefined images that might be stored in database. Optical Character Recognition system is a widely used approach of template matching. Template Matching could be a methodology in digital image processing to identify little components of a figure which match a template image [37]. The template data for our system is shown in the Figure 3.8.

Figure 3.8: Template matching

CHAPTER 4
EXPERIMENTS AND RESULTS

The experiment takes image of military and non-military vehicles of Bangladesh, India, Pakistan and Thailand and applies all the required steps that is mentioned in the figures 1 and 2 to get segmented image and matches the image with the template images. Various logic are applied to differentiate between the military and non-military vehicles.

Bangladeshi civil vehicles consist of Bengali alphabets followed by Bengali numerals and military vehicles have up arrow before Bengali numerals. Indian and Pakistani civil vehicles consist of English alphabets and numerals but military vehicles consist of special symbol such as an up arrow and only English numerals. So, if the segmented image has special symbol then it the output is a military vehicle otherwise nonmilitary.

The military vehicles of Thailand consists of special symbols followed by 4 to 5 Thai numerals on the other hand Thai non-military vehicles have Thai symbols followed by English numerals. Thus logic is applied that if the number plate consists of English numerals then it is a non-military vehicle and if it consists of Thai numerals then it a military vehicle. The result of the following experiment is shown in the figures 9, 10, 12 and 11 for military and non-military vehicles of Bangladesh, India, Pakistan and Thailand respectively.

4.1 Results

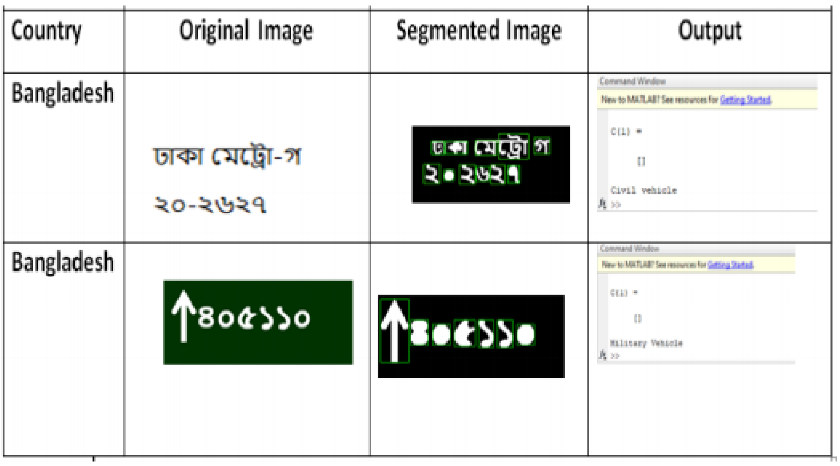
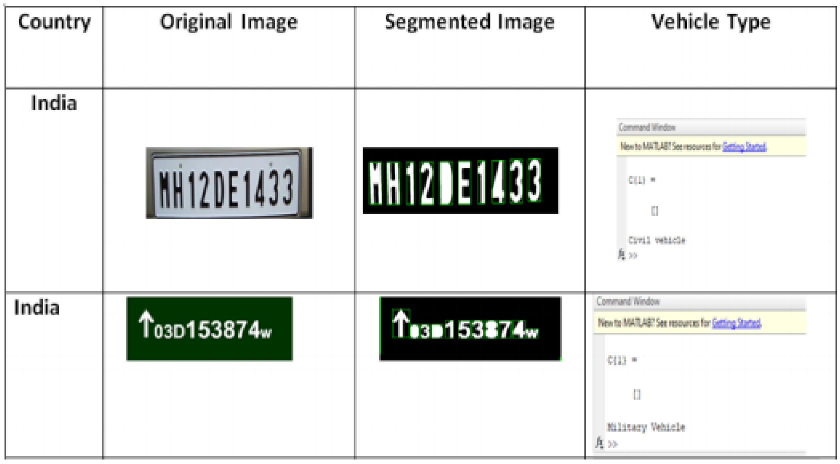
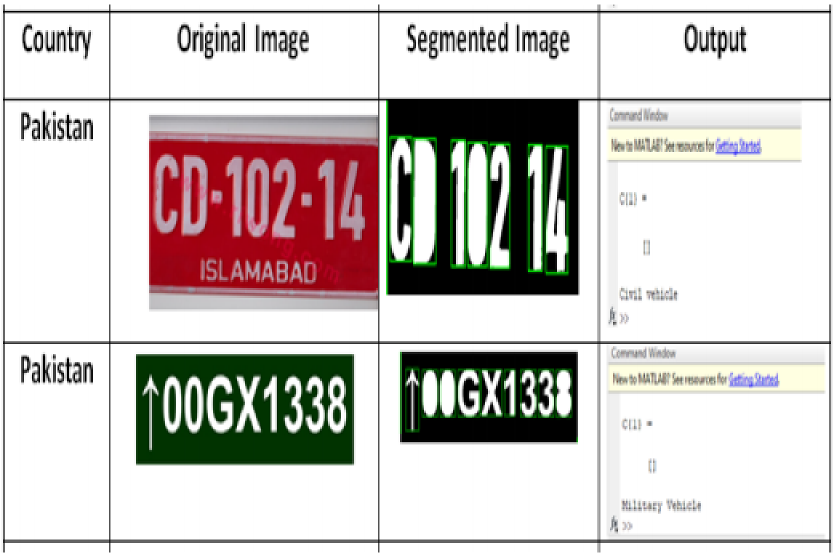


