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# Automatic vehicle plate reorganization and detection by image processing and datamining approach

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## ABSTRACT

***Automatic Vehicle Plate Recognition (AVPR) is the extraction of vehicle license plate information from an image or sequence of images. From the past thirty years, AVPR is becoming the challenging and interesting area of research. AVPR systems include a wide range of applications. Numerous real-world applications such as electronic toll collection, automatic parking management, access control, radarbased speed-control, border control, criminal pursuit, traffic law enforcement, etc. have been benefited from it. A lot of commercial AVPR systems are available today and yet there are many challenges and issues in accurate recognition of licence plates. In India, number plate standards are rarely practised. Licence plates recognition has many problems like unnecessary text, different font size and font type, blur, skew, environmental factors etc. The variations of the licence plate types or environments cause challenges in the recognition of number licence plates. The major objective of this thesis is to develop a robust, accurate and reliable automatic vehicle license plate recognition system. Our suggested approach is performed in three phases: In the first phase, the input image is pre-processed. Character regions are extracted in the second phase, and in the third phase, recognition of extracted characters is performed. The present work has been performed to recognize Indian licence plates***

***Keywords:*** *Automatic Vehicle Plate Recognition, License Plates, Image Processing*

## 1. INTRODUCTION

Pattern recognition and image processing are the vast areas of research in the current scenario. Many researchers worldwide have been working on these areas for the last thirty years to automate processes. In recent years, the number of vehicles has increased considerably. Increase in the number of vehicles needs attention towards efficient administration of road traffic. The controlling of vehicles is important for multiple reasons such as security issues; that need to work on intelligent techniques that manage vehicles. Each vehicle carries a licence plate as a unique identifier of the vehicle. Manual recording of vehicles is time-consuming, costly and not efficient. Therefore, automation of the process of vehicle licence plate recognition is always helpful. Automatic Vehicle Plate Recognition (AVPR) refers to the recognition of vehicle licence plate information from an image or sequence of images of vehicles. The technique that recognizes a vehicle registration number using the machine is called AVPR. It has gained recognition throughout the world with some other names like Automatic Number Plate Recognition (ANPR), Automatic Vehicle Identification (AVI), Automatic Licence Plate Recognition (ALPR), Car Licence Plate Detection and Recognition Systems (CLPDRS), Car Plate Recognition (CPR) or simply Licence Plate Recognition (LPR). AVPR is broadly classified into 2 categories viz. Stationary and Mobile AVPRs, getting their classification category from the fact that how and where the cameras are mounted.

Stationary AVPR systems use high-quality Infrared cameras at fixed locations that are clearly not in motion. The readers can be fixed in different locations like sign- boards, street lights, telephone poles, entry-exit gateways or another stationary object encountered on road. Stationary AVPRs have always been known to be the cost- effective ones.

On the other hand, Mobile AVPR includes cameras fitted on mobile vehicles. The photographs for the licensing plate get captured with the movement of vehicles. The mobile AVPR systems are known to capture on average of 1000 licensing plates per hour and have been known better to track mobile vehicles.Once the image of the licencing plate gets captured be it from a stationary reader or from a mobile reader, the technology identifies the pixel pattern and translates the same to letters and numbers of the plate to a digital format. Further, this data is sent to AVPR databases. The duration of storage of data in databases varies on the system that is set to use the AVPR be it for days or years. As soon as the recognition of number plate is done, automation process is fulfilled.
Reliable automatic vehicle plate recognition is the requirement of the current era of technology. It addresses various issues like

 

security control, toll collection, parking management, access control, crime investigation system, border control, and road patrolling. The AVPR is a promising area of research which has captured the interest of many researchers worldwide. It is a very challenging problem due to the diversity in licence plates and non-uniform illumination conditions during vehicle image acquisition. In the ensuing Section 1.1, background concepts of AVPR are introduced, which are necessary to understand the proposed system.

