2.1 Background of License Plates

License plates (LP) have different size, base material, character format and color standards in all the world.Generally, license plates are characterized by high contrastbetween characters and underlying background. In somecountries LP may contain background texture and images, which introduces extra complexity in localization and extraction of license plate information [6].

Figure 2-1: Illustrates example plate images from different countries

2.1.1 License Plate Types

There are wide variety of plate types:

1- Black characters on white / light background.

2- White characters on black / dark background.

3- Single row plates.

4- Multi row plates[7].

2.2 Introduction to LPR System

LPR is an image-processing technology used to identify vehicles by their license plates.It uses OCR to read the LP. Automatic Number Plate Recognition (ANPR) was invented first time in 1976 at a police station situated in United Kingdom. Prototype systems started working in 1979, and contracts were awarded producing commercial systems. This technology is used in various security and trafficapplication [8]. In different references thistechnology is also referred as Automatic Vehicle Identification, Car Plate Recognition, Automatic Number Plate Recognition, Car Plate Reader or optical character recognition for cars there are a number of techniques used so far forrecognition of number plates such as Bidirectional Associative Memories (BAM) neural networkcharacter recognition, pattern matching etc.

Most LPR systems focus on the processing ofimages with only one vehicle others are able to process more vehicles at once[9] ,the techniques of the license plate recognition have been developed for many years. With the hardware and software improved, the accuracy of LPR has been improved to some extent. But the current accuracy still cannot satisfy all the requirements of the traffic department concerned. The license plate extraction is not a simple process, as under some situations, it is easy for people to judge but it will be very hard for computer to do it[10].

Early LPR systems suffered from a low recognition rate, lower than required by practical systems. The external effects (sun and headlights, bad plates, wide number of plate’s types) and the limited level of the recognition software and vision hardware yielded low quality systems. . Image enhancement technique is very crucial based on filters to remove noise and unwanted effects of the light in order to obtain clear and

readable images, are used.Recent improvements in technology like infrared imaging and high resolution cameras, and utilization of high reflective backgrounds in license plate.Manufacturing have improved the accuracy of LPR systems, Sensors and otherhardware peripherals are used to improve the image acquisition andremoveirrelevant details.

2.2.1 Elements of a Typical LPR System

Any typical LPR system usually have the following components

- Camera
- Illumination
- Computer
- Software
- Hardware
- Database
- Frame grabber