Figure 4.1: License Plate Recognition in Parking Management System



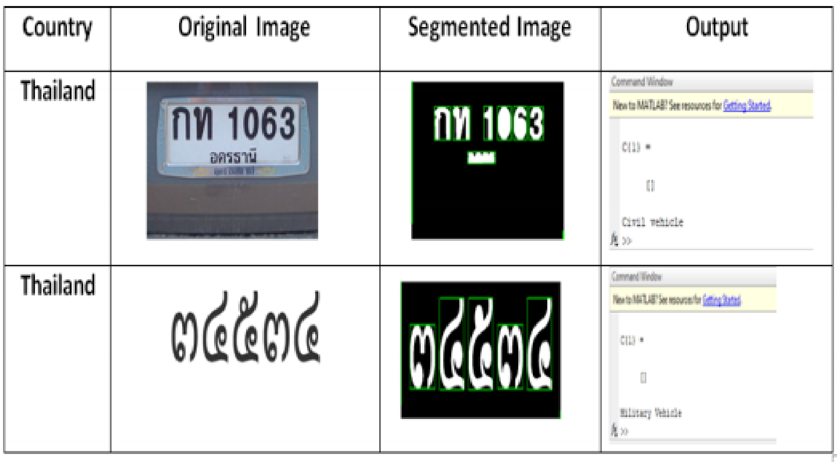
Country	Original Image	Segmented Image	Vehicle Type
India	MH12DE1433	MH12DE1433	Command Window New to MATLAB? See resources for Getting Started. C(1) = [] Civil vehicle
India	↑03D153874W	↑03D153874W	Command Window New to MATLAB? See resources for Getting Started. C(1) = [] Military Vehicle

Figure 4.2: License Plate Recognition in Parking Management System



Country	Original Image	Segmented Image	Output
Pakistan	CD-102-14 ISLAMABAD	CD 102 14	Command Window New to MATLAB? See resources for Getting Started. C(1) = [] Civil vehicle
Pakistan	↑00GX1338	↑00GX1338	Command Window New to MATLAB? See resources for Getting Started. C(1) = [] Military Vehicle

Figure 4.3: License Plate Recognition in Parking Management System



Country	Original Image	Segmented Image	Output
Thailand	กท 1063 อครธานี	กท 1063	Command Window New to MATLAB? See resources for Getting Started. C(1) = [] Civil vehicle
Thailand	๓๔๕๓๔	๓๔๕๓๔	Command Window New to MATLAB? See resources for Getting Started. C(1) = [] Military Vehicle

Figure 4.4: License Plate Recognition in Parking Management System

CHAPTER 5
CONCLUSION

The entire system is implemented in MATLAB. The military vehicle images have been taken from public domain due to non-availability or access of the armed forces vehicles of India, Pakistan and Thailand in Bangladesh. However, the pattern and number format of the read images of the vehicles used are the correct as actual. This system is useful for the UN mission in different countries to identify a military vehicle of a certain country entering or leaving the UN base.