## 2. AUTOMATIC VEHICLE PLATE RECOGNITION

Vehicles are an integral part of the transportation and its usage has been increased tremendously based on unmatched advantages. This leads to an interesting problem in computer vision and pattern recognition as vehicle monitoring and recognition through machines. Each vehicle has an external component as a licence number plate used for its identification. Therefore, automation of the process of vehicle licence plate recognition must be implemented. AVPR system basically involves recognition of vehicle licence plates by capturing the image of the vehicle through a camera. AVPR basically deals with identification, detection, and recognition of licence plate number from an input image of the vehicle.

The state-of-art in AVPR has achieved praiseworthy milestones in last decade. Automatic recognition of car licence plates plays an important role in surveillance systems. These systems which are applied in parking areas, highways, bridges, and tunnels help human operators and improve the overall quality of the transportation systems [1]. AVPR is a mass surveillance method that uses optical character recognition on images to read vehicle registration plates. It is a technique which is used to identify vehicles using their licence plate numbers. It is the process of extraction of vehicle plate number from an image of a vehicle or video of a moving vehicle. As AVPR system has its central role in many applications, it saves time by managing data of vehicles without human intervention. The faults which otherwise would have been caused by a manual system are eliminated.

Data consisting of videos and images is captured using a digital camera. This data consisting of videos and images becomes input to the AVPR system. The AVPR system applies the algorithm on the input data and output is the registration number written on the licence number plate of the vehicle. Figure 1.1 presents the working of AVPR system.

Automatic Vehicle Plate Recognition has been an active research area for more than three decades. The state-of-the-art in AVPR has achieved praiseworthy milestones in last few decades. A lot of commendable research has been carried out in this area in recent past. It has been observed that research related to AVPR attracted many researchers in the past and nowadays as well. A state-of-the-art literature review of AVPR is presented in this chapter. The period of interest for this literature survey is from mainly 1990 to till date. The various methods and techniques of Licence plate detection and recognition are reviewed in this chapter. As discussed in the introduction, AVPR includes four main stages as pre-processing, plate extraction, character segmentation, and character recognition. The ensuing section 2.1 presents a literature survey based on the work done by researchers in each stage of AVPR. Section 2.2 reported the literature review based on work done by researchers in the last three decades. Discussion on literature review is done in section 2.3 and research gap is explained in section 2.4. The literature study encompassed going through various research articles, books and web references pertaining to each of these areas. The overview covers the research papers published between 1990 and 2018. A brief summary of methods and techniques used for AVPR has been presented here. Thorough literature review exercise helps concretize the problem statement for the present research work.

### 2.1 Literature review based on AVPR stages

AVPR is a multi-stage approach to identify the licence plate number from the input image of a vehicle. The established and well-known procedure of AVPR includes four main components: pre-processing, licence plate extraction/detection, character segmentation and character recognition as shown in Figure 2.1. This section will explore the various tools, techniques, and methods employed by researchers in each stage of AVPR. The ensuing sections 2.1.1 to 2.1.4 presents the literature review based on pre-processing, licence plate detection, plate segmentation, and character recognition phases respectively.

**2.1.1 Review based on the pre-processing stage:** This section presents the review of the techniques and methods used by researchers in the pre-processing phase. The pre-processing is the first stage in the AVPR system. It is one of the essential phases of automatic licence plate detection and recognition. First of all, data is acquired in form of videos and images of vehicles using a digital or mobile in-built camera. As the videos and images are taken in real time environment under uncontrolled illumination, there may be noise and low contrast. The image may contain impurities such as holes and dirt particles as shown in Figure 2.2.


