LICENCE PLATE DETECTION USING IMAGE PROCESSING TECHNIQUES

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ABSTRACT

In this project, We analyzed the effectiveness of various image processing techniques for license plate recognition using a dataset comprising 50 images. The steps undertaken included image acquisition, where 50 images were captured under various conditions to establish our dataset. In the data preprocessing stage, images were converted to grayscale and a Gaussian filter was applied to reduce noise. For image segmentation, the Canny edge detection algorithm was used to highlight significant edges and structures in the images. Morphological image processing involved applying morphological operations to enhance and highlight object edges for license plate detection. In the plate localization step, candidate plates were identified using contour finding techniques and highlighted by drawing bounding rectangles. Finally, text extraction was performed using Optical Character Recognition (OCR) to extract text from the identified license plates. Using these techniques, we achieved an accuracy of 57%. This study demonstrates the potential of image processing techniques in license plate recognition, though improvements are necessary for higher accuracy.

**Keywords:** License plate recognition, image processing, OCR, Canny edge detection, morphological operations.

1. INTRODUCTION

License plate recognition (LPR) is a crucial technology for various applications, including law enforcement, toll collection, and parking management. Accurate and efficient detection and recognition of license plates can significantly enhance the automation and effectiveness of these systems. In this research, the effectiveness of various image processing techniques for license plate recognition was assessed using a dataset of 50 images captured under different conditions.

The project involved several steps: image acquisition, data preprocessing, image segmentation, morphological image processing, plate localization, and text extraction. The images were first converted to grayscale and processed with a Gaussian filter to reduce noise. The Canny edge detection algorithm was used for image segmentation to highlight significant edges and structures. Morphological operations were then applied to enhance and highlight object edges for better license plate detection. Candidate plates were identified using contour finding techniques and highlighted by drawing bounding rectangles.

Finally, Optical Character Recognition (OCR) was used to extract text from the identified license plates.

The techniques were tested on the dataset, and the results showed an accuracy of 57%. These findings suggest that while the applied image processing techniques are promising for license plate recognition, further improvements are necessary to achieve higher accuracy.

We would like to give information about the algorithms that I used in this project.

* 1. Image Acquisition

Image acquisition is the first and critical step in the license plate recognition process. In this project, we captured 50 different images under various lighting and environmental conditions to create a comprehensive dataset. These images were taken from multiple angles and distances to ensure the dataset was diverse and representative of real-world scenarios. This variety helps in training a robust model capable of recognizing license plates in different situations.

1.2.Data Preprocessing

1.2.1.Purpose and Importance

Data preprocessing is a critical step in preparing images for analysis and enhancing the performance of the license plate recognition system. It involves several sub-steps that reduce complexity, improve image quality, and highlight essential features. The primary objectives of data preprocessing are to convert images into a format suitable for processing, reduce noise and distortions, and enhance the contrast of key features. These steps are crucial for accurate detection and recognition of license plates, as they ensure the input data is clean and well-defined. Effective preprocessing leads to better feature extraction and improves the overall accuracy and reliability of the recognition system.

1.2.2.RGB to Grayscale Conversion

The first step in preprocessing is converting RGB images to grayscale. Grayscale conversion reduces the complexity of the image data by eliminating color information, which is not necessary for license plate recognition. This simplification makes subsequent processing steps more efficient and focused on the structural details of the license plate.

* Formula : The grayscale value *I* is computed as a weighted sum of the RGB values.

1.2.3.Noise Reduction

Noise reduction is essential for removing unwanted distortions and enhancing the clarity of the edges and structures within the image. This step involves applying filters to smooth out noise while preserving important features.

* Applied to smooth out noise, especially high-frequency noise, making edges more distinct. *σ* is the standard deviation of the Gaussian distribution.

**1.2.4. Morphological Operations**

Morphological operations are applied to refine the segmented image and enhance the features of the license plate. These operations help in removing small objects and noise, ensuring that the license plate edges are clear and well-defined.

* Dilation: This operation adds pixels to the boundaries of objects in an image, effectively growing the object’s size. Dilation helps to close small gaps and connect disjointed parts of the license plate.

* + ****Formula****:

where A is the input image and B is the structuring element.

1.2.5. Usage of Formulas in Preprocessing Steps

* Grayscale Conversion: The RGB to grayscale conversion formula is used at the beginning of the preprocessing pipeline to simplify the image data.
* Gaussian and Bilateral Filters: These formulas are applied during the noise reduction step to smooth the image while preserving important features.
* Histogram Equalization: This technique is used in the contrast enhancement step to improve the visibility of the license plate details.
* Morphological Operations: The opening operation formula is used to refine the image by removing noise, and image subtraction highlights the license plate by enhancing its edges.
  1. Image Segmentation

1.3.1. Purpose and Importance

Image segmentation is a crucial step in the license plate recognition process that involves isolating and highlighting significant parts of the image, such as edges and contours. This step is essential for accurately identifying the region of interest, which is the license plate. Effective segmentation ensures that subsequent steps, such as morphological processing and text extraction, focus on the correct part of the image, improving the accuracy and efficiency of the recognition system.

