An Efficient Approach for Automatic Number Plate Recognition System Using Quick Response Codes

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Abstract— **The ANPR (Automatic Number Plate Recognition System) can be called as a car screening technique that uses optical character recognition(OCR) on images to read vehicle registration plates. The volume of automobile crimes has been on the increase and many new crime detection techniques have evolved on its account. High-speed car chases, automobile thefts are now-a-days very common. The best way to keep track of the cars is their registration numbers. The number plate recognition system is the most suitable solution for such cases.**

The number plates often get corroded and the detection process becomes erroneous. Our contribution towards ANPR is the inclusion of the QR codes (Quick Response codes) on the automobiles, fine-tuning the detection technique. The proposed approach provides quick response, overcomes the noise issues in image processing and at the same time fine tunes the detection technique.

Keywords— **ANPR, OCR, QR codes, CCTV's**

I. INTRODUCTION

ANPR stands for Automatic number plate recognition system. License Plate Recognition (LPR) is an important function in intelligent traffic control systems. These systems have many applications such as parking management systems, access control, border control and monitoring, and tracking vehicles. ANPR is also known as:

1. Automatic vehicle identification (AVI)
2. Car plate recognition (CPR)
3. License-plate recognition (LPR)
4. Automatic license-plate recognition (ALPR)
5. Lecture Automatique de Plaques d'Immatriculation (LAPI)

ANPR Systems are the most widely used systems all across the world. A typical number plate detection system involves the use of OCR technique. With OCR techniques in operation, its performance is governed by the image quality. In turn the environmental condition affecting the number plate that directly hamper the image taken by the camera entirely governs the efficiency of the detection approach. With addition of QR codes, we propose a novel method where the problems arising in the detection are reduced to a great extent. The paper discusses the current OCR technique and the number recognition systems that are in use at present with the applications. The experimentation done with our approach has shown results that are worth to notice.

II. EXISTING METHODOLOGY

A. History

ANPR finds its origin in UK. It was first developed by the Police Scientific Development Branch in 1976. Prototype systems were working by 1979, and contracts were let to produce industrial systems, first at EMI Electronics, and then at Computer Recognition Systems (CRS) in Workingham, UK. Early trial systems were deployed on the A1 road and at the Dartford Tunnel. [1]

B. ANPR System using OCR

At the hub of the system is the OCR (Optical Character Recognition system) which is used to extract the alphanumeric characters present on the number plate. To do this it first uses a series of image manipulation techniques to detect, normalize and enhance the image of the number plate. There are two components in the system, the cameras at the front-end and the remote computers at the back-end. Usually two cameras are used at a time to increase efficiency. The cameras as shown in the Fig. 1 just perform the task of capturing the images of number plates and sending it to the remote computers. The remote computers then perform further operations like OCR on the stored images sent by the cameras at the lane-level. In order to process the high amount of images stored, a "server farm" is used which comprises of many computers working together. An example of a server farm can be the London Congestion Charge project. The remote computers can be linked with the database which stores the details of the car owners and thus the required information can be obtained. Using this information the culprit can be caught. [1], [11]

Fig. 1 CCTV cameras

1. The existing ANPR system consists of two major blocks as shown in the Fig. 2:
   a. Lane level
   b. Remote computers
2. At the lane level, the CCTV (Closed Circuit Television) cameras take a snapshot/video feed [16], [19] of the car in such a way that the number plate is also included in the image. A minimum of two cameras, each fitted with infrared illuminators so they can work day or night, are mounted on gantries above the road, either at

the roadside or in the central reservation. Speed cameras work out the vehicle's average speed, given the time it takes to drive between the two camera positions. As vehicles pass between the entry and exit camera points their number plates are digitally recorded, whether speeding or not. Then, by ANPR recognition, the images on the video of matching number plates are paired up, and because each image carries a date and time stamp, the computer can work out the cars average speed between the cameras.[9], [17]