**Figure 2.2: Noised Image**

 

The noise is removed from the image of the vehicle in the pre-processing stage. Contrast adjustment is also performed on the image in this stage. The image is enhanced and pre-processed so that it is easy to recognize the number. Various pre- processing techniques are proposed in the literature. In [4], [5] and [6] Gaussian filter is used to remove the noise from the input image. A Gaussian filter smooths an image by calculating weighted averages. The blur of the image is also controlled by Gaussian filter. Authors in [1] used histogram equalization for contrast enhancement. Authors [7], [8] and [9] used Median Filtering to remove noise from the foreground of the image. Median filtering is a technique that removes noise from the image while preserving the edge information. It works by moving through the image pixel by pixel, replacing each value with the median value of neighboring pixels. A Mexican Hat Filtering is used to remove noise and distortion on the images in [10]. This method is used to enhance spots in noisy images. Reference [7] and [10] used Morphological operators to further refine the image. Image corrosion technology is used to remove the effect of the image edge burr in [11]. In [12], brightness variation is corrected by gamma intensity correction, a difference of Gaussian, local histogram matching and local normal distribution. The erosion method is used in [13] for noise removal. It computes for each pixel in the image a local minimum in the area covered by a 3*3 pixel kernel. ULEA (Unwanted Lines Elimination Algorithm) is used in [14] to remove noise and enhance the image. Various methods such as Gaussian, Median, Kalman could be used to remove the noise and reduces sharp edges in the image. The gaussian filter has a better performance as compared to the median filter in high noise image processing [15]. The image of the vehicle after pre-processing is shown in Figure 2.3.


**Fig. 2.3: Pre-processed Image**

**2.1.2 Review based on licence plate detection stage:** This section presents the review of techniques and methods used by researchers in Licence plate detection phase. Licence plate detection or localization is the second stage of the AVPR system. This phase in AVPR carries a significance of its own. The focus of this phase is to detect the licence plate in the image of the vehicle. In this phase, the licence number plate is extracted from the pre-processed image of the vehicle. The input of this stage is a vehicle image and output is the portion of the image carrying the vehicle plate. The main objective is to identify the location of the vehicle plate in the image. The candidates regions are extracted according to the features of the licence plates such as the rectangular shape of plates, the presence of characters on the plates and the specific color of the plate. The localization of the plate is a very important phase of AVPR system. The success of AVPR system depends upon the accuracy of the plate detection step. Figure 2.4 contains the image of licence number plate extracted from the pre-processed image of the vehicle shown in Figure 2.3.


**Fig. 2.4: Detected Licence Plate**

After the pre-processing phase, characters of the licence plate are extracted from the pre-processed image of the vehicle. This phase in AVPR carries a significance of its own. The focus of this phase is to extract characters regions. In this phase, characters and numbers are segmented from the licence plate. The input to this stage is the pre-processed image of vehicle and output is the extracted characters. A variety of techniques which have been used for characters extraction are discussed in the literature survey. In this study, an innovative algorithm that extracts character regions and their recognition with high accuracy for the real-life dataset is proposed. The presence of characters is used to identify the region of interest. This algorithm employed a novel region extraction technique based on image structural properties. Such image sub-regions properties are intra- as well inter-dependent. This approach covered both intra- regions and inter- regions properties for characters extraction. After the preliminary stage 1, the system goes into character extraction stage. During this stage, all the possible regions of the pre-processed image are extracted. The main idea in this stage is to identify various regions in the vehicle image having similar features. The groups according to the features of characters like area, height, width, perimeter and aspect ratio are built. Then intersection of groups is taken and then finally characters like regions are extracted. The following steps are used to extract character regions:

Step1: The image of the vehicle is divided into atomic regions. All the possible regions of the Image are identified

Step2: Then all the character regions are filtered on the basis of features of characters like size, perimeter and aspect ratio.

Step 3: If the numbers of extracted regions are greater than the desired number then the regions are further processed based on grouping criteria to identify the false regions and removing the surplus regions.

Step 4: If the number of regions is less than the desired number then Re-grouping is performed to extract more character like areas.

