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Fingergan

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Abstract*: Latent fingerprints are often of low quality, characterized by unclear ridge structures, uneven contrast, or overlapping patterns. Despite these challenges, they are crucial for criminal identification. Enhancing these latent fingerprints is essential for accurately identifying suspects. Our proposed method improves latent fingerprint enhancement by leveraging prior knowledge of fingerprint structures, represented through a dictionary of reference orientation patches derived from high-quality fingerprints. This approach involves estimating ridge orientation and ridge frequency for the latent fingerprint. We introduce a novel method that frames latent fingerprint enhancement as a constrained fingerprint generation problem within a Generative Adversarial Network (GAN) framework, which we call FingerGAN. This network ensures that the enhanced latent fingerprint is nearly indistinguishable from the true fingerprint in terms of the fingerprint skeleton map weighted by minutia locations and the orientation field regularized by the FOMFE model. Since minutiae are crucial for fingerprint recognition and can be directly extracted from the fingerprint skeleton map, our holistic framework directly optimizes minutia information to significantly enhance latent fingerprint identification*

Keywords: Latent Fingerprint Enhancement, Generative Adversarial Network, Fingerprint Skeleton Map

I. INTRODUCTION

In crime scene investigations and forensic analysis, recording latent fingerprints from uneven and noisy surfaces is a challenging task, with conventional algorithms often failing. Our project aims to effectively minimize the difficulties associated with separating ridges and segmenting latent images, reduce search time and computational complexity, and accurately identify patterns from latent or partial fingerprints while optimizing system retrieval performance.Latent fingerprint identification is a critical forensic activity for clarifying criminal acts, but its computational cost can hinder rapid decision-making, especially with large databases. To accelerate the process of generating fingerprint candidates for comparison, fingerprint indexing algorithms are developed to reduce the search space while minimizing any increase in error rates. In this study, we propose an indexing algorithm for latent fingerprints based on minutia cylinder codes (MCC), a minutiae descriptor known for its fixed structure and efficiency. Recent studies have shown that MCC has a lower identification error rate at the local level compared to other descriptors. Our algorithm begins by constructing indices using the k-means++ clustering algorithm, which groups similar minutia cylinder codes from a set of databases. K-means++ is chosen for its ability to select optimal centroids, providing better outcomes than other clustering methods. The background databases populate the buckets associated with each index. For a given latent fingerprint, the algorithm extracts the minutia cylinder codes corresponding to the clusters' indices with the smallest distance to each descriptor of the latent fingerprint. Finally, the algorithm integrates votes from the retrieved fingerprints to select the candidate impressions.

II. LITERATURE SURVEY

Orientation Field Estimation for Latent Fingerprint Enhancement: Jianjiang Feng, Jie Zhou, and Anil K. Jain introduce a robust method for estimating fingerprint orientation fields, especially for poor-quality latents. They draw an analogy between fingerprint orientation fields and sentences in natural language, where sentences are made up of words and words are made up of letters. Similarly, a fingerprint orientation field consists of orientation patches (analogous to words) and orientation elements (analogous to letters). The method involves first building a dictionary of reference

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orientation patches from high-quality fingerprints. Since initial estimates from poor-quality fingerprints are often noisy, the method refines these estimates by leveraging the dictionary and additional contextual information to correct errors."

Latent Fingerprint Matching Using DBHT: In their paper, Alessandra A. Paulino, Jianjiang Feng, and Anil K. Jain present a new fingerprint matching algorithm specifically designed for latent fingerprints. The proposed method utilizes a robust alignment technique called Descriptor-Based Hough Transform (DBHT) to align fingerprints and assess their similarity by considering both minutiae and orientation field data. Matching latents with rolled prints poses challenges due to the typically small number of minutiae and significant skin distortion present in latents. To address these issues, the authors introduce DBHT, which combines the generalized Hough transform with a local minutiae descriptor known as Minutia Cylinder Code (MCC). The underlying principle is that correctly matched minutiae pairs will consistently support similar alignment parameters, while mismatched pairs will distribute their votes randomly. Consequently, the alignment parameters that receive the most support are deemed the most accurate.

