Chapter 3

Problem Formulation and Solution Strategies

The formulation of the research problem based on the extensive literature review and various strategies so as to tackle the identified problems to get a solution is presented in this chapter. The comparison along with the limitations of existing VNPR systems are brought out in the previous chapter 2. The selected issues along with their treatment are discussed. The strategies to find solution are also discussed in this chapter.

3.1 Introduction

The VNPR is a mass surveillance method that uses optical character recognition on images to read the license plates on vehicles. These can use existing closed-circuit television or road-rule enforcement cameras, or ones specifically designed for the task. These are used by various police forces and as a method of electronic toll collection on pay-per-use roads and monitoring traffic activity, such as red light adherence in an intersection.

There are four phases in VNPR, namely image acquisition, license plate localization, license plate segmentation and character recognition. These phases are generally implemented with separate algorithm and the imperfect logic or methodologies used in any of these algorithms will result into the incorrect recognition of the license plate.

In spite of potential benefits of these approaches, the inaccuracy in the license plate recognition under different conditions and assumptions keep the research in active state. From our studies, we conclude the following necessary requirements that need to be addressed. These requirements lie in the scope of the four phases of VNPR, as discussed above.

Researchers, academicians and practitioner engineers are continuing to propose models for VNPR. In the first phase the image is captured which contains many other objects, other than car image. The existing approaches assume that the camera is at the proper angle and hence the view is un-skewed. However, initially, there is a possibility that the installed camera does not have the appropriate orientation because of the position of number plate in vehicles of different dimensions. Further due to other climatic or aging effect of related hardware, such possibility may occur. These issues have been taken care in our research.

Next, it is necessary to locate and extract the license plate region from a larger scene image. The extraction is based on the features of the license plate. There are numerous techniques, proposed by the researchers, which are discussed in the previous chapter. It is shown that these techniques work under certain conditions or assumptions. Moreover, when the car is in motion, the viewed image contains several noisy data, which needs to be considered. Therefore, there is a need to deal with such conditions or assumptions.

Segmentation is required to extract the characters of the license plate, after extraction. It consists of pre-processing to deal with the issues, from the extraction phase. The issues may include sizing, brightness, etc. Several approaches are available for segmentation, as discussed in the previous chapter. Some of the techniques highly depend on the format, color, texture of the plate. Also, very limited approaches deal with the plate orientation and it is assumed that the text lines in a plane whose angles are normal to the horizontal axis of the plate. In order to extend the application of VNPR into various fields, it is necessary to consider the skewness of the text for proper recognition.

After segmentation, the text is read for license plate recognition. Due to the quality of camera, the quality of the text may be weak. Further, varying font size, color, lighting effects add complexity. For this reason, researchers are continuing

to address these issues for proper recognition of the text by proposing different methodologies. Such methodologies are also based on some assumptions and do have some limitations.

3.2 Problem Formulation

The issues that are identified in different stages of VNPR process need proper treatment to ensure the reliability of the VNPR system. After critical literature review regarding the existing VNPR systems, the research problem is four folded as shown in figure 3.1 on page 41, explained in the subsequent sections.

3.2.1 Orientation of camera, skewness of license plate or text

Due to improper installation of the camera or aging effect of the holdings, the orientation of the camera may be improper and so the captured image will be skewed. In such cases there should be an approach which can address this issue. Further, it may be possible that the supporting nails to hold the license plate is not proper. In this case the license plate may be in slight tilt position and hence the license plate image will be skewed. But in general, the existing approaches of VNPR systems assume that the text vertical axis is perpendicular to the horizontal axis of the license plate. Hence there must be an approach to deal with such situation for accurate recognition of the license plate

3.2.2 Uncertainty in localization of license plate

The stage of license plate extraction influences the accuracy of VNPR. Locating the license plate from a large image is a challenging task. When the images are processed, it is difficult and complicated to detect “characters”, which are exactly the parts of the license plate. Although there is some fix location of the license plate in the vehicle, the sizes of the bumper parts, where the plates are fitted, are different in different models. It can be distinguished by its features. Moreover, the existing approaches have limitations with respect to climatic conditions, size,

complex images, etc. Some generate broken objects, which are difficult to segment. Many of them are computationally complex and time consuming. Further, localizing the plate from its view, which has been taken when the car was in motion, is much difficult due to the noisy objects in the image. Hence there must be a robust solution to deal with such limitations.