Step 5: If the number of regions are between the desired range then print extracted characters

 

Figure 4.15, 4.16 and 4.17 contains the images of eight, nine and ten extracted characters regions respectively from images of vehicles.

**Figure: 4.15: Eight characters extracted**

**Figure: 4.16: Nine characters extracted**

**Figure: 4.17: ten characters extracted**

**Character recognition**

This phase brings the actual recognition in to play. In this phase, extracted character regions are recognized. After each character is segmented from the licence plate, the final operation is the character recognition. The input to this stage is extracted characters from the licence plate. The output of this stage is the recognized alphanumeric characters present on the licence number plate. Character recognition may have some challenges due to camera zoom factor, non-uniform font size, and font type. Extracted alpha-numeric characters may be broken and may contain some noise. Researches have used a variety of techniques like artificial neural networks, support vector machine, and template matching etc. in literature. Each extracted character is separately recognized in the proposed system. Then, the correlation technique is applied to match characters regions to complete the working of proposed character regions technique efficiently. This character recognition system consists of two sub-phases: Learning phase and recognition phase.

a) Learning phase: Learning phase is the training phase of the system. In this phase following steps are used to train the system.

Step 1: The prototype of each extracted character is learned.
Step 2: Each extracted character is allocated a template.
Step 3: This learned prototype and corresponding template are stored in the memory.
Step 4: Step 1 and step 2 are repeated for all the extracted characters and accordingly allocation is done.
Step 5: Template vector will be created for all the extracted characters.

b) Recognition phase: In this phase, the trained prototype is used to classify the unknown extracted characters. Extracted characters are recognized to generate actual output. The following steps are performed for classification.

 

Step 1: Each unknown extracted character will be compared with a set of templates from template vector.
Step 2: A number of similar templates will be generated on the basis of comparison.
Step 3: The correlation between extracted character and similar templates is calculated. The correlation between two images A and B are computed as the following formula:

$$r = \frac{\sum \sum (A - A)(B - B)}{(\sum \sum (A - A))(\sum \sum (B - B))}$$

Where m and n are mean values for m by n images

Step 4: The similarities are compared with each other using correlation.
Step 5: The most similar template will be the recognized character.
Step 6: Step 1 to 4 is performed on all the extracted characters of the licence plate.
Step 7: Print licence plate number.

In fold 4, 320 images are taken in training set and another group of 180 images are taken in test set randomly. The system is trained for 320 vehicle images and tested on another 180 vehicle images. The character region extraction and character results are summarized in Table 5.7 and Figure 5.7 respectively. The character extraction regions accuracy for train datasets are 96.87% (all correct), 97.81% (all correct except one) and 98.43% (all correct except two). Similarly, test dataset accuracy percentages are 95.00% (all correct), 96.11% (all correct except one) and 96.66% (all correct except two).

**Table 5.7: Character regions extraction results for Fold 4**

| Data | Total Images | $X_1$ | $X_2$ | $X_3$ |
|---|---|---|---|---|
| Trained | 320 | 310 | 313 | 315 |
| Test | 180 | 171 | 173 | 174 |