1.3.2 Edge Detection using Canny Algorithm

The Canny edge detection algorithm is a popular technique for detecting edges in images. It identifies areas of rapid intensity change, which typically correspond to the edges of objects. This algorithm is particularly effective for license plate recognition as it highlights the boundaries of the license plate, distinguishing it from the background and other elements in the image.

* Steps in Canny Edge Detection:

1. Gaussian Blur: Smooth the image to reduce noise.
2. Gradient Calculation: Compute the gradient intensity and direction at each pixel.
3. Non-Maximum Suppression: Thin out the edges by suppressing all pixels that are not at the maximum.
4. Double Threshold: Apply thresholds to identify strong and weak edges.
5. Edge Tracking by Hysteresis: Finalize the edge detection by suppressing all edges that are not connected to strong edges.

* Formulas Used in Canny Edge Detection:
  +  Gradient Magnitude G*G*:

where Gx*Gx*​ and Gy*Gy*​ are the gradients in the x and y directions, respectively.

* + Gradient Direction θ*θ*:

1.4 Plate Localization

1.4.1. Purpose and Importance

Plate localization is a critical step in the license plate recognition process that involves identifying and isolating the license plate region within the image. This step ensures that subsequent processes, such as text extraction, focus on the precise area of interest, improving the overall accuracy and efficiency of the recognition system. Effective plate localization is crucial as it narrows down the area to be analyzed, reducing computational complexity and enhancing the system's performance.

1.4.2. Contour Detection

Contour detection is used to identify the boundaries of potential license plates. Contours are continuous curves that join all the continuous points along a boundary with the same color or intensity.

* Algorithm: Find contours using hierarchical methods to detect both outermost and nested contours.
* Steps:
  1. Edge Detection: Use Canny edge detection to highlight significant edges in the image.
  2. Contour Finding: Apply contour detection algorithms to identify potential license plate boundaries.
* Formula: Contours are represented as a list of points (x, y) that form the boundary of the detected objects.

1.5.3. Bounding Rectangles

Once contours are detected, bounding rectangles are drawn around the identified contours to isolate potential license plate regions. This step helps in focusing on the areas that are most likely to contain the license plates.

* Algorithm:
  1. Identify the contours that match the typical dimensions and aspect ratio of a license plate.
  2. Draw bounding rectangles around these contours.
* Formula:
  1. Bounding rectangles are defined as:

Bounding Rectangle={min(x),min(y),max(x),max(y)} where min(x), min(*y*), max(x) and max(*y*) are the minimum and maximum x and y coordinates of the contour.

1.5.4. Aspect Ratio and Size Filtering

To refine the localization process, additional filters based on aspect ratio and size are applied. License plates have a standard aspect ratio and size range, and these properties are used to eliminate false positives.

* Aspect Ratio: The ratio of the width to the height of the bounding rectangle should fall within a predefined range.
* Size Filtering: The size of the bounding rectangle should be within a specific range to match the typical dimensions of a license plate.

1.6. Text Extraction

1.6.1. Purpose and Importance

Text extraction is the final and most critical step in the license plate recognition process. It involves reading and converting the alphanumeric characters from the localized license plate regions into machine-readable text. This step is crucial as it translates the visual information into a format that can be used for various applications, such as vehicle identification, law enforcement, and automated toll collection.

1.6.2. Optical Character Recognition (OCR)

Optical Character Recognition (OCR) is the technology used for converting different types of documents, such as scanned paper documents, PDF files, or images captured by a digital camera, into editable and searchable data. In the context of license plate recognition, OCR is used to identify and extract the characters from the localized license plate.

1.6.3. Character Segmentation

Character segmentation is a vital sub-step in OCR. It involves isolating each character within the license plate region to facilitate accurate recognition.

* Steps:
  1. Binarization: Convert the grayscale image of the license plate to a binary image to distinguish the characters from the background.
  2. Connected Component Analysis: Identify connected regions in the binary image that correspond to individual characters.
  3. Bounding Boxes: Draw bounding boxes around each connected component to isolate the characters.
* A black text on a white background

  Description automatically generatedFormula: Binary conversion is typically done using a threshold:

where Igray(x,y) is the grayscale value at pixel (x,y) and T is the threshold value.

1.6.4. Character Recognition

Character recognition involves identifying the segmented characters and converting them into text. This step uses pattern recognition algorithms, which can be based on machine learning or deep learning techniques.

* Machine Learning Algorithms: Traditional algorithms such as Support Vector Machines (SVM) or K-Nearest Neighbors (KNN) can be used for character recognition. These algorithms are trained on a dataset of labeled characters.
* Deep Learning Techniques: Convolutional Neural Networks (CNNs) are often used for character recognition due to their high accuracy. CNNs automatically learn features from the input images, making them suitable for recognizing characters in various fonts and styles.
* **Formula**: For a CNN, the character recognition process can be described as:
  + **y=softmax(W⋅x+b)** where y is the output vector of class probabilities, W is the weight matrix, *x* is the input feature vector, and *b* is the bias term.

