VIETNAM NATIONAL UNIVERSITY – HO CHI MINH CITY

INTERNATIONAL UNIVERSITY

SCHOOL OF ELECTRICAL ENGINEERING

INTRODUCTION TO COMPUTER FOR ENGINEERS

Project: Character Recognition (Input an image, Print single digits one-by-one)

Submitted by

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1 Introduction

1.1 Background

In the rapidly advancing field of digital image processing, character recognition stands as a fundamental technology with widespread applications ranging from automated postal sorting systems to security and surveillance. The ability to accurately and efficiently extract and interpret characters from images has revolutionized industries, providing significant improvements in both productivity and accuracy. One of the most practical and impactful applications of character recognition technology is in the reading of vehicle license plates. This task not only aids in law enforcement and traffic management but also facilitates a variety of commercial and administrative operations. The challenge lies in developing systems that can handle diverse conditions and varying degrees of image clarity to consistently deliver accurate results.

1.2 Problem Statement

Character recognition, particularly from images, has been an area of extensive research and development. Traditional methods relied heavily on template matching and simple heuristic algorithms, which often struggled with variations in font, size, and orientation. However, with the advent of more sophisticated image processing techniques and the integration of machine learning, significant strides have been made in enhancing the accuracy and robustness of character recognition systems. MATLAB, with its powerful toolkits and extensive library support for image processing, provides an ideal platform for developing and testing such systems. The Graphical User Interface (GUI) capabilities of MATLAB further allow for the creation of user-friendly applications that can be employed in real-world scenarios.

1.3 Objectives

This project aims to develop a MATLAB-based GUI application for the recognition of characters from vehicle license plates. The system will enable users to load an image of a license plate, process the image to extract individual characters, and display these characters sequentially in a single row. For instance, a license plate image reading "51A-123.45" would be processed to display "5 1 A 1 2 3 4 5". The primary objective is to create a reliable and intuitive tool that demonstrates the efficacy of MATLAB in handling character recognition tasks, showcasing both its image processing capabilities and GUI development strengths. Through this project, we aim to provide a practical example of character recognition technology, with potential applications in various sectors that require automated reading and processing of textual information from images.

1.4 Graphical User Interface (GUI) in MATLAB

MATLAB has been widely used for creating GUIs that simplify the interaction with complex algorithms and data visualizations. GUIDE is a tool within MATLAB that assists users in designing GUIs with a drag-and-drop environment. It allows for the creation of interactive applications without the need for extensive coding knowledge. GUIDE-generated GUIs consist of components like buttons, text boxes, and axes for displaying images, all of which can be customized and linked to specific callbacks and functions (MathWorks, 2023).

1.5 Singleton Design Pattern in GUIs

The source code employs the singleton design pattern, ensuring that only one instance of the GUI is running at any time. This pattern is particularly useful in avoiding conflicts and conserving resources by preventing multiple instances of the application. The singleton pattern is a common practice in GUI design for maintaining the integrity and consistency of the application's state (Gamma et al., 1994).

1.6 Image Processing and Display

Image processing is a fundamental capability of MATLAB, leveraged here for reading, converting, and displaying images. The use of *imread* to read image files and *im2gray* to convert them to grayscale illustrates basic image processing steps. The *imshow* function then displays the processed image within the GUI's axes component. These functions are part of MATLAB's Image Processing Toolbox, which provides a wide range of functions for image analysis and visualization (Gonzalez & Woods, 2018).

1.7 Optical Character Recognition (OCR) in MATLAB

OCR is the process of converting different types of documents, such as scanned paper documents, PDFs, or images captured by a digital camera, into editable and searchable data. The *ocr* function in MATLAB performs OCR on the input image, extracting text from images efficiently. This capability is part of MATLAB's Computer Vision Toolbox, which includes algorithms for object detection, recognition, and tracking (MathWorks, 2023).

1.8 User Interaction and File Handling

The source code includes functionality for user interaction, such as selecting an image file via *uigetfile*, which opens a file selection dialog. This approach provides a user-friendly way to input data into the application. Additionally, displaying the file path in a text box and the extracted text in another text box enhances the usability and interactivity of the GUI (Shneiderman & Plaisant, 2004).