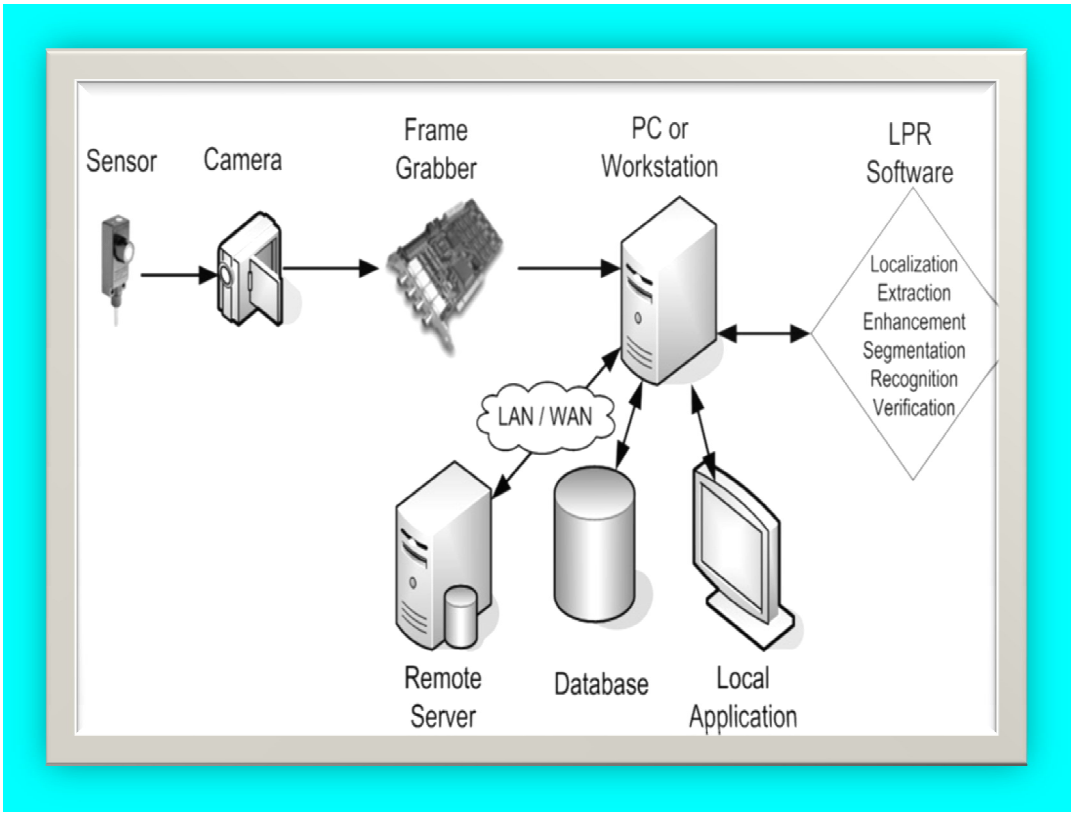

Figure 2.2: A Typical LPR System

A typical LPR system operates as follows. When the car approaches the secured area or gate, it starts the cycle by stepping over a magnetic loop detector (which is the most popular vehicle sensor). The loop detector senses the car and sends signals to the LPR unit. The LPR unit activates the illumination (invisible Infra-red in most cases) and takes pictures of the rear plates from the LPR camera. The images of the vehicle include the plate and the pixel information is read by the LPR unit's image processing hardware (the frame grabber). The LPR unit analyzes the image with different image processing software algorithms, enhances the image, detects the plate position, extracts the plate string, and identifies the fonts using special artificial intelligence methods (such as Neural Networks). The extracted license plate information can be logged, stored along with the captured image or used for authentication depending on the LPR application.

The recognition is not absolute and may contain errors due to problems in any ofthe LPR stages. Applications need to employ proper verification and controlmethods in order to compensate for the potential problems[6].

2.2.2 Imaging hardware

At the front end of any ANPR system is the imaging hardware which captures the image of the license plates. The initial image capture forms a critically important part of the ANPR system whichwill often determine the overall performance.

License Plate Capture (LPC) is typically performed by specialized cameras designed specifically for the task, although new software techniques are being implemented that support any I.P. based surveillance camera and increase the utility of ANPR for perimeter security applications. Factors which pose difficulty for LP imaging

cameras include speed of the vehicles being recorded, varying ambient lighting conditionsand harsh environmental conditions. Most dedicated LPC cameras will incorporate infrared illumination in order to solve the problems of lighting and plate reflectivity.

Many countries now use license plates that are retroreflective. This returns the light back to the source and thus improves the contrast of the image. In some countries, the characters on the plate are not reflective, giving a high level of contrast with the reflective background in any lighting conditions. A camera that makes use of active infrared imaging (with a normal colour filter over the lens and an infrared illuminator next to it) benefits greatly from this as the infrared waves are reflected back from the plate. This is only possible on dedicated ANPR cameras, however cameras must rely more heavily on the software capabilities. Further, when a full-colour image is required as well as use of the ANPR-retrieved details it is necessary to have one infrared-enabled camera and one normal camera working together.

To maximize the chances of effective LPC, installers should carefully consider the positioning of the camera relative to the target capture area. Exceeding threshold angles of incidence between camera lens and license plate will greatly reduce the probability of obtaining usable images due to distortion. Manufacturers have developed tools to help eliminate errors from the physical installation of LPC cameras [11].

2.2.3Difficulties

Many difficulties occur during the detection and extraction of number plate due to the following reasons:

- The efficiency of extraction is affected by scene complexity.
- Different vehicles have plates located on different position
- Noise can occur during camera capture
- Weather conditions responsible for noise arrival
- Time of day affects lighting thus resulting into contras problems
- Unwanted characters, frames and screws introduce confusion
- Wrong camera or plate position result into distortion that affect efficiency plate position result into distortion that efficiency of plate extraction
- Low or uneven illumination, blurred image, low resolution input image, reflection,shadow affect the efficiency of number plate area extraction[12].