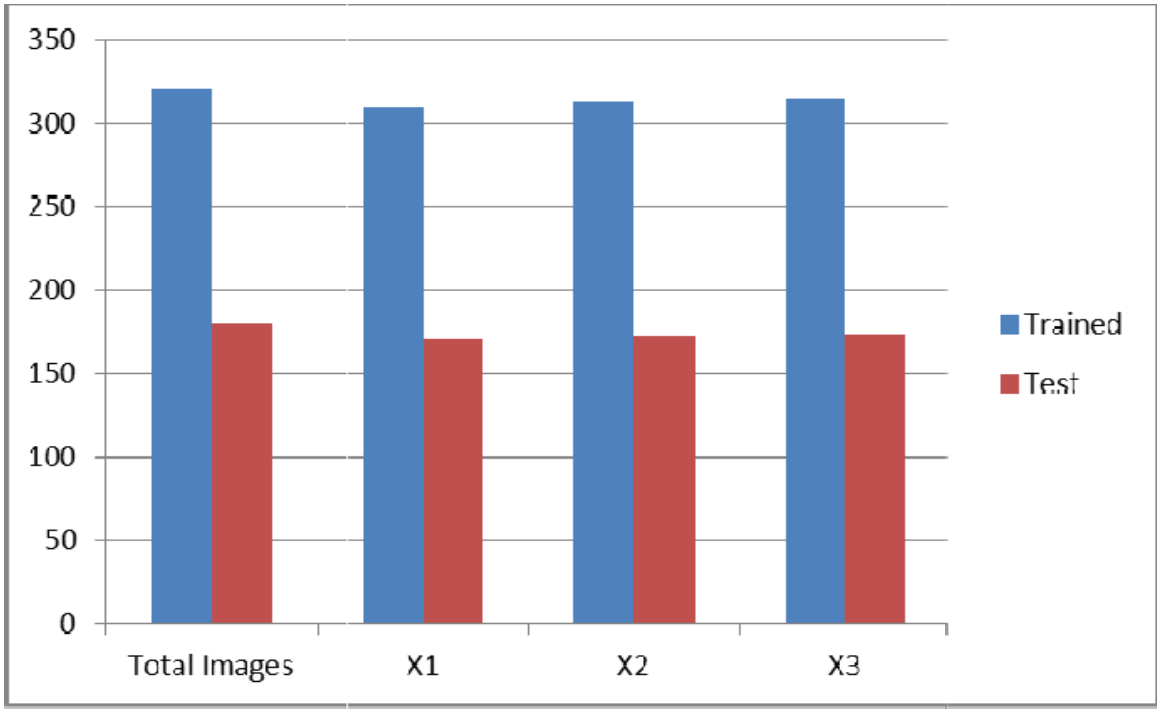


**Figure 5.7: Graph for Character regions extraction (Fold 4)**

The character recognition results are summarized in Table 5.8 and Figure 5.8. For character recognition, it is concluded that the success rate for trained images and test images is 95.60% and 95.0% respectively. The recognition accuracy percentages for train datasets are 95.62% (all correct), 96.87% (all correct except one) and 98.43% (all correct except two). Similarly, test dataset accuracy percentages are 94.44% (all correct), 95.00% (all correct except one) and 96.11% (all correct except two).

**Table 5.8: Character recognition results for Fold 4**

| Data | Total Images | $Y_1$ | $Y_2$ | $Y_3$ |
|---|---|---|---|---|
| Trained | 320 | 306 | 310 | 312 |
| Test | 180 | 170 | 171 | 173 |

 