5.1 Future work

In future the system can be used to identify the civil vehicles authenticity and ownership by connecting the system with the national database of vehicle registration of traffic department. This will allow the security agencies or guards deployed at various important places to identify the vehicle well in advance before any vehicle ramming or suicide bombing attempts.

The method is devised for universal acceptance across the nations. This research will further be introduced to identify and classify vehicles from USA, Europe and South-East Asian countries. The system can also be used to track and identify the stolen vehicles on road. Moreover it can play a vital role in ensuring security of individuals by preventing vehicle suicide bombing and vehicle ramming situations.

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APPENDIX A
Codes

```
function [r takethisbox]=takeboxes(NR,container,chk)
takethisbox=[];
for i=1:size(NR,1)
if NR(i,(2*chk))>=container(1) && NR(i,(2*chk))<=container(2)
takethisbox=cat(1,takethisbox,NR(i,:));
end
end
r=[];
for k=1:size(takethisbox,1)
var=find(takethisbox(k,1)==reshape(NR(:,1),1,[]));
if length(var)==1
r=[r var];
else
for v=1:length(var)
M(v)=NR(var(v),(2*chk))>=container(1) && NR(var(v),(2*chk)) <=container(2);
end
var=var(M);
r=[r var];
end
end
end
function [r takethisbox]=takeothers(NR,container,chk)
takethisbox=[];
if (chk==2)
```

```
for i=1:size(NR,1)
if (((NR(i,(2*chk))<container(1) && NR(i,(2*chk))>3) ||NR(i,(2*chk))>container(2)) &&
NR(i,(1.5*chk))>3)
takethisbox=cat(1,takethisbox,NR(i,:));
end
end
else
for i=1:size(NR,1)
if NR(i,(2*chk))<container(1) && NR(i,(2*chk))>container(2)
takethisbox=cat(1,takethisbox,NR(i,:));
end
end
end
r=[];
for k=1:size(takethisbox,1)
var=find(takethisbox(k,1)==reshape(NR(:,1),1,[]));
if length(var)==1
r=[r var];
else
for v=1:length(var)
M(v)=NR(var(v),(2*chk))>=container(1) && NR(var(v),(2*chk))<=container(2);
end
var=var(M);
r=[r var];
end
end
end
function [r takethisbox]=connn(NR)
```

```
[Q,W]=hist(NR(:,4),20);
q1=max(Q);
ind=find(Q==q1);
if length(ind)==1
MP=W(ind);
binsize=W(2)-W(1);
container=[MP-(binsize/2) MP+(binsize/2)];
[r takethisbox]=takeboxes(NR,container,2);
else
r=[];
takethisbox=[];
end
end
function [r takethisbox]=connn2(NR)
[Q,W]=hist(NR(:,4));
q1=max(Q);
ind=find(Q==q1);
if length(ind)==1
MP=W(ind);
binsize=W(2)-W(1);
container=[MP-(binsize/2) MP+(binsize/2)+1];
[r takethisbox]=takeothers(NR,container,2);
else
r=[];
takethisbox=[]
end
end
function [ y ] = template( x )
```

```
y=x;
aa(1:42,1:24)=1;
aa(1:42,1)=0;
aa(1:42,24)=0; aa(1,1:24)=0;
aa(42,1:24)=0;
imwrite(aa,'pen.bmp','bmp');
A=imread('A.bmp');
B=imread('B.bmp');