  While some of these problems can be corrected within the software, it is primarily left to the hardware side of the system to work out solutions to these difficulties. Increasing the height of the camera may avoid problems with objects (such as other vehicles) obscuring the plate but introduces and increases other problems, such as the adjusting for the increased skew of the plate.

On some cars, tow bars may obscure one or two characters of the license plate. Bikes on bike racks can also obscure the number plate, though in some countries and jurisdictions, such as Victoria, Australia, "bike plates" are supposed to be fitted. Some small-scale systems allow for some errors in the license plate. When used for giving specific vehicles access to a barricaded area, the decision may be made to have an acceptable error rate of one character. This is because the likelihood of

an unauthorized car having such a similar license plate is seen as quite small. However, this level of inaccuracy would not be acceptable in most applications of an ANPR system[11].

2.3 MATLAB

An automated system is developed using MATLAB in which image is captured from camera and converted in Gray scale image for pre-processing. After conversion, dilation process is applied on image and unwanted holes in image have been filled. After dilation, horizontal and vertical edge processing of has been done and passed these histograms through low pass filters. Low pass filters filter out unwanted regions or unwanted noise from image. After this filtering, image is segmented and region of interest is extracted and image is converted into binary form. Binary images are easily processed as compared to colored images. After Binarization, each alphanumeric character on number plate is extracted and then recognized with the help of template images of alphanumeric characters. After this, each alphanumeric character is stored in aFile and whole number plate is extracted successful[13].

2.4 Application

LPR applications have a wide range of applications, which use the extracted plate number and optional images to create automated solution for various problems. These include the following sample application

Parking:the recognition of license plates is used to calculate the duration in which the car has been parked. When a vehicle arrives at the entrance to the parking, the registration number is automatically

recognized and stored inthe database. When the vehicle leaves the parking later and reaches the door, the registration number of the plate is recognized again and compared to the first stored in the database. The time difference is used to calculate the cost of parking .This technology is used in some companies to grant access only to authorized personnel vehicles.

Access Control:a gate automatically opens for authorized members in a secured area, thus replacing or assisting the security guards. The events are logged on a database and could be used to search the history of events.

Tolling:the car number is used to calculate the travel fee in a toll-road, or used to double-check the ticket.

Border Control: the car number is registered in the entry or exits to the Country, and used to monitor the border crossings. It can short the border crossing turnaround time and cut short the typical long lines

Stolen cars: a list of stolen cars or unpaid fines is used to alert on a passing 'hot' cars. The 'black list' can be updated in real time and provide immediate alarm to the police force. The LPR system is deployed on the roadside, and performs a real-time match between the passing cars and the list. When a match is found a siren or display is activated and the police officer is notified with the detected car and the reasons for stopping the car.

Enforcement: the plate number is used to produce a violation fine on speed or red-light systems,the manual process of preparing a violation fine is replaced by an automated process which reduces the overhead and turnaround time. The fines can be viewed and paid on-line

Traffic control: the vehicles can be directed to different lanes according to their entry permits (such as in University complex projects). The system effectively reduces traffic congestions and thenumber of attendants

Marketing Tool: the car plates may be used to compile a list of frequent visitors for marketing purposes, or to build a traffic profile (such as the frequency of entry verses the hour or day).

Travel: A number of LPR units are installed in different locations in city routes and the passing vehicle plate numbers are matched between the points. The average speed and travel time between these points can be calculated and presented in order to monitor municipal traffic loads. Additionally, the average speed may be used to issue a speeding ticket [14].

2.5 Development of Algorithm

Many plate detection, segmentation algorithm have been proposed to implement VNPI system.

- The most popular method used for license plate identification is described by Dening Jiang, Tulu Muluneh, TirunehEmbiale , AshenafiGebrehiwot in Car Plate Recognition System[15].
- OCR is proposed by Morgan and Johson but time consuming in recognition of characters. Neural Networks using fuzzy logic was proposed by Nijhuis[7].
- Chit Ode developed algorithm which is applied on the car park systems tomonitorand manage parking services. Algorithm is developed on the basis of morphological operationsand used for number plate

recognition.Pong presented an algorithm named Document Image Recognition (DIR).DIR is mosteffective approach which is used to find most similar template for input image in a database. The algorithms is developed on the basis of global matching of CBP .CHUNYU presented a techniquefor recognition of number plate from vehicle image. This technique is implementedusing MATLAB and characters are recognized using edge detection segmentation and preprocessing of image[13].