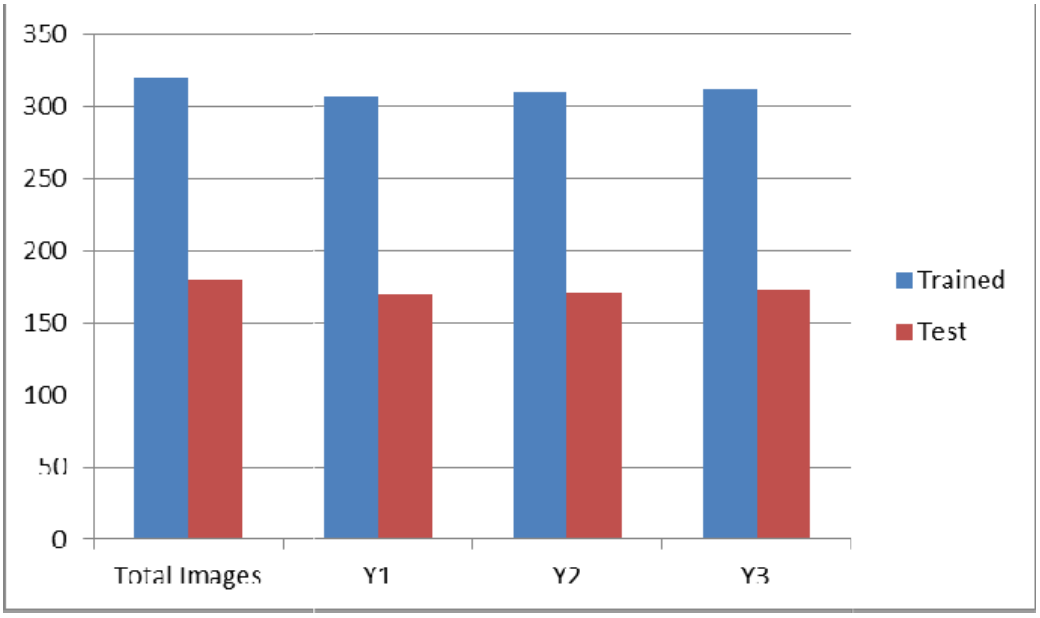


**Figure 5.8: Graph for Character recognition (Fold 4)**

## 3. RESULTS ANALYSIS

Table 5.9 and Figure 5.9 summarises the results for character regions extraction and character recognition for the trained data set. It is concluded that average characters region extraction accuracy and character recognition accuracy for trained data is 96.95% and 95.70% respectively.

**Table 5.9: Summary of results for trained data**

| Fold | Characters Regions Extraction | Character Recognition |
|---|---|---|
| Fold 1 | 97.00% | 95.66% |
| Fold 2 | 97.20% | 95.60% |
| Fold 3 | 96.66% | 95.92% |
| Fold 4 | 96.87% | 95.62% |

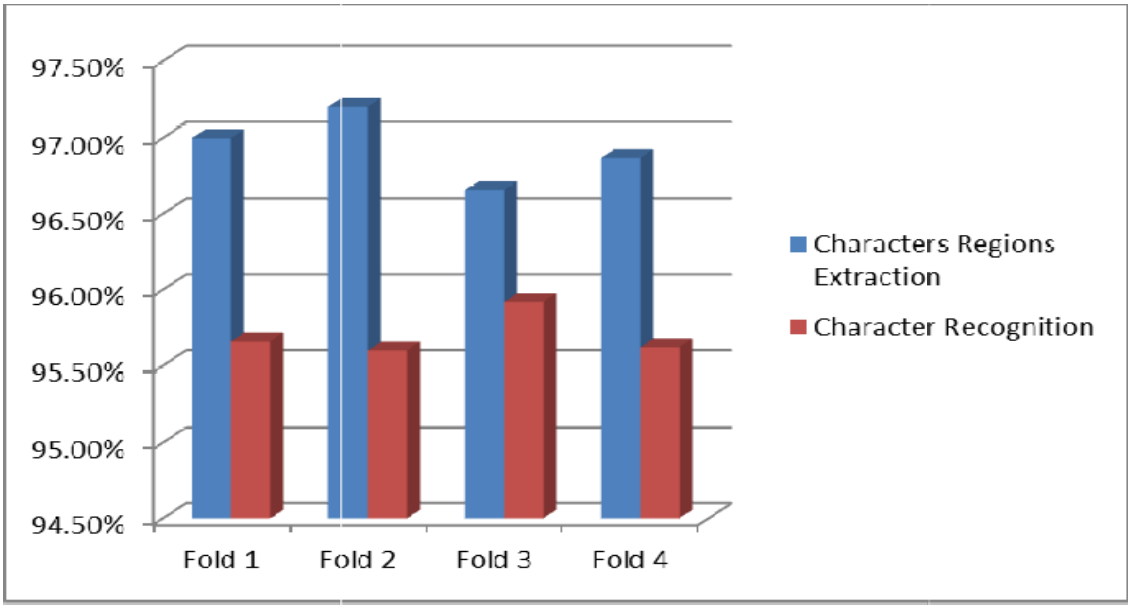


**Figure 5.9: Graph for Summary of results for trained data**

Table 5.10 and Figure 5.10 summarises the results for character regions extraction and characterrecognition for the test data set.It is concluded that average charactersregion extraction accuracy and character recognition accuracy for 96.44% and 94.97% respectively.