C=imread('C.bmp');
D=imread('D.bmp');
E=imread('E.bmp');
F=imread('F.bmp');
G=imread('G.bmp');
H=imread('H.bmp');
I=imread('I.bmp');
J=imread('J.bmp');
K=imread('K.bmp');
L=imread('L.bmp');
M=imread('M.bmp');
N=imread('N.bmp');
O=imread('O.bmp');
P=imread('P.bmp');
Q=imread('Q.bmp');
R=imread('R.bmp');
S=imread('S.bmp');
T=imread('T.bmp');
U=imread('U.bmp');
V=imread('V.bmp');
```

```
W=imread('W.bmp');
X=imread('X.bmp');
Y=imread('Y.bmp');
Z=imread('Z.bmp');
Afill=imread('fillA.bmp');
Bfill=imread('fillB.bmp');
Dfill=imread('fillD.bmp');
Ofill=imread('fillO.bmp');
Pfill=imread('fillP.bmp');
Qfill=imread('fillQ.bmp');
Rfill=imread('fillR.bmp');
ba1=imread('ba1.bmp');
ba2=imread('ba2.bmp');
ba3=imread('ba3.bmp');
ba4=imread('ba4.bmp');
ba5=imread('ba5.bmp');
ba6=imread('ba6.bmp');
ba7=imread('ba7.bmp');
ba8=imread('ba8.bmp');
ba9=imread('ba9.bmp');
ba10=imread('ba10.bmp');
ba11=imread('ba11.bmp');
ba12=imread('ba12.bmp');
ba13=imread('ba13.bmp');
ba14=imread('ba14.bmp');
ba15=imread('ba15.bmp');
ba16=imread('ba16.bmp');
ba17=imread('ba17.bmp');
```

```
ba18=imread('ba18.bmp');
ba19=imread('ba19.bmp');
ba20=imread('ba20.bmp');
ba21=imread('ba21.bmp');
ba22=imread('ba22.bmp');
ba23=imread('ba23.bmp');
ba24=imread('ba24.bmp');
ba25=imread('ba25.bmp');
ba26=imread('ba26.bmp');
ba27=imread('ba27.bmp');
ba28=imread('ba28.bmp');
ba29=imread('ba29.bmp');
ba30=imread('ba30.bmp');
ba31=imread('ba31.bmp');
ba32=imread('ba32.bmp');
ba33=imread('ba33.bmp');
ba34=imread('ba34.bmp');
ba35=imread('ba35.bmp');
ba36=imread('ba36.bmp');
ba37=imread('ba37.bmp');
ba38=imread('ba38.bmp');
ba39=imread('ba39.bmp');
ba40=imread('ba40.bmp');
ba41=imread('ba41.bmp');
ba42=imread('ba42.bmp');
ba43=imread('ba43.bmp');
ba44=imread('ba44.bmp');
ba45=imread('ba45.bmp');
```

```
ba46=imread('ba46.bmp');
ba47=imread('ba47.bmp');
ba48=imread('ba48.bmp');
ba49=imread('ba49.bmp');
ta50=imread('ba50.bmp');
ta1=imread('ta1.bmp');
ta2=imread('ta2.bmp');
ta3=imread('ta3.bmp');
ta4=imread('ta4.bmp');
ta5=imread('ta5.bmp');
ta6=imread('ta6.bmp');
ta7=imread('ta7.bmp');
ta8=imread('ta8.bmp');
ta9=imread('ta9.bmp');
ta10=imread('ta10.bmp');
ta11=imread('ta11.bmp');
ta12=imread('ta12.bmp');
ta13=imread('ta13.bmp');
ta14=imread('ta14.bmp');
ta15=imread('ta15.bmp');
ta16=imread('ta16.bmp');
ta17=imread('ta17.bmp');
ta18=imread('ta18.bmp');
ta19=imread('ta19.bmp');
ta20=imread('ta20.bmp');
ta21=imread('ta21.bmp');
ta22=imread('ta22.bmp');
ta23=imread('ta23.bmp');
```

```
ta24=imread('ta24.bmp');
ta25=imread('ta25.bmp');
ta26=imread('ta26.bmp');
ta27=imread('ta27.bmp');
ta28=imread('ta28.bmp');
ta29=imread('ta29.bmp');
ta30=imread('ta30.bmp');
ta31=imread('ta31.bmp');
ta32=imread('ta32.bmp');