- B.ANISHIYA, Prof. S. Mary JOANS focused a number plate localization and recognition system for vehicles in India is proposed. This system is developed based on digital images and can be easily applied to commercial car park systems for the use of documenting access of parking services, secure usage of parking houses and also to prevent car theft issues. The proposed algorithm is based on a combination of morphological operation with area criteria tests for number plate localization[16].
- An efficient method of locating vehicle license plate is proposed by Zhigang Xu and Honglei Zhu[15].
- FAHAMY proposed BAM neural network for number plate reading. It'sappropriate for small numbers of patterns[17].
- Sarfraz. M. utilized vertical edge detection andfiltering which is then followed by vertical edge matching inthelocalization of Saudi Arabian license plates. As it is observed that images have more horizontal lines than vertical lines, this approach reduces computation time by detecting only vertical lines,Wu, C. et al combine morphological operations and projection searching algorithm for vehicles in Macao Theprojection searching algorithm is used to detect region of thecharacters in the license plate through vertical and horizontal projections[18].
- K. M. Kim, at al, (1997) has used morphological operations like smoothing, closing, opening and threshold to isolate the desired features.

The disadvantage is that, this method requires huge memory and is computationally expensive[19].

- Hadi Sharifi presented the studyand evaluation of some important license plate detection algorithms and compared them in terms of performance, accuracy, complexity, and their usefulness in different environmental condition. The dynamic programming algorithm is the fastest and the Gabor transform is the mostaccuracy algorithm compared to other license plate detection algorithms[12].

- S. H. Kasaei, S. M. Kasaei Presented a novel method of identifying and recognizing of Iranian car license plates. Firstly we extracted the plate location, and then we separated the plate characters by segmentation and applied a correlation based template matching scheme for recognition of plate characters. This system is customized for the identification of Iranian license plates. The system is tested over a large number (more than 150) of images, where this algorithm performs well on different types of vehicles including Iranian car and motorcycle plates as well as diverse circumstances. Finally it is proved to be %97.3 correct in the extraction of plate region and %94 correct in the segmentation of the characters and %92 in the recognition of the characters. He believe that this system can be redesigned and tested for multinational car license plates in the future time regarding their own attributes[16].

2.6 Character Recognition

It can be divided into two main categories

2.6.1 On-line Character Recognition

It deals with a data stream which comes from a transducer while the user is writing. The typical hardware to collect data is a digitizing tablet which is electromagnetic or pressure sensitive .when the user writes on

the tablet, the successive movements of the pen are transformed to a series of electronic signal which is memorized and analyzed by the computer

2.6.2 Off line Character Recognition

It is performed after the writing is finished. The major difference between on-line and off-line character recognition is that on-line character recognition has time-sequence contextual information but off-line data does not. This difference generates a significant divergence in processing architectures and methods

The off-line character recognition can be further grouped into

Magnetic character recognition (MCR):-

The characters are printed with magnetic ink. The reading device can recognize the characters according to the unique magnetic field of each character. It is mostly used in banks for check authentication.

-Optical character recognition (OCR):

OCR deals with the recognition of characters acquired by optical means typically a scanner or a camera. The characters are in the form of pixelized images, and can be either printed or handwritten, of any size, shape, or orientation.

The OCR can be subdivided into handwritten character recognition and printed character recognition

* Handwritten character recognition is more difficult to implement than printed character recognition due to the diversified human handwriting styles and customs.

* In printed character recognition, the images to be processed are in the forms of standard fonts like Times New Roman, Arial, Courier, etc. [20]

2.7 OCR's History

As early as 1929, Tausheck obtained a patent named "Reading Machine" in Germany this patent reflects the basic concept of today's OCR. The principle of Tausheck'spatent is template matching which is still used in some applications even today[**20**].

