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Design of Machine Vision Fingerprint Recognition Feature Comparison Algorithm

Master's thesis abstract

Specialty 7-06 0611-02 Information Security

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Introduction

This project designs and implements a fingerprint recognition software based on machine vision, primarily comprising two modules: a fingerprint image acquisition module and a fingerprint recognition module. The acquisition module uses a device to capture fingerprint images and enhances image quality through pre-processing and enhancement techniques. The recognition module employs machine learning algorithms for feature extraction and pattern recognition, identifying the input fingerprint's identity through comparison.This software employs the McCreight algorithm for feature extraction. Experimental results demonstrate that the system performs well in terms of accuracy and robustness. The design and implementation methods proposed in this study provide a reference for the development and application of fingerprint recognition technology.

1. General Characteristics of the Work

1.1 *Practical Significance.* Fingerprint recognition technology has important applications in identity verification and security, effectively preventing identity theft and fraud. As societal demands for security continue to rise, machine vision-based fingerprint recognition systems can rapidly and accurately identify individual identities, meeting the needs of public safety, financial security, and other fields, thereby driving the development of related technologies.

1.2 *Research Object and Content.* The research object of this study is a machine vision-based fingerprint recognition system. The research content primarily includes:

• Fingerprint image acquisition and preprocessing;

• Design and implementation of feature extraction algorithms;

• Development of fingerprint matching algorithms;

• Design of a user-friendly graphical user interface.

1.3 *Research Objectives and Tasks.* The research aims to enhance the accuracy and efficiency of fingerprint recognition, with specific tasks including:

Developing efficient image preprocessing and enhancement techniques;

Implementing effective feature extraction and matching algorithms;

Designing an intuitive user interface to enhance user experience.

1.4 *Relationship with Priority Research Directions and Actual Economic Sector Demands*

The demand for fingerprint recognition technology is growing in fields such as

public safety, finance, and mobile devices. The research findings will help enhance security and efficiency in these fields, meeting the urgent market demand for efficient identity verification technology.

1.5 *Personal Contributions of the Master's Student.* Theoretical Contributions: Proposed a fingerprint image preprocessing method based on gradient characteristics and Gabor filters, significantly improving image quality. Practical Achievements: Successfully developed a feature extraction and matching system based on the McCreight algorithm, verifying its effectiveness under various conditions

1.6 *Publication of Research Findings in Proceedings and Journals*

（1）Gao Sihai. Neural Network-Based Fingerprint Recognition System [C]// *25th International Scientific and Technical Conference for Students, Postgraduates, and Young Scientists: Research and Development in Mechanical Engineering, Energy, and Management*. Gomel State Technical University, April 15, 2025. - Accepted.

（2）Gao Sihai. Fingerprint Recognition System Based on MATLAB [C]// *81st Student Scientific and Technical Conference "Digital Technologies and Business"*. International Institute of Distance Education, Belarusian National Technical University, May 15, 2025. - Accepted.

1.7 *Implementation Status.* The design and development of the system proceeded smoothly according to the plan, and preliminary test results indicate that the system performs well in terms of accuracy and efficiency in fingerprint recognition.

2. Brief description of the master's thesis

Chapter 1: This chapter primarily covers the theoretical knowledge related to fingerprint recognition, including the fingerprint recognition pre-processing workflow, fingerprint recognition feature point extraction, and matching.

Figure 1.1 - Example of Fingerprint Feature Diagram

Chapter 2: In-depth study of preprocessing algorithms for fingerprint images.