ta33=imread('ta33.bmp');
ta34=imread('ta34.bmp');
ta35=imread('ta35.bmp');
ta36=imread('ta36.bmp');
ta37=imread('ta37.bmp');
ta38=imread('ta38.bmp');
ta39=imread('ta39.bmp');
ta40=imread('ta40.bmp');
ta41=imread('ta41.bmp');
ta42=imread('ta42.bmp');
ta43=imread('ta43.bmp');
ta44=imread('ta44.bmp');
ta45=imread('ta45.bmp');
ta46=imread('ta46.bmp');
one=imread('1.bmp');
two=imread('2.bmp');
three=imread('3.bmp');
four=imread('4.bmp');
five=imread('5.bmp');
```

```
six=imread('6.bmp');
seven=imread('7.bmp');
eight=imread('8.bmp');
nine=imread('9.bmp');
zero=imread('0.bmp');
zerofill=imread('fill0.bmp');
fourfill=imread('fill4.bmp');
sixfill=imread('fill6.bmp');
sixfill2=imread('fill6_2.bmp');
eightfill=imread('fill8.bmp');
ninefill=imread('fill9.bmp');
ninefill2=imread('fill9_2.bmp');
arrow=imread('arrow.bmp');
star=imread('star.bmp');
a1=imread('pen.bmp');
ba51=imread('ba51.bmp');
ba52=imread('ba52.bmp');
ba53=imread('ba53.bmp');
ba54=imread('ba54.bmp');
ba55=imread('ba55.bmp');
ba56=imread('ba56.bmp');
ba57=imread('ba57.bmp');
ba58=imread('ba58.bmp');
ba59=imread('ba59.bmp');
ba60=imread('ba60.bmp');
ta47=imread('ba47.bmp');
ta48=imread('ba48.bmp');
ta49=imread('ba49.bmp');
```

```
ta50=imread('ba50.bmp');

ta51=imread('ba51.bmp');

ta52=imread('ba52.bmp');

ta53=imread('ba53.bmp');

ta54=imread('ba54.bmp');

ta55=imread('ba55.bmp');

ta56=imread('ba56.bmp');

letter=[A Afill B Bfill C D Dfill E F G H I J K L M ... N O Ofill P Pfill Q Qfill R Rfill S T U V W X Y Z];

number=[];

character=[];

number=[one two three four fourfill five six sixfill sixfill2 seven ... eight eightfill nine ninefill ninefill2 zero zerofill a1];

character=[letter number];

NewTemplates=mat2cell(character,42,[24 24 24 24 24 24 24 24 ... 24 24 24 24 24 24 24 ... 24 24 24 24 24 24 24 ... 24 24 24 24 24 24 24 ... 24 24 24 24 24 24 24 ... 24 24 24 24 24 24 24 ... 24 24 24 24 24 24 24 24]);

save ('NewTemplates','NewTemplates')

end

function letter=readLetter(snap, i1)

load NewTemplates

snap=imresize(snap,[42 24]);

comp=[ ];

if (i1==1)

for n=1:(length(NewTemplates)-1)

sem=corr2(NewTemplates{1,n},snap);

comp=[comp sem];

end

vd=find(comp==max(comp));
```

```
if vd==1 ||vd==2
letter='A';
elseif vd==3 ||vd==4
letter='B';
elseif vd==5
letter='C';
elseif vd==6 ||vd==7
letter='D';
elseif vd==8
letter='E';
elseif vd==9
letter='F';
elseif vd==10
letter='G';
elseif vd==11
letter='H';
elseif vd==12
letter='I';
elseif vd==13
letter='J';
elseif vd==14
letter='K';
elseif vd==15
letter='L';
elseif vd==16
letter='M';
elseif vd==17
letter='N';
```

```
elseif vd==18 ||vd==19
letter='O';
elseif vd==20 ||vd==21
letter='P';
elseif vd==22 ||vd==23
letter='Q';
elseif vd==24 ||vd==25