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┌─────────────────────────────────┐
│    Search for number plate       │
└─────────────────────────────────┘
                │          LANE LEVEL
                ▼
┌─────────────────────────────────┐
│      Snapshot/Video feed          │
└─────────────────────────────────┘
                │
                ▼
┌─────────────────────────────────┐
│   Image/video sent to             │
│         servers                   │
└─────────────────────────────────┘
                │
                ▼
┌─────────────────────────────────┐
│      Plate localization           │
└─────────────────────────────────┘
                │
                ▼
┌─────────────────────────────────┐
│   Plate orientation and           │
│          sizing                   │
└─────────────────────────────────┘
                │
                ▼
┌─────────────────────────────────┐
│    Character Segmentation         │
└─────────────────────────────────┘
                │          OCR AT
                ▼
┌─────────────────────────────────┐
│        Normalization              │
└─────────────────────────────────┘
                │          REMOTE
                ▼
┌─────────────────────────────────┐
│    Character Recognition          │
└─────────────────────────────────┘
                │          COMPUTER LEVEL
                ▼
┌─────────────────────────────────┐
│   Syntactical/Geometrical         │
│          analysis                 │
└─────────────────────────────────┘
```
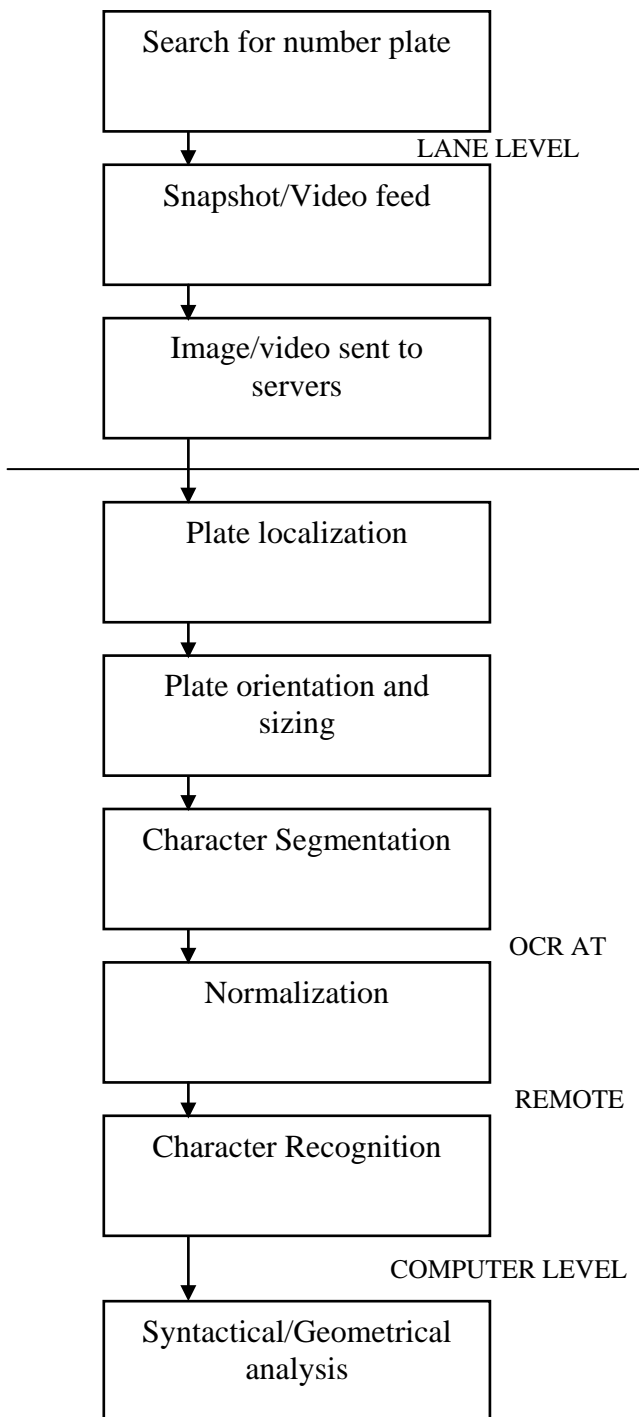
Fig. 2 Overview of the automatic plate recognition technique [4]

3. The optical recognition technique is performed at the remote computer level and consists of the following algorithms: [15]
   a. Plate localization: Isolates the number plate from the snapshot. [18]
   b. Plate orientation and sizing: The isolated number plate is then resized and rotated as per the requirements of the recognition software.
   c. Character Segmentation: Each character on the number plate is separated by drawing vertical and horizontal edges and thus forming rectangles around the character as shown in the Fig. 3.
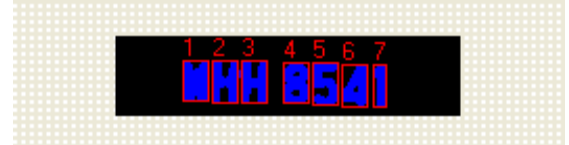

Fig. 3 Recognition of the number plate using OCR

   d. Normalization: After character segmentation the brightness and contrast of the image is adjusted.
   e. Character Recognition: Each character is then recognized by the software. The software implements the technique of pattern matching to detect the characters, thus matching the characters with the stored samples. The characters are then combined together to form the number plate [20].
   f. Syntactical analysis: Checks characters and positions against country-specific rules.

4. The percentage of recognition is as follows [4]:

TABLE 1
PERCENTAGE OF ANGULAR RECOGNITION USING OCR [4]

Angles (Degree)	Plate Localization (%)	Number Plate Recognition (%)
5.00	96.00	95.65
7.50	96.00	91.30
10.00	96.00	86.95
12.5	96.00	82.61
15	96.00	78.26

From the table 1 we infer that the efficiency of the system reduces as the angle goes on increasing.

C. Applications of OCR

The ANPR system using OCR has the following applications [28]:
1) Crime investigation:
   The ANPR can be used for tracking of lost vehicles. In case of a car/vehicle theft, the car can be detected by searching in the vicinity of the area by using ANPR system. This can help in speeding up the process of searching thus reducing the workload of the police force.
2) Illegal racing:
   The practice of illegal car sale in the black market is not unheard of. The cars are dismantled and exported part by part to other countries and then such cars are used for illegal racing and other money-making / entertainment purposes.

