

License Plate Recognition (LPR) Pipeline Overview

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1 Introduction

License Plate Recognition (LPR) automatically detects, segments, and recognizes characters from vehicle plates. This project implements a robust LPR pipeline in MATLAB for predefined test images.

2 Pipeline Overview

The system follows a 3-stage pipeline:

1. **Detection** – locate the plate in the full image
2. **Segmentation** – isolate individual characters
3. **Recognition** – identify each character using templates

3 License Plate Detection

3.1 Contrast Enhancement

Adaptive histogram equalization (CLAHE) boosts local contrast in images with shadows or glare.

3.2 Edge Detection

A Sobel filter highlights vertical and horizontal character edges.

3.3 Morphological Closing

Fragmented edges are connected using `imclose` to produce candidate regions.

3.4 Candidate Selection

Connected components are filtered using:

- **Aspect Ratio:** 2–6
- **Area Filtering:** remove small/large regions
- **Edge Density Score:**

$$\text{Score} = \frac{\text{edge pixels}}{\text{bounding box area}}$$

Highest score selects the plate.

3.5 Plate Extraction

The selected plate is cropped with padding to avoid clipping characters.

4 Character Segmentation

4.1 Binarization

Otsu's method converts the plate to binary (white characters on black background).

4.2 Post-Processing

- Noise removal (`bwareaopen`)
- Border removal (`imclearborder`)
- Morphological refinement (erosion/dilation)

4.3 Component Filtering

Character blobs are filtered by:

- Height ratio (40–100% of plate height)
- Aspect ratio (reject overly wide/narrow blobs)
- Left-to-right ordering

5 Character Recognition

5.1 Templates and Matching

Characters resized to 42×24 px are compared to alphanumeric templates using normalized cross-correlation (`corr2`). **Note:** Templates by Kumar (2016), BSD License.

5.2 Decision Logic

- Adaptive thresholds: letters (≥ 0.35), numbers/others (≥ 0.30)
- Low-confidence characters marked as ‘?’

6 Mathematical Model

Edge Density Score:

$$\text{Edge Density Score: Score} = \frac{\text{edge pixels}}{\text{bounding box area}}$$

balances plate detection and noise rejection.

7 Results

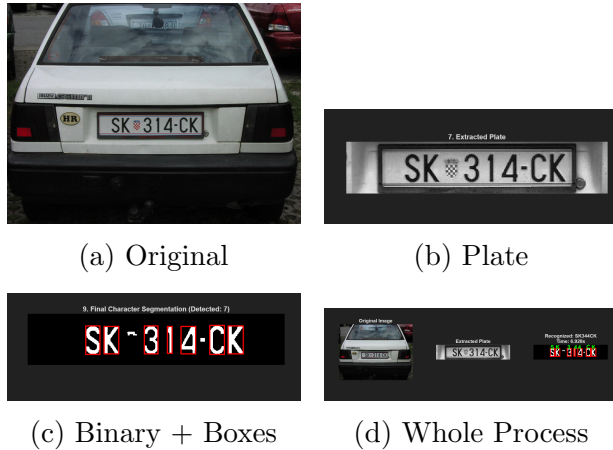


Figure 1: License Plate Recognition Pipeline

8 Discussion and Limitations

Pipeline performs well on controlled images with moderate shadows and slight distortions. Limitations:

- Skewed/rotated plates
- Heavily occluded characters
- Unusual fonts or extreme lighting

9 Conclusion

The LPR pipeline detects, segments, and recognizes license plate characters using MATLAB and template matching, balancing robustness and simplicity.

References

1. MATLAB Documentation: *Image Processing Toolbox* functions, <https://www.mathworks.com/help/images/>
2. Gonzalez, R. C., & Woods, R. E. (2018). *Digital Image Processing* (4th ed.). Pearson.
3. Du, S., Ibrahim, M., Shehata, M., & Badawy, W. (2013). Automatic license plate recognition (ALPR): A state-of-the-art review. *IEEE Trans. Circuits and Syst. Video Technol.*, 23(2), 311–325.
4. Kumar, N. (2016). *License Plate Character Templates* [MATLAB .mat file]. BSD License.