letter='R';
elseif vd==26
letter='S';
elseif vd==27
letter='T';
elseif vd==28
letter='U';
elseif vd==29
letter='V';
elseif vd==30
letter='W';
elseif vd==31
letter='X';
elseif vd==32
letter='Y';
elseif vd==33
letter='Z';
elseif vd==34
letter='1';
elseif vd==35
letter='2';
```

```
elseif vd==36
letter='3';
elseif vd==37 ||vd==38
letter='4';
elseif vd==39
letter='5';
elseif vd==40 ||vd==41 ||vd==42
letter='6';
elseif vd==43
letter='7';
elseif vd==44 ||vd==45
letter='8';
elseif vd==46 ||vd==47 ||vd==48
letter='9';
elseif vd==49 ||vd==50
letter='0';
elseif vd==51
letter='-';
elseif vd==52
letter='?';
elseif vd==53
letter='ba1';
elseif vd==54
letter='ba2';
elseif vd==55
letter='ba3';
elseif vd==56
letter='ba4';
```

```
elseif vd==57
letter='ba5';
elseif vd==58
letter='ba6';
elseif vd==59
letter='ba7';
elseif vd==60
letter='ba8';
elseif vd==61
letter='ba9';
elseif vd==62
letter='ba10';
elseif vd==63
letter='ba11';
elseif vd==64
letter='ba12';
elseif vd==65
letter='ba13';
elseif vd==66
letter='ba14';
elseif vd==67
letter='ba15';
elseif vd==68
letter='ba16';
elseif vd==69
letter='ba17';
elseif vd==70
letter='ba18';
```

```
elseif vd==71
letter='ba19';
elseif vd==72
letter='ba20';
elseif vd==73
letter='ba21';
elseif vd==74
letter='ba22';
elseif vd==75
letter='ba23';
elseif vd==76
letter='ba24';
elseif vd==77
letter='ba25';
elseif vd==78
letter='ba26';
elseif vd==79
letter='ba27';
elseif vd==80
letter='ba28';
elseif vd==81
letter='ba29';
elseif vd==82
letter='ba30';
elseif vd==83
letter='ba31';
elseif vd==84
letter='ba32';
```

```
elseif vd==85
letter='ba33';
elseif vd==86
letter='ba34';
elseif vd==87
letter='ba35';
elseif vd==88
letter='ba36';
elseif vd==89
letter='ba37';
elseif vd==90
letter='ba38';
elseif vd==91
letter='ba39';
elseif vd==92
letter='ba40';
elseif vd==93
letter='ba41';
elseif vd==94
letter='ba42';
elseif vd==95
letter='ba43';
elseif vd==96
letter='ba44';
elseif vd==97
letter='ba45';
elseif vd==98
letter='ba46';
```

```
elseif vd==99
letter='ba47';
elseif vd==100
letter='ba48';
elseif vd==101
letter='ba49';
elseif vd==102
letter='ba50';
elseif vd==103
letter='ba51';
elseif vd==104
letter='ba52';
elseif vd==105
letter='ba53';
elseif vd==106
letter='ba54';
elseif vd==107
letter='ba55';
elseif vd==108
letter='ba56';
elseif vd==109
letter='ba57';
elseif vd==110
letter='ba58';
elseif vd==111
letter='ba59';
elseif vd==112
letter='ba60';
```

```
elseif vd==113
letter='ta1';
elseif vd==114
letter='ta2';
elseif vd==115
letter='ta3';
elseif vd==116
letter='ta4';
elseif vd==117
letter='ta5';
elseif vd==118
letter='ta6';
elseif vd==119
letter='ta7';
elseif vd==120
letter='ta8';
elseif vd==121
letter='ta9';
elseif vd==122
letter='ta10';