**Table 5.10: Summary of results for test data**

| Fold | Characters Regions Extraction | Character Recognition |
|---|---|---|
| Fold 1 | 96.00% | 95.00% |
| Fold 2 | 96.40% | 94.80% |
| Fold 3 | 96.52% | 95.65% |
| Fold 4 | 96.87% | 94.44% |

 

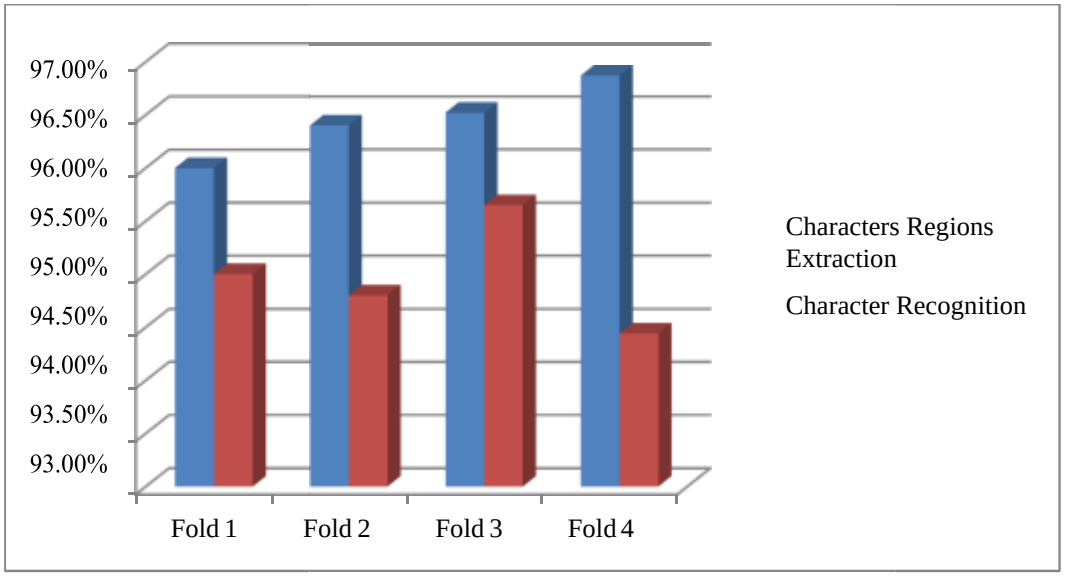


**Figure 5.10: Graph for Summary of results for test data**

It is concluded that overall character region extraction success rate is 96.69% and overall character recognition success rate is 95.34% for all the experiments.

## 4. CONCLUSION

Licence plate detection and recognition has been an area of research for more than three decades now. The work done by researchers in this area of Automatic Vehicle Plate Recognition is praise-worthy. Variations in licence plates are one prominent problem and achieving a high degree of recognition accuracy is a tedious task. This entire research effort has been executed in a step-by-step fashion. This research study is based on a detailed and comprehensive literature review in the field of AVPR. After an extensive literature survey, gaps have been identified that need to be addressed. The main goal of this thesis is to design and develop an automatic vehicle recognition system. This goal was met as the developed system recognizes Indian licence plates accurately. This thesis proposed a robust and reliable vehicle plate character extraction and recognition algorithm (VeLiPET) for Indian number licence plates. In this algorithm, the features of characters like area, height, width, perimeter and aspect ratio are used to extract the vehicle number characters from the image of the vehicle. Template matching is used for character recognition. The proposed system is evaluated over a data-set of 500 images of vehicles taken in real time scenario.

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