Segmentation and Enhancement of Latent Fingerprints: A Coarse To Fine Ridge Structure Dictionary:Kai Cao, Eryun Liu, and Anil K. Jain developed an automatic latent segmentation and enhancement algorithm based on image decomposition and a coarse-to-fine ridge structure dictionary. Their approach aims to enable "lights-out" latent identification systems through a dictionary-based method. The algorithm features an offline stage for dictionary learning and an online stage for segmentation and enhancement. The quality of a ridge patch used for segmentation is determined by the structural similarity between the patch and its reconstructed form. This proposed method surpasses current state-of-the-art segmentation and enhancement techniques and enhances the performance of advanced commercial latent matchers.

III. WORKING OF PROPOSED SYSTEM

The proposed paradigm enhances latent fingerprint matching by incorporating feedback during the matching stage to refine the features extracted from latent images. It introduces an indexing structure based on the clustering of minutia cylinder codes, which ensures that these descriptors remain close in proximity while optimizing the retrieval of impressions that match the query fingerprint. This indexing structure maintains homogeneity without compromising the proximity of descriptors, even when they are distributed heterogeneously. The algorithm specifically focuses on minutia cylinder codes to reduce the error rate in latent fingerprint indexing. This approach is particularly valuable because the features extracted from latent fingerprints are often unreliable due to their poor quality. When latent images are matched solely based on the initially extracted features, without any prior information (a bottom-up approach), there is a high risk of errors. The paradigm addresses this issue by incorporating additional top-down feedback, allowing the system to use the hypothesized exemplar mate to refine the initially extracted features. This feedback loop significantly improves the accuracy of matching latent fingerprints, making it a robust solution for overcoming the challenges posed by the low quality of latent fingerprint features.

IV. TECHNOLOGY USED

Java

Java is a concurrent, class-based, object-oriented programming language designed to have minimal implementation dependencies, allowing developers to "write once, run anywhere" (WORA). Java applications are typically compiled into bytecode, which can be executed on any Java Virtual Machine (JVM), regardless of the underlying computer architecture. As of 2014, Java remains one of the most popular programming languages, particularly for client-server web applications, with around 9 million developers using it. Java was initially developed by James Gosling at Sun Microsystems, which later merged with Oracle Corporation, and was first released in 1995 as part of Sun's Java platform. The language's syntax is heavily influenced by C and C++, though it offers fewer low-level features than these languages. Sun Microsystems developed the original and reference implementations of Java compilers, virtual machines, and class libraries, with the first release occurring in 1995 after development began in 1991. In May 2007, Sun relicensed most of its Java technologies under the GNU General Public License, in accordance with the Java Community Process specifications. Alternative implementations, such as the GNU Compiler for Java, GNU Classpath, and IcedTea-Web, have also been developed by other groups.

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NetBeans

NetBeans is an Integrated Development Environment (IDE) primarily designed for developing applications in Java, but it also supports other languages, such as PHP, C/C++, and HTML5. Additionally, it serves as an application platform framework for Java desktop applications and more. The NetBeans IDE is written in Java and can run on various platforms, including Windows, OS X, Linux, Solaris, and any other system that supports a compatible JVM.The NetBeans Platform allows developers to build applications from modular software components known as modules. The NetBeans Team actively supports the product and welcomes suggestions from the broader community, with each release being preceded by a period of community testing and feedback.NetBeans IDE 6.5, released in November 2008, expanded existing Java EE features, including support for Java Persistence, EJB 3, and JAX-WS. The NetBeans Enterprise Pack also supported the development of Java EE 5 enterprise applications, offering SOA visual design tools, XML schema tools, web services orchestration for BPEL, and UML modeling. The NetBeans IDE Bundle for C/C++ included support for C/C++ and FORTRAN development. NetBeans IDE 6.8 was the first IDE to provide complete support for Java EE 6 and the GlassFish Enterprise Server v3. NetBeans IDE 6.9, released in June 2010, added support for OSGi, Spring Framework 3.0, Java EE dependency injection (JSR-299), Zend Framework for PHP, and improved code navigation features, such as "Is Overridden/Implemented" annotations, along with enhanced formatting, hints, and refactoring across multiple languages. NetBeans IDE 7.0 was released in April 2011, followed by NetBeans IDE 7.0.1 on August 1, 2011, which included full support for the official release of the Java SE 7 platform.