elseif vd==123
letter='ta11';
elseif vd==124
letter='ta12';
elseif vd==125
letter='ta13';
elseif vd==126
letter='ta14';
```

```
elseif vd==127
letter='ta15';
elseif vd==128
letter='ta16';
elseif vd==129
letter='ta17';
elseif vd==130
letter='ta18';
elseif vd==131
letter='ta19';
elseif vd==132
letter='ta20';
elseif vd==133
letter='ta21';
elseif vd==134
letter='ta22';
elseif vd==135
letter='ta23';
elseif vd==136
letter='ta24';
elseif vd==137
letter='ta25';
elseif vd==138
letter='ta26';
elseif vd==139
letter='ta27';
elseif vd==140
letter='ta28';
```

```
elseif vd==141
letter='ta29';
elseif vd==142
letter='ta30';
elseif vd==143
letter='ta31';
elseif vd==144
letter='ta32';
elseif vd==145
letter='ta33';
elseif vd==146
letter='ta34';
elseif vd==147
letter='ta35';
elseif vd==148
letter='ta36';
elseif vd==149
letter='ta37';
elseif vd==150
letter='ta38';
elseif vd==151
letter='ta39';
elseif vd==152
letter='ta40';
elseif vd==153
letter='ta41';
elseif vd==154
letter='ta42';
```

```
elseif vd==155
letter='ta43';
elseif vd==156
letter='ta44';
elseif vd==157
letter='ta45';
elseif vd==158
letter='ta46';
elseif vd==159
letter='ta47';
elseif vd==160
letter='ta48';
elseif vd==161
letter='ta49';
elseif vd==162
letter='ta50';
elseif vd==163
letter='ta51';
elseif vd==164
letter='ta52';
elseif vd==165
letter='ta53';
elseif vd==166
letter='ta54';
elseif vd==167
letter='ta55';
elseif vd==168
letter='ta56';
```

```
end
end
if (i1==2)
for n=52:length(NewTemplates)-1
sem=corr2(NewTemplates{1,n},snap);
comp=[comp sem];
max(comp);
end
if (max(comp)>.3)
letter='?';
else
letter=[];
end
end
end
clc;
close all;
clear all;
f=imread('cartest4.jpg');
f=imresize(f,[400 NaN]);
imshow(f);
g=rgb2gray(f);
g=medfilt2(g,[3 3]);
conc=strel('disk',1);
gi=imdilate(g,conc);
ge=imerode(g,conc);
gdiff=imsubtract(gi,ge);
gdiff=mat2gray(gdiff);
```

```
gdiff=conv2(gdiff,[1 1;1 1]);
gdiff=imadjust(gdiff,[0.5 0.7],[0 1],.1);
B=logical(gdiff);
[a1 b1]=size(B);
figure(2)
imshow(B)
er=imerode(B,strel('line',100,0));
figure(3)
imshow(er)
out1=imsubtract(B,er);
F=imfill(out1,'holes');
H=bwmorph(F,'thin',1);
H=imerode(H,strel('line',3,90));
figure(4)
imshow(H)
final=bwareaopen(H,floor((a1/15)*(b1/15)));
final(1:floor(.9*a1),1:2)=1;
final(a1:-1:(a1-20),b1:-1:(b1-2))=1;
figure(5)
imshow(final)
Iprops=regionprops(final,'BoundingBox','Image');
hold on
for n=1:size(Iprops,1)
rectangle('Position',Iprops(n).BoundingBox,'EdgeColor','g','LineWidth',2);
end
hold off
NR=cat(1,Iprops.BoundingBox);
[r ttb]=connn(NR);
```

```
if ~isempty(r)
xlow=floor(min(reshape(ttb(:,1),1,[])));
xhigh=ceil(max(reshape(ttb(:,1),1,[])));
xadd=ceil(ttb(size(ttb,1),3));
ylow=floor(min(reshape(ttb(:,2),1,[])));
yadd=ceil(max(reshape(ttb(:,4),1,[])));