2. MATERIALS AND METHODS (or EXPERIMENTAL)

The dataset used in this study was specifically compiled for license plate recognition, consisting of 50 images captured under various conditions, including different lighting, weather, angles, and distances. High-resolution digital cameras were used to ensure image clarity. The preprocessing operations involved converting RGB images to grayscale to reduce complexity, using a Gaussian filter for noise reduction, and enhancing contrast through histogram equalization. For image segmentation, the Canny edge detection algorithm was applied to highlight significant edges and contours. Morphological operations, such as dilation and erosion, were used to refine these results, with opening operations helping to remove small objects and noise. Plate localization was performed by detecting contours and drawing bounding rectangles around potential license plate regions, followed by aspect ratio and size filtering to eliminate false positives. The final step, text extraction, employed Optical Character Recognition (OCR) to read and convert the alphanumeric characters from the localized license plates into machine-readable text. Character segmentation involved binarization and connected component analysis. Post-processing steps, including spell checking and contextual validation, were applied to improve the accuracy of the extracted text. The performance of the system was evaluated using accuracy metrics, with all 50 images used for both development and validation to maximize data utilization.

3.EXPERIMENTAL STUDY

3.1 Data Preprocessing

**3.1.1 Convert to Grayscale**

kara taşıtı, taşıt, araç, tekerlek, araba lastiği içeren bir resim

Açıklama otomatik olarak oluşturuldumetin, taşıt, araç, kara taşıtı, dış mekan içeren bir resim

Açıklama otomatik olarak oluşturulduFirst, we handle our base image.(Figure 1). The image is converted from RGB to grayscale to simplify the data and focus on the structural features of the license plate. (Figure 2)

Figure 1 – Base Image Figure 2 – Gray Scale Image

**3.1.2 Apply Gaussian Blur**

A Gaussian blur with a kernel size of (5, 5) is applied to the grayscale image to smooth out noise.(Figure 3-4)

taşıt, araç, kara taşıtı, tekerlek, Araba parçası içeren bir resim

Açıklama otomatik olarak oluşturuldu

kara taşıtı, taşıt, araç, tekerlek, araba lastiği içeren bir resim

Açıklama otomatik olarak oluşturuldu

Figure 3 – Gray Scale Image Figure 4 – Blurred Image

**3.2 Image Segmentation**

**3.2.1 Edge Detection**

**sanat, kara tahta içeren bir resim

Açıklama otomatik olarak oluşturuldu**The Canny edge detection algorithm is used to highlight (Figure 6) the important edges and structures in the blurred image (Figure 5).

**taşıt, araç, kara taşıtı, tekerlek, araba lastiği içeren bir resim

Açıklama otomatik olarak oluşturuldu**

Figure 5 – Blurred Image Figure 6 – Edge Detected Image

**3.3 Morphological Image Processing**

ekran görüntüsü, sanat içeren bir resim

Açıklama otomatik olarak oluşturuldusanat, kara tahta içeren bir resim

Açıklama otomatik olarak oluşturulduMorphological operations were applied for license plate detection, enhancing and highlighting object edges. The detected edges are dilated using a 3x3 kernel to make the edges more pronounced. (Figure 7-8)

Figure 7 – Edge Detected Image Figure 8 – Dilated Image

**3.3 Plate Localization**

A car parked on a street

Description automatically generatedThe candidate plates are detected using contour finding techniques, and then highlighted by drawing bounding rectangles around them on the image (Figure 10). The candidate plates are detected using contour finding techniques. Once detected, these plates are highlighted by drawing bounding rectangles around them on the image.

Figure 10 – Plate Detected Image

**3.4 Text Extraction**

metin, kara taşıtı, taşıt, araç, taşıt plakası içeren bir resim

Açıklama otomatik olarak oluşturulduOptical Character Recognition (OCR) was used for extracting text from candidate plates. Characters which places on the candidate plates are read by OCR with using Python. (Figure 11)

Figure 11 – Read Plates

4.CONCLUSIONS

4.1 Performance Metrics

Below is a summary of the key performance metrics for the license plate detection model based on the provided dataset.

* True Positive (TP): 36
* False Positive (FP): 25
* False Negative (FN): 27

A graph with different colored squares

Description automatically generatedThese metrics are visualized in the following bar chart: (Figure 12)

Figure 12 – Performance Metrics Chart

4.2 F1 Score Calculation

The F1 Score, Precision, and Recall for the model are calculated as follows:

* Precision:

Precision=TP / (TP+FP) = 36 / (36+25) = 36 / 61 ≈ 0.59

* Recall:

Recall =TP / (TP+FN) = 36 / (36+27) = 36 / 63 ≈ 0.57

* F1Score:

F1 Score = 2 × (Precision × Recall) / (Precision+Recall) = 2 × (0.59 × 0.57) / (0.59+0.57) = 2 × (0.3363 / 1.16) ≈ 0.58

5.REFERENCES

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