ANPR provides a strong mechanism to put a stop to these activities.

3) Over-speeding:

If a police officer detects an over-speeding car he can use ANPR system to track down the car details and fine the driver. This can help keep the accidents at bay.

4) Parking in the NO PARKING AREA:

The cars parked in the no parking zones can be detected even though no ground force is available on site.

5) Identification of traffic density :

ANPR system can also be used to identify the low and high traffic density areas, based on the number of vehicles passing through a particular CCTV camera coverage per unit time. Thus if the number of plates detected by a camera in unit time is greater than usual then it implies high traffic density otherwise the density may be low.

6) Electronic toll collection:

ANPR system is also employed for the electronic toll collection system. This reduces the manual labor increasing the efficiency of the toll collection system. An example can be the London Congestion Charge Project.

III. LITERATURE SURVEY

Since the mid 90's a lot of research works has been carried out in the field of Vehicle Number Plate (VNP) recognition. The manufacturers of SPECS CCTV cameras quote that the SPECS system is so efficient and user friendly that Manchester CTO processed 2,500 offences in 6 man hours [9].

Image Acquisition is the first step in an ANPR system and there are a number of ways to acquire images. The existing literature discusses different image acquisition methods. Yan et. al. [21] uses an image acquisition card that converts video signals to digital images based on some hardware-based image pre-processing. Naito et. al. [22], [23], [24] developed a sensing system, which uses two CCDs (Charge Coupled Devices) and a prism to split an incident ray into two lights with different intensities. The main feature of this sensing system is that it covers wide illumination conditions from twilight to noon under sunshine, and this system is capable of capturing images of fast moving vehicles without blurring. Salgado et. al. [25] uses a Sensor subsystem having a high resolution CCD camera supplemented with a number of new digital operation capabilities. However the installation of such a device is costly.

Kim et. al. [26] uses a video camera to acquire the image. Comelli et. al. [27] uses a TV camera and a frame grabber card to acquire the image for the developed vehicle LPR system [15]. But processing on the video feed is more complex as every frame needs to be analysed and best frame is to be chosen for analysis. If a wrong frame is chosen then the recognition becomes erroneous.

For extracting the number plate from the detected image, the LPL technique is used. License Plate Localization (LPL) methods are broadly classified into Morphology based LPL methods, Edge statistics, and neural networks and fuzzy based, template based and so on. The aspect ratio, colour, variance, edge density are some of the license plate features used by these methods. High contrast between characters and background in a license plate is a strong feature which

is considered in edge analysis. Character segmentation is an important step in license plate recognition (LPR) system. [14]

Retrieving the literature it was evident that, the previous system has some kind of limitation like it is plate size dependent, colour dependent, works only in certain conditions or environment like indoor images etc.