final1=H(ylow:(ylow+yadd+(floor(max(reshape(ttb(:,2),1,[])))-ylow)),xlow:(xhigh+xadd));
[a2 b2]=size(final1);
final1=bwareaopen(final1,floor((a2/20)*(b2/20)));
figure(6)
imshow(final1)
Iprops1=regionprops(final1,'BoundingBox','Image');
NR3=cat(1,Iprops1.BoundingBox);
I1={Iprops1.Image};
carnum=[];
if (size(NR3,1)>size(ttb,1))
[r2 to]=connn2(NR3);
for i=1:size(Iprops1,1)
ff=find(i==r2);
if ~isempty(ff)
N1=I1{1,i};
letter=readLetter(N1,2);
else
N1=I1{1,i};
letter=readLetter(N1,1);
end
if ~isempty(letter)
carnum=[carnum letter];
```

```
end

end

else

for i=1:size(Iprops1,1)

N1=I1{1,i};

letter=readLetter(N1,1);

carnum=[carnum letter];

end

end

fid1 = fopen('carnum.txt', 'wt');

fprintf(fid1,'%s',carnum);

fclose(fid1);

winopen('carnum.txt');

fileID = fopen('carnum.txt', 'r');

C = textscan(fileID,' %*s %d','Delimiter','-');

fclose(fileID);

celldisp(C);

else

fprintf('license plate recognition failure \n');

fprintf('Characters are not clear \n');

end

if isempty(carnum)

disp('Military Vehicle')

elseif carnum(1,1) == '0' ||carnum(1,1) == '1' ||carnum(1,1) == '2' ||carnum(1,1) == '3' ||carnum(1,1) == '4' ||carnum(1,1) == '5' ||carnum(1,1) == '6' ||carnum(1,1) == '7' ||carnum(1,1) == '8' ||carnum(1,1) == '9'

disp('Military Vehicle')

elseif (carnum(1,1) = '0' ||carnum(1,1) = '1' ||carnum(1,1) ~= '2' ||carnum(1,1) ~= '3' ||carnum(1,1) ~= '4' ||carnum(1,1) ~= '5' ||carnum(1,1) ~= '6' ||carnum(1,1) ~= '7' ||carnum(1,1)
```

```
~= ’8’ ||carnum(1,1) ~= ’9’) && (carnum(1,2) ~= ’0’ ||carnum(1,2) ~= ’1’ ||carnum(1,2) ~= ’2’ ||carnum(1,2) ~= ’3’ ||carnum(1,2) ~= ’4’ ||carnum(1,2) ~= ’5’ ||carnum(1,2) ~= ’6’ ||carnum(1,2) ~= ’7’ ||carnum(1,2) ~= ’8’ ||carnum(1,2) ~= ’9’)

if carnum(1,3) == ’0’ ||carnum(1,3) == ’1’ ||carnum(1,3) == ’2’ ||carnum(1,3) == ’3’ ||carnum(1,3) == ’4’ ||carnum(1,3) == ’5’ ||carnum(1,3) == ’6’ ||carnum(1,3) == ’7’ ||carnum(1,3) == ’8’ ||carnum(1,3) == ’9’

flag = 1;

if carnum(1,4) == ’0’ ||carnum(1,4) == ’1’ ||carnum(1,4) == ’2’ ||carnum(1,4) == ’3’ ||carnum(1,4) == ’4’ ||carnum(1,4) == ’5’ ||carnum(1,4) == ’6’ ||carnum(1,4) == ’7’ ||carnum(1,4) == ’8’ ||carnum(1,4) == ’9’

flag = 1;

if carnum(1,5) == ’0’ ||carnum(1,5) == ’1’ ||carnum(1,5) == ’2’ ||carnum(1,5) == ’3’ ||carnum(1,5) == ’4’ ||carnum(1,5) == ’5’ ||carnum(1,5) == ’6’ ||carnum(1,5) == ’7’ ||carnum(1,5) == ’8’ ||carnum(1,5) == ’9’

disp(’Civil vehicle’)

end

end

elseif carnum(1,3) ~= ’0’ ||carnum(1,3) ~= ’1’ ||carnum(1,3) ~= ’2’ ||carnum(1,3) ~= ’3’ ||carnum(1,3) ~= ’4’ ||carnum(1,3) ~= ’5’ ||carnum(1,3) ~= ’6’ ||carnum(1,3) ~= ’7’ ||carnum(1,3) ~= ’8’ ||carnum(1,3) ~= ’9’

disp(’Civil vehicle’)

end

else

disp(’Civil vehicle’)

end
```