3.2.3 Improper segmentation of license plate

For proper character recognition, the images of the characters should be segmented first from the license plate images. An extracted license plate from the previous stage may have some problems like non-uniform brightness, etc. There are several approaches for license plate segmentation that are based on pixel connectivity, prior knowledge of characters or combined features. Many of these approaches fail to extract all the characters when there are joined or broken characters. Some of them are limited by prior knowledge, in which any change may result in error. Some of them are slow and computationally complex. Therefore there is a need of proper treatment of these shortcomings to get better accuracy.

3.2.4 Improvement in feature based Character recognition

The extracted characters are recognized after segmentation to give the output as license plate number. Character recognition may face some challenges due to zooming effects of the camera, which can change the size or thickness of the extracted characters. The other issues include the font size and font style. Also there is a possibility of getting noisy or broken characters as an input. There are several approaches in literature to recognize the characters. Many of them are slow because non-important pixels are also processed or in some case non-robust features degrade the recognition performance. Hence there must be a methodology which can take very less time to recognize the characters and it should be able to find the robust character features.

3.3 Solution Strategies

3.3.1 Strategy for dealing with orientation of camera, skewness of license plate or text

An approach based on Radon transform is proposed to deal with the situation when the camera is not installed at the proper orientation, or license plate is not located in line with the horizontal axis. The proposed methodology works on all kinds of tilted images irrespective of their color, texture and climatic conditions. 2-D Median filter is used to remove the blur, after rotating the image to the desired angle. The approach has been validated on 350 tilted license plate images.

3.3.2 Strategy for dealing with the uncertainty in localization of license plate

As mentioned before, the system of automatic number plate recognition faces many challenges. So, this step is essential to enhance the input image capturing and making it more suitable for the next processing steps. To overcome the limitations involved in this step, wavelet decomposition is exercised to compute the approximation coefficients matrix and details coefficients matrices. To find the location of the license plate in any condition, the energy curve of the pixel intensity of each column and row of the horizontal and vertical frequency band is plotted. For smoothing Gaussian filter is used. The advantage of Gaussian filter is that it is separable and hence it first convolves the image with a one dimensional horizontal filter, and then convolves the result of the first convolution with a one dimensional vertical filter. Finally finer adjustments can be done by doing thresholding. The main advantage of this approach is robustness that is capable to overcome all the limitations as discussed in section 3.2.2. For the moving vehicles, Spatio-Temporal filtering is used to locate the license plate; it brings out image locations that change with time, so 'moving cars' light up in the filtered image. The proposed method is validated on 250 different types of images, having different shape, size and color and under varying lighting conditions and distance.

3.3.3 Strategy for dealing with improper segmentation of license plate

Segmentation, for character recognition, is done by plotting the energy curves after binarization. When the slope of the curve reaches to minimum, end of the character is declared. This algorithm is very simple and efficient with respect to the processing time and has no computational complexity. Through this, the issues mentioned in the section 3.2.3 can be addressed. The proposed method is validated on 250 sets of images that contains on total 2500 characters.

3.3.4 Strategy for improvement in feature based Character recognition

Characters can be well recognized based on their unique features. Identification of unique features of all the types of characters available in the world is a challenging task. The challenge in recognizing the text lies in the nature of humans, having unique styles in terms of font, contours, etc. The number plate can contain the text in any language, depending on the transportation rules of the respective countries. Two different approaches are proposed for identification of the unique features of the characters; one based on vector contour, MCS and ANN; other based on snakes and PCA. The proposed method is validated on 370 sample characters.