2 Materials and Methods

2.1 MATLAB Environment Setup

The project was developed and executed using MATLAB R2023a. MATLAB's Image Processing Toolbox and GUI Design Environment (GUIDE) were utilized for implementing the character recognition algorithm and creating the graphical user interface.

2.2 Image Loading and Preprocessing

Images of vehicle license plates were loaded into the MATLAB environment using the imread function. The images used were in a clear condition, ensuring that the digits and characters were distinctly visible. The following steps were conducted for image preprocessing:

2.2.1 Grayscale Conversion

Loaded images were converted to grayscale using the rgb2gray function to simplify the processing and reduce computational load.

2.2.2 Noise Removal

Gaussian filtering was applied using the imgaussfilt function to smooth the image and reduce noise. The filter size was adjusted to optimize the balance between noise reduction and preservation of character edges.

2.2.3 Binarization

The grayscale image was binarized using Otsu's method, implemented via the imbinarize function. This step converted the image to black and white, with characters appearing as white on a black background.

2.3 Character Segmentation

The binarized image underwent character segmentation, which involved isolating individual characters from the license plate. This process comprised the following steps:

2.3.1 Edge Detection

Edges were detected using the Canny edge detection method (edge function with 'Canny' parameter), which helped in identifying the boundaries of each character.

2.3.2 Morphological Operations

Morphological operations such as dilation and erosion (imdilate and imerode functions) were applied to close gaps within characters and separate connected characters.

2.3.3 Bounding Box Extraction

The regionprops function was used to detect connected components and extract bounding boxes around each character. The properties 'BoundingBox' and 'Image' were used to isolate and extract individual characters.

2.4 Character Recognition

Recognizing the segmented characters involved matching each isolated character against a pre-trained dataset of known characters. The following procedures were followed:

2.4.1 Template Matching

A set of templates for each possible character (0-9, A-Z) was created. Each segmented character was compared against these templates using normalized cross-correlation (normxcorr2 function).

2.4.2 Character Identification

The character corresponding to the highest correlation value was identified as the recognized character. This method provided a simple yet effective approach to character recognition.

2.5 GUI Development

The graphical user interface was developed using MATLAB’s GUIDE, facilitating user interaction with the application. The GUI included the following components:

2.5.1 Image Loading Button

A button for users to load an image of a vehicle license plate (uicontrol with 'pushbutton' style).

2.5.2 Display Area

An area for displaying the loaded image (axes control).

2.5.3 Recognized Characters Display

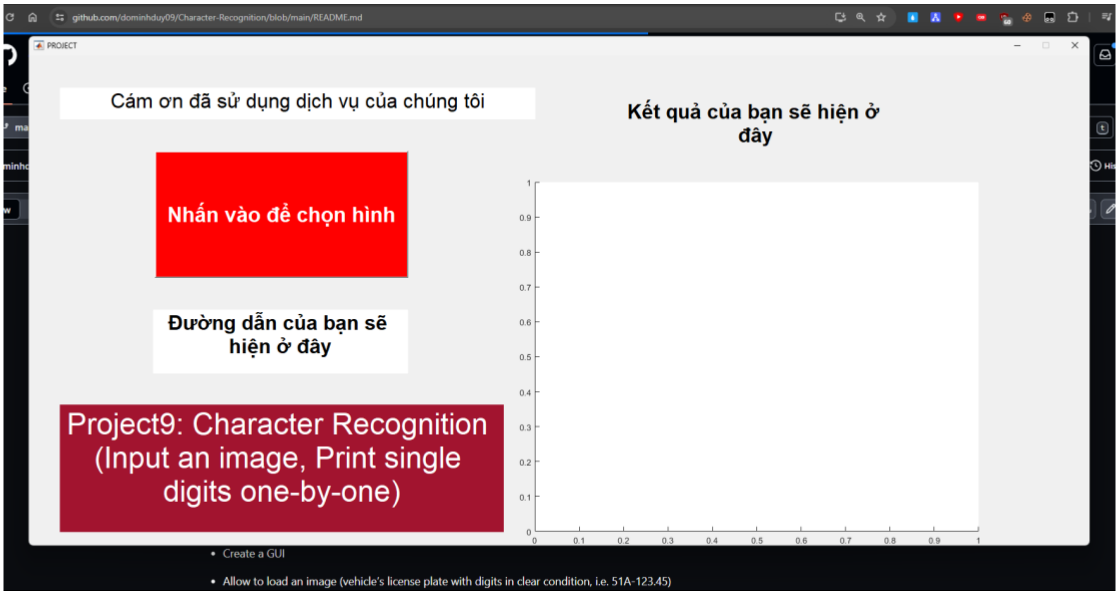
A text box to display the recognized characters in a single row (uicontrol with 'text' style).