MYSQL

It forms the backbone of many modern web applications, including popular platforms such as WordPress and Joomla. Designed to handle large volumes of data efficiently, MySQL is known for its speed and scalability. Its SQL (Structured Query Language) interface allows users to perform various database operations, including data retrieval, insertion, updating, and deletion, with ease.MySQL's architecture is based on a client-server model where the MySQL server manages databases and handles requests from client applications. It supports a range of data types and indexing options, which contribute to its flexibility and efficiency in managing complex datasets. The system also includes robust security features to protect data integrity and access control.The open-source nature of MySQL means it benefits from a large community of developers who contribute to its continuous improvement and provide extensive support. Its versatility and strong performance make MySQL a popular choice for both small-scale projects and large enterprise applications.

XAMPP

XAMPP also supports creating and managing databases in MySQL and SQLite, among others. Once XAMPP is installed, you can treat localhost as if it were a remote host by connecting with an FTP client. Using a program like FileZilla offers many advantages when installing a content management system (CMS) such as Joomla or WordPress. It is also possible to connect to localhost via FTP using an HTML editor. default MySQL user is "root", and there is no default MySQL password. XAMPP is a versatile and widely used open-source software package that plays a crucial role in web development. Its name is an acronym for X (cross-platform), A (Apache), M (MySQL), P (PHP), and P (Perl), which reflects the key components it provides. This essay explores the features, advantages, and applications of XAMPP, highlighting its importance in the field of web development.At its core, XAMPP includes several essential components needed to run a web server and manage databases. The Apache HTTP Server is one of the most critical elements, as it is responsible for handling HTTP requests and serving web pages to users. Apache's inclusion in XAMPP allows developers to create a local web server environment on their own machines. Alongside Apache, XAMPP integrates MySQL, a robust relational database management system that is fundamental for storing and managing data in web applications. Another vital component included in XAMPP is PHP (Hypertext Preprocessor), a server-side scripting language designed for web development. PHP enables the creation of dynamic web pages and applications, making it an essential tool for developers. Additionally, XAMPP includes Perl, a high-level programming language known for its text-processing capabilities, which can be useful for specific scripting tasks and web applications.To facilitate database management, XAMPP comes with phpMyAdmin, a web-based tool that provides an intuitive interface for managing MySQL databases. This tool simplifies administrative tasks such as creating, modifying, and deleting databases and tables, making database management more accessible to developers.One of the primary advantages of using XAMPP is its ease of installation. By bundling all the necessary components into a single package, XAMPP eliminates the need for separate installations of Apache, MySQL, PHP, and Perl. This streamlined installation process is particularly beneficial for beginners who might find the individual setup of these components challenging.

V. DATABASE DESIGN

Database design is a fundamental aspect of software development, concentrating on the creation of interrelated files for real-time processing. Effective database systems facilitate problem-solving and support simultaneous access by multiple users. The primary goal of database design is to ensure that data access is straightforward, cost-effective, and adaptable. This involves defining the structure of business data for client/server systems and normalizing it to ensure data integrity and efficiency. In the Legal Liaison System, MongoDB is used for data storage. A crucial element of designing a database with MongoDB is determining the necessary collections, which involves both designing the physical database and establishing access paths. MongoDB, a prominent NoSQL database, employs a document-oriented model where data is represented as JSON-like documents rather than traditional tables. This model provides enhanced flexibility and scalability, making it ideal for modern applications that require rapid development and deployment. MongoDB organizes data into collections, similar to tables in relational databases but with greater flexibility. Each collection contains documents-JSON-like objects with key-value pairs, which can include arrays and nested objects. Documents within a collection can vary in structure, accommodating complex and dynamic data models. Additionally, MongoDB supports indexing, which improves query performance by enabling efficient retrieval of documents based on specific criteria.

Table_Exemplar

Field Name	Data Type	Size	Constraint	Description
Exemplar_id	int	11	Primary key	Exemplar identification number
Original_path	varchar	200	Not null	Original path address
Template_path	varchar	200	Not null	Template path address

Table_Matchlist

Field Name	Data Type	Size	Constraint	Description
Match_id	int	11	Primary key	Match identification number
User_id	varchar	100	Foreign key	User identification number
Exemplar_ids	varchar	200	Foreign key	Exemplar identification number
Process_time	double	10	Not null	Processing time

Table_Users

Field Name	Data Type	Size	Constraint	Description
User_id	int	11	Primary key	User identification number
User_name	varchar	100	Not null	User name
password	varchar	100	Not null	Password of user
role	varchar	100	Not null	Role of user