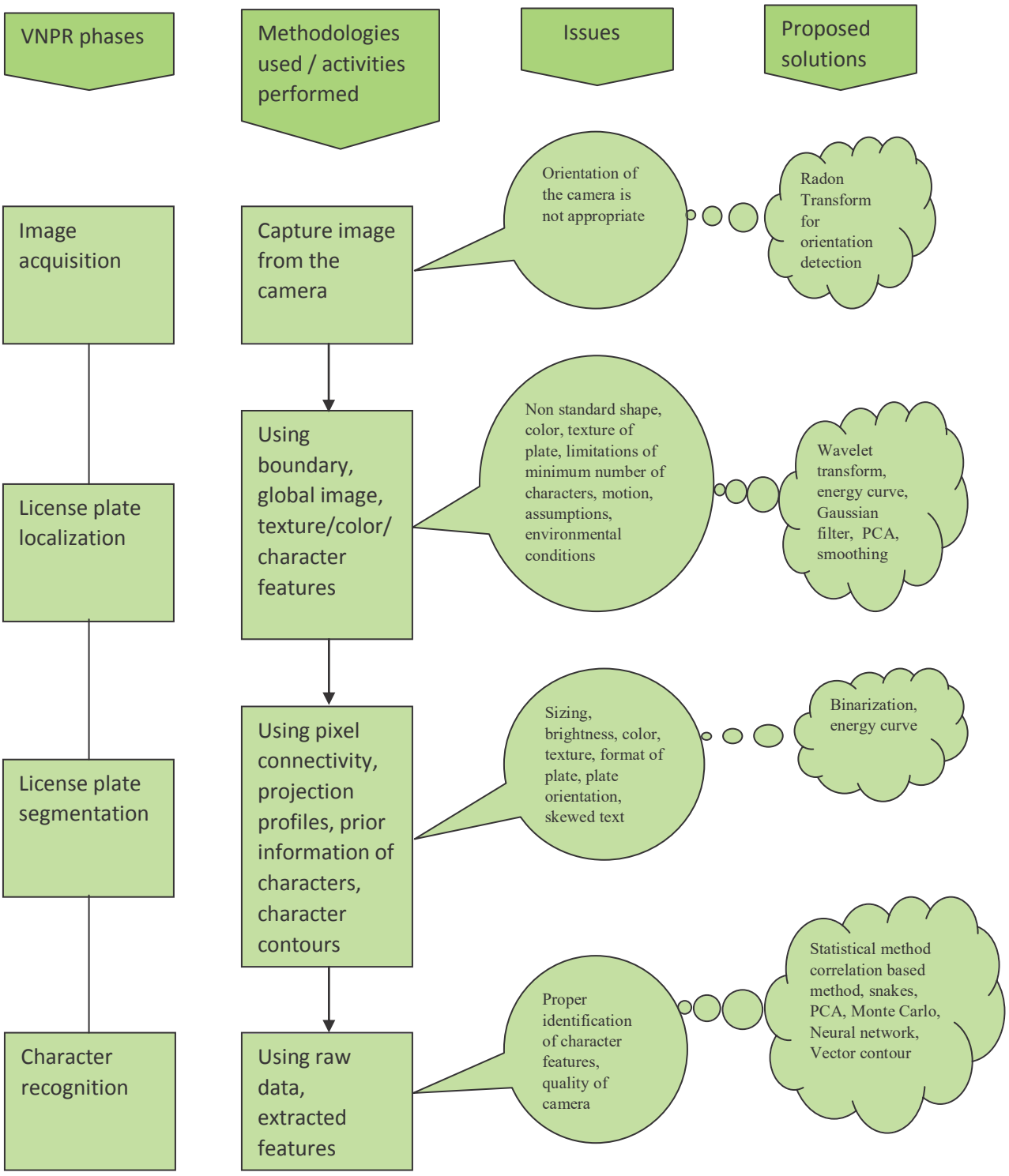

Figure 3.1: Issues and proposed solutions to address the selected limitations of existing VNPR systems.