The ANPR system requires a large database to store the information. The National ANPR Data Centre uses an Oracle database, with data for analysis extracted to a PostgreSQL database to avoid affecting core performance, and custom-written Java software with specific police networks rather than the internet used to send and receive data [12].

The best example of automatic number plate detection system can be the London Congestion Charge Project. Transport for London (TfL) uses ANPR systems and charges motorists a daily fee of £10 paid before 10pm if they enter, leave or move around within the congestion charge zone between 7 a.m. and 6:00 p.m., Monday to Friday. A reduced fee of £9 is paid by vehicle owners who sign up for the automatic deduction scheme. Fines for traveling within the zone without paying the charge are £60 per infraction if paid before the deadline, doubling to £120 per infraction thereafter [7].There are currently 1,500 cameras, which use Automatic Number Plate Recognition (ANPR) technology. There are also a number of mobile camera units which may be deployed anywhere in the zone. Based on the statistics describing the use of ANPR system [8], an example is discussed. A scenario where a car is parked in a no-parking area and a CCTV camera snaps a picture of its number plate at 7:34 p.m. Then within 250 milliseconds the image is sent to the remote computer along with the date and time. 1 second of conventional OCR processing generates 18 seconds of editing time (7.50+10.5) and 3.4 errors (8.4-5.0) that get past manual error correction. After OCR the license number is obtained. The Police officer in charge may then track the exact owner of the car by accessing the recognized number plate record and thus take a strict action against him. This can be done in a matter of seconds based on the server workload and network congestion.

The ANPR system using OCR was found to have the following shortcomings /disadvantages:

1) Misidentification

- In case the number is read partially, the remote computer might identify the number plate incorrectly or would not be able to decrypt at all.

Fig. 4 Misidentification

- Characters and numbers may be detected wrongly and interchanged identity may occur; characters may be read as numbers and vice versa. The fig. 4 shows a sample that describes the example. E.g.: 'o' as '0', '5' as 'S'

2) Hazy images:

Hazy images can also make the detection process erroneous or there is a possibility of no detection at all. An example for such cases is the Fig. 5.

Fig. 5 Hazy image

3) Flaws in angular detection:

Fig. 6 Angular detection not possible

Angular detection is not possible in case of ANPR as the rectangulation algorithm, implemented in OCR is not possible thus characters may be misread/ overlapped. The character recognition fails even if the angle made by the camera's line of sight with the vertical is a mere 15^0 angle. Thus the possibility of catching a wrong person increases substantially.

E.g. 'T' may be read as 'I' or 'C' as 'O' or '2' as '1' or 'G' as 'C' or 'C' as 'O' as shown in the Fig. 6.

4) Problems in recognition under bad weather conditions:

Natural Calamities like heavy rainfall or snowfall may hinder the detection system.

5) High speed cameras are required hence general cost of deployment is high.
6) Optical character recognition (OCR) is slow.
7) Depends highly on the efficiency of camera.
   E.g.:
   - Dust settled on the camera lens.
   - Power cuts/battery discharged
   - Short circuits
   - Low resolution
8) Non-standardized number plates. E.g. Number plates written in different scripts like 'Devnagari' cannot be recognized by the system.
9) Duplication of number plates is easily possible.

Hence there is a need for development of a new technique that would be capable of masking the drawbacks of the existing ANPR system.