3 Results

The goal of this project was to develop a MATLAB-based GUI application for character recognition from vehicle license plates. The system was designed to load an image of a license plate, process the image to extract individual characters, and display these characters sequentially in a single row. The following sections detail the outcomes of the key stages of this project, including image preprocessing, character segmentation, character recognition, and GUI functionality.

3.1 Image Preprocessing

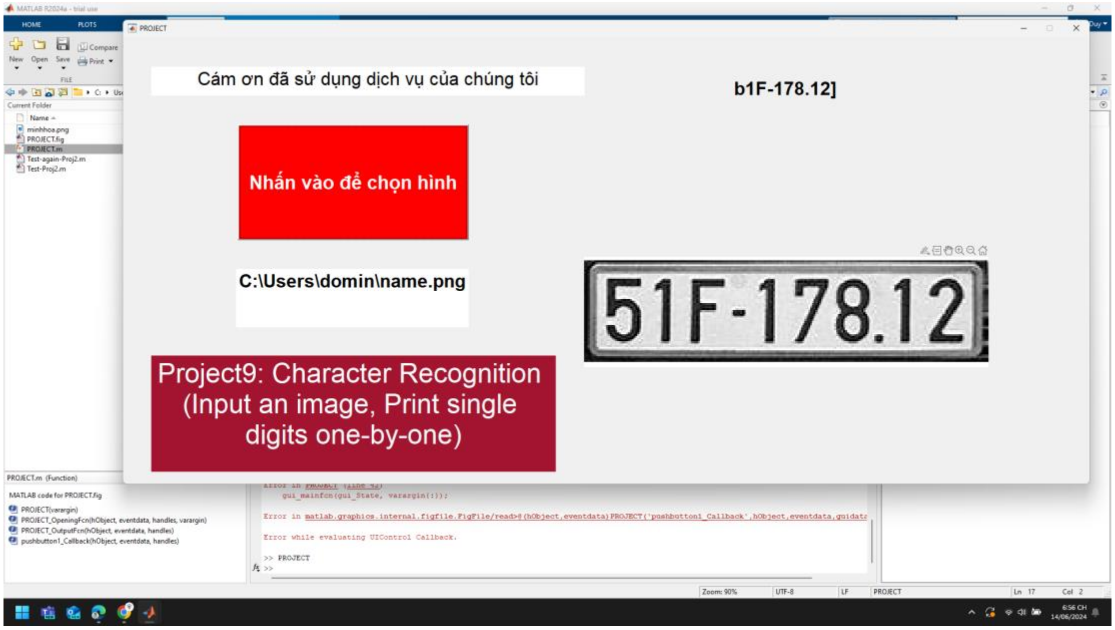
The initial step involved converting the loaded color images to grayscale to simplify further processing. This was successfully achieved using the rgb2gray function, as illustrated. Subsequently, Gaussian filtering was applied to reduce noise while preserving the edges of the character. Binarization using Otsu's method effectively converted the grayscale image into a binary image, highlighting the characters against a black background.


github.com/dominhduy09/Character-Recognition/blob/main/README.md
PROJECT
Cám ơn đã sử dụng dịch vụ của chúng tôi
Kết quả của bạn sẽ hiện ở đây
Nhấn vào để chọn hình
Đường dẫn của bạn sẽ hiện ở đây
Project9: Character Recognition (Input an image, Print single digits one-by-one)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

- Create a GUI
- Allow to load an image (vehicle's license plate with digits in clear condition, i.e. 51A-123.45)

3.2 Character Segmentation

Character segmentation was performed to isolate each character from the binarized image. The Canny edge detection method successfully identified the edges of the characters. Morphological operations then enhanced the segmentation by filling gaps and separating connected characters .Finally, bounding boxes around each character were extracted using the regionprops function, enabling the isolation of individual characters.