2.7.1 The Start of OCR

By 1950 the technological revolution was moving forward at a high speed, and electronic data processing was becoming an important field data entry was performed through punched cards and cost-effective way of handling the increasing amount of data was needed.At the same time technology for machine reading was becoming sufficiently mature for application, and by the middle of the 1950's OCR machines became commercially available. The first true OCR reading machine was installed at Reader's Digest in 1954. This equipment was used to convert typewritten sales reports into punched cards for input to the computer. [21].

2.7.2Problems of OCR

- The device that obtains the image can enter gray levels that do not belong to the original image.
- The resolution of these devices can introduce noise into the image, affecting the pixels to be processed.
- Connecting two or more characters in common pixels can also produce errors.

The complexity of each of these subdivisions of the program determines the accuracy of the system.

2.7.3 Objective of OCR System

To recognize alphabetic letters, numbers, or other characters, which are in the form of digital images, without any human intervention .This is accomplished by searching a match between the features extracted from the given character's image and the library of image models[20,22].

2.8 Digital Image Processing

It is use of computer algorithms to perform image processing on digital images. As a subcategory or field of digital signal processing, digital image processing has many advantages over analog image processing. It allows a much wider range of algorithms to be applied to the input data and can avoid problems such as the build-up of noise and signal distortion during processing. Since images are defined over two dimensions digital image processing may be modeled in the form of multidimensional systems[23].

There are six primary algorithms that are require for identifying a license plate:

1- Location license plate, it responsible for finding and isolating the plate in the image. It should be located and extracted from the image for further processing

2- Extraction number plate,is an important step in license plate recognition system. The accuracy of the system is significantly influenced at this stage. This phase extracts the license plate from the image. The proposed approach involves:

- converting the RGB into gray scale
- Binarization of the image, and
- finding and filtering the noise from the image

3- Orientation and plate size, offset angles that make the plate look - "crooked" and adjust the size.

4- Segmentation of individual characters is present in plate.

Algorithm that locates the separate alpha numeric characters on a license plate. Algorithms also look for characters of equal color and equidistance, with similar font structures to break apart each individual character. This sequential congruency of the characters embodies a characteristic set that is typically uniform, regardless of the type of license plate. Character Segmentation separates each letter or number where it is subsequently processed by OCR algorithms.

5- OCR for each image we segmented individual character. The output of the recognition of each character is processed as ASCII code associated with the image of the character. By recognizing all successive images of the characters are completely read the license plate.

6- Syntactical /Geometrical analysis.

Algorithm to verify alpha numeric information and arrangement with a specific rule set .The algorithms operate sequentially with instructions being executed in milliseconds. The successful completion of each algorithm is required before subsequent algorithms can be operational[23, 22].

2.8.1 Aspects of Image Processing

- Image Enhancement: Processing an image so that the result is more suitable for particular application(sharpening or deblurring an out of focus image, highlighting edges, improving image contrast, or brightening an image, removing noise.

- Image Restoration: This may be considered as reversing the damage done to an image by a known cause(removing of blur caused by linear motion, removal of optical distortions)

- Image Segmentation: This involves subdividing an image into constituent parts, or isolating certain aspects of an image finding lines, circles, or particular shapes in an image, in an aerial photograph, identifying cars, trees, buildings, or roads[24].

2.8.2 Filters

Image processing is based on filtering the content of images. Filtering is used to modify an image in some way. This could entail blurring, deblurring, locating certain features within an image, etc…

Linear filtering is accomplished using convolution. A filter, or convolution kernel as it is also known, is basically an algorithm for modifying a pixel value, given the original value of the pixel and the values of the pixels surrounding it. There are literally hundreds of types of filters that are used in image processing [25].

2.9 Hot lists

Once the OCR read is obtained, the information is then compared against a database of vehicles of interest, typically known as a “hot list.” Hot list information can come from a variety of sources, the purpose of these

lists is to alert the officer that a vehicle displaying a license plate number that is included on a hot list has been identified by the ALPR camera[20].

2.10 Complexities of License Plate Recognition Variance

The complexity of each of these subsections of the program determines the accuracy of the system. During the third phase some systems useedge 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.Algorithms must be able to determine what part of the vehicle is actually the license plate. Different countries, states, cities and regions have different standards, dimensions, colors and character sets for license plates. This inconsistency requires algorithms to be inclusive to such extensive criteria [23].