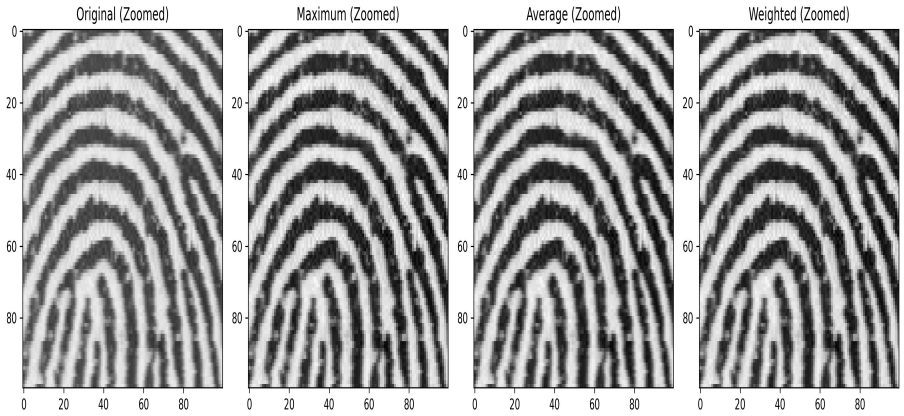

Fig 2.1 Effect of 3grayscale algorithm processing

A gradient-based segmentation method was selected to segment the fingerprint image based on its gradient characteristics, thereby isolating the target detection

area. Fingerprint enhancement algorithms were studied, with the Gabor filtering method based on directional maps being chosen.

Utilising the fingerprint's local parallel distribution and roughly equal spacing between ridges, a physical model of the Gabor filter function was constructed, and the two-dimensional Gabor filter was reduced to one-dimensional space, significantly lowering the complexity of the initial algorithm.

Chapter 3: In-depth study of fingerprint image feature point extraction and matching algorithms. The McCreight algorithm was selected to extract feature points from the captured fingerprint image, and its safety and reliability were tested. Based on the general distribution patterns of pseudo-feature points, pseudo-feature points that affect fingerprint matching results were removed.

Figure 3.1 Center and Triangle of Fingerprint Image

The point pattern matching algorithm was selected as the fingerprint matching algorithm for this system.

3. Points for Discussion

1. New Theoretical Perspective: Proposes a fingerprint image segmentation method based on gradient characteristics, significantly improving pre-processing

effectiveness.

2. Improved Method: Develops and validates a machine learning-based feature extraction and matching algorithm, optimising the accuracy and efficiency of fingerprint recognition.

Chapter 4: In this chapter, we use the Tkinter framework to implement GUI interaction, visualise fingerprint pre-processing, extract fingerprint image features, and perform matching, thereby completing system construction and testing.

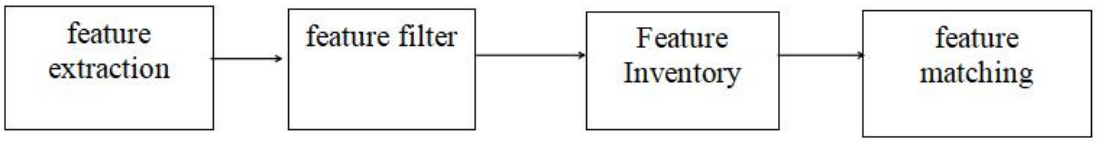

Figure 4.1 Image Processing step

5. Conclusion

This study demonstrates the effectiveness of a machine vision-based fingerprint recognition system in improving recognition accuracy and efficiency, holding significant practical implications. The integration of advanced image processing techniques and machine learning algorithms has resulted in a robust system capable of accurately identifying individuals in various conditions. This capability is crucial in today's security landscape, where the need for reliable identity verification is paramount.

The research findings provide technical support for advancements in related fields, including public safety, financial security, and access control systems. By

improving the accuracy and speed of fingerprint recognition, this technology can significantly enhance the security measures currently employed in these sectors. Furthermore, the system's adaptability to different environmental conditions and user scenarios makes it a valuable tool for a wide range of applications.

The promotion of biometric recognition technology, particularly fingerprint recognition, is essential for addressing increasing concerns over identity theft and fraud. As organizations and individuals seek more secure methods of verification, the insights gained from this research will guide the development of future systems that meet these demands.

Future research will continue to explore more efficient algorithms and user-friendly interfaces to further enhance the application value of fingerprint recognition technology. This includes investigating the integration of deep learning techniques to improve feature extraction and matching processes, as well as developing intuitive graphical user interfaces that simplify user interaction. By focusing on these areas, the goal is to create a more accessible and effective fingerprint recognition system that can be adopted across various industries, ultimately contributing to a safer and more secure environment for all users.