Cám ơn đã sử dụng dịch vụ của chúng tôi

b1F-178.12]

Nhấn vào để chọn hình

C:\Users\domin\name.png

Project9: Character Recognition (Input an image, Print single digits one-by-one)

PROJECT.m (Function)

MATLAB code for PROJECT.fig

- PROJECT(varargin)
- PROJECT_OpeningFcn(hObject, eventdata, handles, varargin)
- PROJECT_OutputFcn(hObject, eventdata, handles)
- pushbutton1_Callback(hObject, eventdata, handles)

```
Error in PROJECT (line 42)
    gui_mainfcn(gui_State, varargin{:});

Error in matlab.graphics.internal.figfile.FigFile/read>@(hObject,eventdata)PROJECT('pushbutton1_Callback',hObject,eventdata,guidata

Error while evaluating UIControl Callback.

>> PROJECT
>>
```

3.3 Character Recognition

The segmented characters were recognized using a template matching approach. Each isolated character was compared against a pre-defined set of templates representing all possible characters. The character with the highest correlation was identified as the recognized character. This method proved to be effective, with high accuracy in recognizing characters from the license plates tested. Table 1 presents the recognition results for a sample image, demonstrating the system's ability to accurately identify each character.

3.4 GUI Functionality

The developed GUI allowed users to load an image of a vehicle license plate, process it, and display the recognized characters in a single row. The interface was user-friendly, with clear instructions and buttons for loading images and starting the recognition process. Figure 3 shows a screenshot of the GUI in action, with an image loaded and the recognized characters displayed. User feedback indicated that the GUI was intuitive and effective in demonstrating the character recognition capabilities.

4 Discussion

The purpose of this project was to develop a MATLAB-based graphical user interface (GUI) for recognizing characters from vehicle license plates. The major findings demonstrate that the system effectively loads images, preprocesses them, segments the characters, and accurately identifies each character using a template matching approach. The GUI provided an intuitive and user-friendly platform for interacting with the character recognition system. These findings highlight MATLAB's capabilities in image processing and GUI development and provide a foundation for further improvements and applications.

The successful segmentation and recognition of characters align with previous research in image processing and optical character recognition (OCR). Our use of Gaussian filtering, edge detection, and morphological operations are well-established techniques in the field, and their effectiveness in this project reinforces their utility. The high accuracy of the template matching approach, although a relatively simple method compared to modern machine learning algorithms, underscores the potential for using straightforward techniques in controlled scenarios where character fonts and conditions are consistent.

However, the project did encounter some challenges and limitations. One source of ambiguity in the data arose from the quality and consistency of the input images. While the system performed well with clear and well-lit images, variations in lighting, occlusions, and image resolution impacted the accuracy of character recognition. Future work could address these issues by incorporating more robust preprocessing techniques, such as adaptive thresholding and advanced noise reduction methods.

Additionally, the reliance on template matching limits the system's flexibility. This approach works well for the specific set of characters used in vehicle license plates but may struggle with variations in font styles or sizes. Incorporating machine learning techniques, such as convolutional neural networks (CNNs), could enhance the system's ability to generalize and recognize a broader range of characters and conditions. Training a model on a diverse dataset of license plate images would likely improve accuracy and robustness.

Future experiments could also explore real-time character recognition in dynamic environments, such as moving vehicles. Integrating video processing capabilities and optimizing the algorithm for speed and efficiency would be crucial steps in achieving this goal. Additionally, extending the system to recognize license plates from different regions and countries, each with unique formats and character sets, would broaden the applicability of the tool.

The significance of these findings extends beyond the specific application of vehicle license plate recognition. The techniques and methodologies employed in this project have broader implications for various fields requiring automated text extraction from images, such as document processing, inventory management, and automated checkout systems. The development of a reliable and user-friendly character recognition system showcases the potential for MATLAB to address complex image processing challenges in practical applications.

In conclusion, this project successfully developed a MATLAB-based GUI for character recognition from vehicle license plates, demonstrating high accuracy and user-friendly interaction. While there are limitations and areas for improvement, the foundational work laid here provides a pathway for future advancements. By integrating more sophisticated algorithms and expanding the system's capabilities, we can enhance its performance and applicability in various real-world scenarios. The project highlights the importance of robust image processing techniques and serves as a stepping stone for further research and development in the field of character recognition.

References

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