IV. PROPOSED METHODOLOGY

Taking into consideration, the shortcomings of the existing ANPR system we propose the methodology of using QR code for the recognition of vehicles and their respective owners.

A. *QR codes (Quick response codes):*

1. QR code is trademark of matrix type (two-dimensional) barcode. [13]
2. More recently, the system has become popular outside the industry due to its fast readability and large storage capacity compared to standard UPC barcodes. The code consists of black modules (square dots) arranged in a square pattern on a white background. The information encoded can be made up of four standardized kinds ("modes") of data (numeric, alphanumeric, byte/binary), or through supported extensions, virtually any kind of data.
3. Invented in Japan by the Toyota subsidiary Denso Wave in 1994 to track vehicles during the manufacturing process, the QR Code is one of the most popular types of two-dimensional barcodes.[2]
4. It was designed to allow its contents to be decoded at high speed.

Fig. 7 Sample QR code embedded with information "Paper by: Pranav, Chaitanya, Vijayendra, Bhupendra"

Unlike the old bar code that was designed to be mechanically scanned by a narrow beam of light, the QR code is detected as a 2-dimensional digital image by a semiconductor image sensor and is then digitally analyzed by a programmed processor. The processor locates the three distinctive squares at the corners of the image, and normalizes image size, orientation, and angle of viewing, with the aid of a smaller square near the fourth corner. The small dots are then converted to binary numbers and validity checked with an error-correcting code. A sample QR code can be fig. 7.

The amount of data that can be stored in the QR Code symbol depends on the data type (*mode*, or input character set).

The data types that can be stored on the QR codes are numeric, alphanumeric and binary.

B. How do QR codes work?

The format information records two things: the error correction level and the mask pattern used for the symbol. Masking is used to break up patterns in the data area that might confuse a scanner, such as large blank areas or misleading features that look like the locator marks. The mask patterns are defined on a 6×6 grid that is repeated as necessary to cover the whole symbol as shown in fig. 8. Modules corresponding to the dark areas of the mask are inverted. The format information is protected from errors with a BCH (Bose and Ray- Chaudhuri code, a code which is a cyclic error correcting code) [5], and two complete copies are included in each QR symbol.
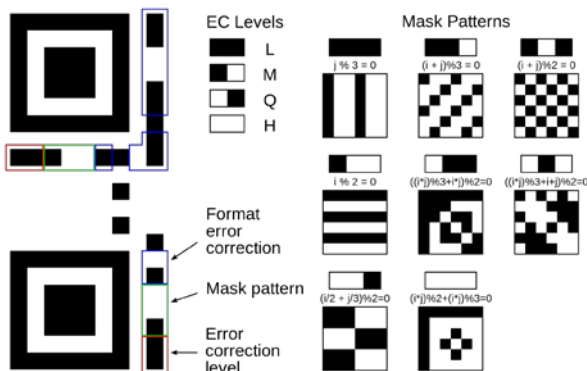
Fig. 8 Format information

The message data is placed from right to left in a zigzag pattern, as shown in fig. 9. In larger symbols, this is complicated by the presence of the alignment patterns and the use of multiple interleaved error-correction blocks.
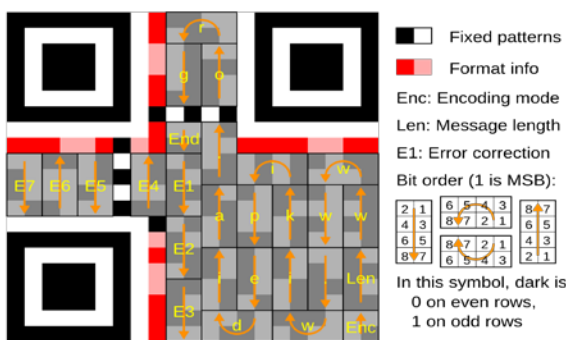

Fig. 9 Message placement within a QR symbol

Four-bit indicators are used to select the encoding mode and convey other information. Encoding modes can be mixed as needed within a QR symbol.

C. Advantages of QR codes over OCR

The existing ANPR system may fail to identify the vehicle under unsuitable circumstances as mentioned in the Literature Survey. The advantages of QR codes over OCR are as follows:

1. Faster scanning.
2. Quicker response of the system due to faster recognition.
3. Angular Detection possible
4. Detection is possible even if the QR code is damaged, distorted as shown in fig. 10 or mud smeared.

Fig. 10 Damaged QR code

5. Scanning possible even if the camera resolution is less which may not be possible in case of OCR technique.
