CHAPTER 1

INTRODUCTION

1.1 Rationale

A license plate serves as a crucial identifier for vehicles that navigate the roads, housing their unique combinations of characters. As the primary means of vehicle identification, each plate holds distinctive information about the vehicle itself and its owner Susanto et al. [1]. Law enforcement agencies and parking facilities often rely on this information for various purposes, including monitoring traffic violations and managing accidents. They gather evidence through various types of devices, not solely relying on CCTV cameras with optimal viewing angles; even random captures from different angles can yield helpful results Zhang and Wan [2].

However, challenges arise when license plate images are taken at extreme angles. Optical Character Recognition (OCR) systems have limitations and can typically handle tilted text no more than 10 degrees Huang [3]. Beyond that, many character recognition systems struggle to read the text on a license plate accurately. This limitation necessitates a rectification system to address perspective distortions, ensuring that OCR technologies can effectively read and retrieve the required information from the license plate.

The ideal position for capturing license plate images is directly in front of the plate itself bib [4]. To address this issue, several methods for perspective rectification can be implemented. Previous research has outlined various rectification techniques that yield accurate results, particularly for angles between 45 and 50 degrees, either vertically or horizontally. These approaches often employ initial transformations that are effective for moderate distortions.

Current methodologies demonstrate satisfactory performance within moderate angles Sihombing et al. [5], Alhussein et al. [6], Xu et al. [7]; however, limited research has been dedicated to employing trigonometric parameters for addressing perspective distortions exceeding forty-five to fifty degrees. This limitation suggests that the utilization of trigonometric concepts significantly enhances the rectification outcomes for images captured at extreme angles.

This study explores various strategies, avoiding AI or deep learning methods, to achieve successful license plate rectification Rao et al. [8], Ali et al. [9], Damayanti et al. [10], Yoo and Jun [11]. While existing rectification methods demonstrate promising results, they often fail to pinpoint the optimal reference point for rectifying objects like license plates. It is concluded that the edges of every license plate provide a consistent frame, as all plates share the same rectangular shape but vary in proportions. Our approach involves identifying key points in license plate images captured at extreme angles above 45 degrees.

Utilize trigonometric parameters to precisely identify the locations of the key points, what is called "ghost points". According to trigonometric calculations, these ghost points represent the maximum and minimum positions of each key point (x,y). As only four key points are requisite, it is essential to eliminate any extraneous data to ensure both precision and accuracy.

1.2 Theoretical Framework

Integrating multiple vision and geometry-based techniques offers a robust framework for detecting, correcting, and evaluating license plate images. Canny Edge detection lies at the core of many feature extraction pipelines. it provides a stable set of edge pixels by applying non-maximum suppression and hysteresis thresholding, which helps guide further transformations or alignment checks. Building on these edges, BRISK (Binary Robust Invariant Scalable key points) identifies local key points invariant to scale and rotation. Matching these key points across different views can reveal whether a plate is already aligned or requires geometric correction.

From a trigonometric filtering perspective, analyzing angles and distances between detected edges or key points helps quantify skew. For instance, calculating the dominant orientation of a cluster of key points can signal an overall tilt, while vertical or horizontal edge alignments indicate minimal skew. Once the tilt or perspective distortion is estimated, projective transforms can map the plate to a rectangular coordinate system, "unwarping" the image effectively. These transforms leverage the notion that four corresponding points—corners or well-defined key points—define a homography, which geometrically corrects distortions introduced by perspective changes.

Finally, piecewise linear methods refine alignment by allowing localized corrections, particularly if the plate has nonuniform warping or the edges are partially occluded. Instead of forcing a single global homography, a piecewise strategy applies smaller, localized linear transformations in different regions. This piecewise approach can handle challenging cases where plate parts are at slightly different depths or angles. These techniques—Canny Edge detection, BRISK key points, trigonometric filtering for skew estimation, projective transforms, and piecewise linear corrections—provide a cohesive theoretical and algorithmic foundation for ensuring geometrically correct and visually interpretable license plate images.

1.3 Conceptual Framework/Paradigm

In this approach, the image is first cropped if the license plate is too small or too distant, ensuring that only the relevant region is processed. Next, a color-based thresholding step filters out background pixels, leaving a mask that isolates the plate. Canny edge detection is then applied to delineate the masked plate's boundaries, and Binary Robust Invariant Scalable Keypoints (BRISK) are extracted at these edges. Trigonometric parameters help filter out extraneous keypoints, retaining only those necessary for the rectification process. Both projective and piecewise rectification methods are subsequently employed to correct geometric distortions, thus improving the plate's clarity. Finally, evaluation metrics include reference-based angle measurements (to gauge vertical and horizontal alignment), sharpness or blur assessment via BRISQUE, and an Optical Character Recognition step to confirm the readability of the rectified plate.

1.4 Statement of the Problem

Current methodologies Susanto et al. [1], Zhang and Wan [2], Huang [3], bib [4], Sihombing et al. [5] demonstrate effectiveness for moderate distortions, typically ranging from [0,50] degrees. However, when the angle of a license plate exceeds 50 degrees, the system's capability to manage distortion effectively is significantly diminished. Furthermore, the exist-ing techniques cannot correct license plate datasets from multiple countries; as a result, they are limited to facilitating retrieval from a single nation.

1.5 Objective and Hypotheses

The study objective is to improve the current limitation perspective rectification, which is only effective at 50 degrees horizontally and vertically, and also address license plates that have undergone deformation or distortion before or after the rectification process. This research can improve the maximum degree of perspective rectification using trigonometric parameters combined with hybrid image transformation; it can also adjust the deformation or distortion of license plates.

1.6 Assumption

There is an assumption in this thesis. The method used in this research can rectify every license plate with a degree of more than 50 vertically and horizontally; it also repairs object deformation or distortion.

1.7 Scope and Delimitation

The scope of this research encompasses a tilt degree angle of the license plate ranging from 0 to 80 degrees, both horizontally and vertically, while ensuring the legibility of the characters for adequate correction. A limitation of this study arises from conditions encountered at midnight, characterized by low light levels and the presence of dark-colored license plates. Additionally, the distance between the license plate and the camera has not been quantified in this analysis.

1.8 Significance of the Study

This study contributions are as follows: (1) the existing capabilities to rectify images are extended to angles greater than 50 degrees, with this proposed system handling tilts of up to 80 degrees; (2) the proposed method accommodates license plates from various regions, including the United States, Europe, Indonesia, China, and Japan; and (3) the implementation based on trigonometric parameters effectively identifies the essential set of key points needed for our system.

Chapter 2 outlines a mathematical framework for the proposed scheme and details the fundamental assumptions. Chapter 3 elaborates on the comprehensive process of license plate rectification. In Chapter 4, presents our research findings, encompassing all aspects of the evaluation metrics and providing a discussion of the results. Finally, Chapter 5 concludes the research with our final thoughts.