6. Each QR code is unique, due to which there is least possibility for misidentification.

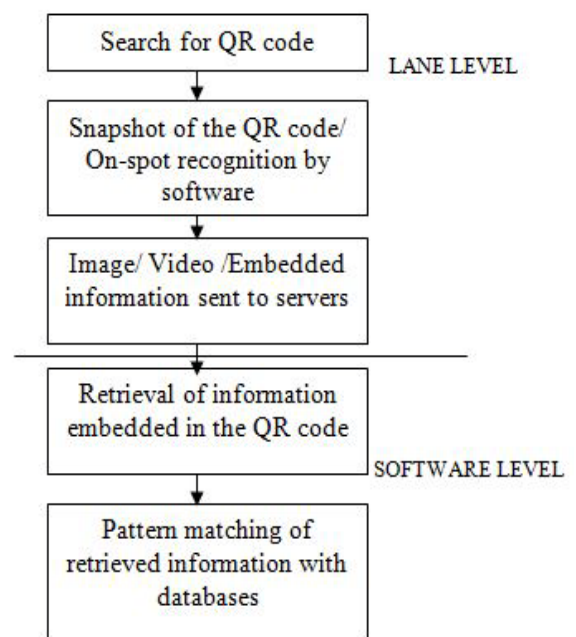### D. Proposed approach towards inclusion of QR codes in ANPR:

Fig. 11 Block diagram for QR code detection

1. The ANPR system using QR code will consist of two major blocks as shown in the Fig. 11:
   a. Lane level
   b. Software Level
2. At the lane level, the CCTV (Closed Circuit Television) cameras take a snapshot of the car in such a way that the QR code is also included in the image. Otherwise a small optical QR code scanner can be installed for on spot recognition. As vehicles pass under the camera/scanner their QR codes are digitally recorded.

3. The image/video/QR code embedded information is sent along with the date and time stamp to the remote computer.
4. The QR code recognition technique is performed at the software level and consists of the following steps:
5. If direct information is sent from lane level forward it for searching the record in database.
6. Else if image/video feed is received then focus the QR code recognition software component on to the QR code received to retrieve the information and then search for the record in database.

E. Proposed implementation of QR codes in ANPR system
1. The QR codes can be embedded on the back side beside the company logo for every vehicle.
2. The QR codes can also be printed on the number plate itself or on inner side of the windshield.
3. Q-R codes can be painted using invisible paint on the roof (as shown in fig. 12) of the vehicles during the manufacturing process, which can be detected under specific wavelength of light. This can help in overhead detection.

Fig. 12 Invisible paint detection

4. QR codes can also be printed in stylish formats on the car.

E.g. Q-R codes can be printed as vinyl as shown in the fig. 13.

Fig. 13 QR code embedded in stylish vinyl

5. Logos can also be included on the QR codes as in fig. 14.

Fig. 14 Logos included on the QR code

6. Q-R codes can be printed using radioactive material e.g. Radium to improve detection even in unfavourable weather conditions (Rainfall, snowfall). Radioactive ink is made by mixing a small amount of ^{32}P with waterproof black drawing ink. Based on the wavelength of the ink it can be detected by the cameras. Thus, even if dust particles are settled or mud smeared on the vehicle the QR code can be detected. Using this technique, night time detection is also possible.

F. Special Applications of Automatic Number Plate Recognition system using QR codes(Dynamic Scanning):
Dynamic scanning is searching of a particular QR code among all the QR codes passing by. If a small detection system is installed at prime locations then a stolen car or suspicious car can be tracked at further locations by continuously scanning of the suspicious QR code. If detected, an alarm will activate at the RTO office and inform them about the location of the car.

This system when clubbed along with the GPS can help in catching the culprit faster.

Police patrol vehicles can be equipped with QR code scanners for dynamic scanning.

G. Tackling the problem of Number plate duplication

As mentioned in the Literature Survey, duplication of number plates is easily possible. Similarly QR code duplication is also possible. This can become a threat for the proposed methodology. Hence we suggest the algorithm for avoiding the same.

Algorithm to avoid duplication:

1. Detect the QR code on the vehicle.
2. Scan the QR code and retrieve the embedded information.
3. Save the scanned information in the database along with the time stamp.
4. The QR codes detected would be duplicate if the same QR code is scanned more than once within a particular time span.
5. For this the region in which the car can be detected during the time span needs to be fixed otherwise

the same car could be detected and reported as a duplicate.

6. If the same QR code is detected beyond the limits of the calculated region then it would imply a duplicate QR code.

7. In order to define the maximum possible distance that the car can travel in a particular time span, we need to calculate distance based on its maximum speed.

8. A circle of radius equal to the maximum distance possible is then plotted on the map surrounding the tracked location as shown in Fig 15.

9. Now to detect a duplicate QR code we search the region (country/state) excluding the plotted circular region.

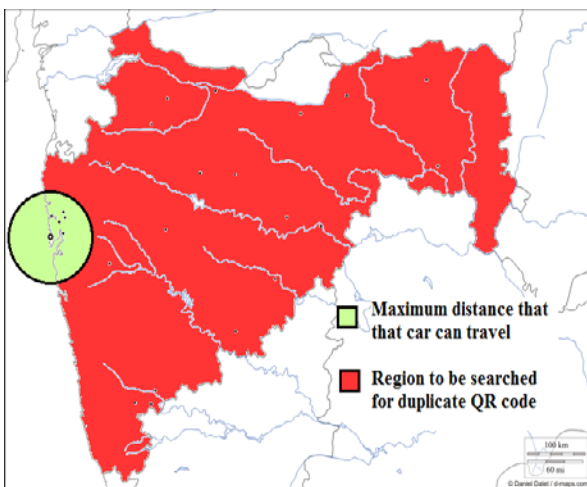10. If a match is found then the code can be checked for validity and the criminal can be penalized.

Fig. 15 Algorithmic view for finding of duplicates

H. *Methods for information embedding in QR codes*

1. The QR codes may contain URL. The URL will be a link to a particular page on the remote server through which the necessary information can be obtained.

2. Another method could be directly putting the information on the QR codes as shown in the Fig. 16.

Fig.16 Vehicle No.MH-12 AB 1234 Name: Tom R. Licence No.123456789 Expiry Date: 1 Jan 2013 Contact No.9876543210 Vehicle registration No.ABCD1234 [6]

3. Otherwise a unique code can be stored on the QR code and then the RTO officers can identify the car owner. The sample of such QR code can be Fig. 17.

Fig.17 Vehicle ID: 123454567890 [6]

4. The QR codes can be scanned even by using low resolution camera. Thus anyone can scan the QR code through his mobile phone/camera and immediately lodge a complaint in cases such as:
   1) Vehicle parked in a private area.
   2) Unidentified vehicle found.
   3) Rash driving and other malpractices

   This will help the authorities in charge to pin-point the location of the vehicles reported. A Block diagram of the same is shown in the fig. 18.

Fig. 18 capturing the image through cell phone

V. EXPERIMENTAL RESULTS

To support our proposed approach we carried out experimentation on the angular detection of QR codes. As mentioned in the Literature Survey, the maximum range of accurate number plate detection using OCR is -15^0 to 15^0 i.e. total 30^0. But with the inclusion of the QR codes the maximum range becomes -37.42^0 to 37.42^0 i.e. 74.84^0. Also the results show 100 % detection and beyond 74.84^0 there is no detection possible at all. Thus the chances of incorrect detection are completely eliminated.

TABLE 2
EXPERIMENTAL RESULTS OF ANGULAR QR CODE
DETECTION

Angles (Degree)	Number of Samples	QR code Recognition (%)
10.00	10	100
20.00	10	100
30.00	10	100
37.4	15	100
50.00	3	0

The experimentation is done using a 3.2 MP resolution camera android phone using the application "Barcode Scanner v4.1" [10]. The results for the same are as described in the table 2.

VI. CONCLUSION

The paper highlights the drawbacks of the conventional ANPR system using OCR technique and proposes an efficient method with inclusion of QR codes.

Through the experiments we carried out on the angular detection, accuracy of 100% is achieved. Even the response time is low and the issues of image processing are resolved. With addition of invisible ink or radioactive ink night time detection and detection in extreme climatic conditions can be made possible.

Considering the positive aspects of the QR, the proposed method if brought into actual practise will definitely prove to be a boon.

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