VI. IMPLEMENTATION

The implementation plan for a new system begins with the creation of a detailed strategy outlining how the system will be introduced and operationalized. This plan covers essential aspects such as the necessary equipment, resources, and testing procedures. It provides a comprehensive overview of what the task aims to achieve, the resources required, the key personnel responsible, and the criteria for successfully completing the task.Major tasks within this implementation plan include several critical actions. First, there is a need for overall planning and coordination to ensure that all aspects

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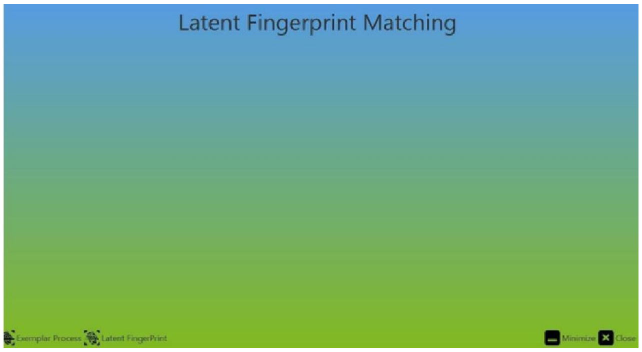
of the implementation are addressed. This includes providing appropriate training for personnel to ensure they are well-prepared to use the new system effectively. It is also crucial to verify that all relevant manuals are applicable and that technical requirements are met. Additionally, it is important to ensure that all prerequisites are fulfilled before the implementation date, including assembling the implementation team, acquiring any special software or hardware, performing necessary data conversions, and preparing site facilities. This stage is where theoretical plans are translated into practical application. The system's programs are loaded onto the user's computer, and user training commences. This training encompasses various aspects such as how to execute the package, enter data, process data, and generate reports.

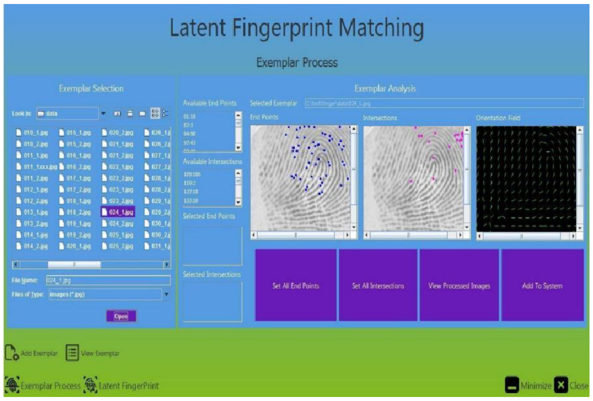
Two primary strategies are employed during the system's operation to ensure a smooth transition. The first is the Parallel Run strategy, where both the new computerized system and the existing manual system are operated simultaneously for a defined period. This approach has several benefits. It allows for a direct comparison between the results generated by the manual and computerized systems, demonstrating the effectiveness of the new system. Additionally, if any issues arise with the computerized system, the manual system remains functional, ensuring that organizational operations continue uninterrupted. This dual operation helps mitigate risks and ensures a successful transition to the new system.

VII. RESULT

Mainform



Open an exemplar finger



Look In: data

File Name: 024_1.jpg

Files of Type: images (*.jpg)

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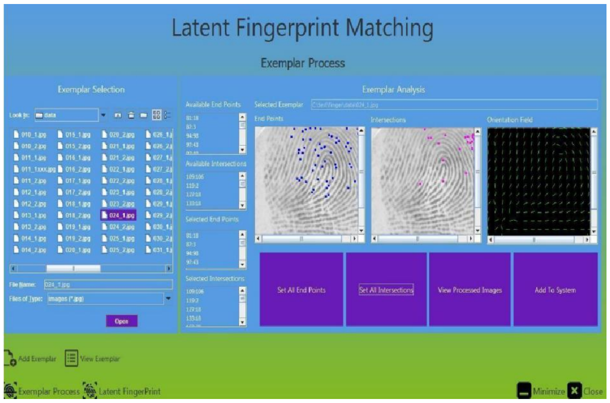
Set features



Selected Exemplar: C:\des\finger\data\024_1.jpg

File Name: 024_1.jpg

Files of Type: images (*.jpg)

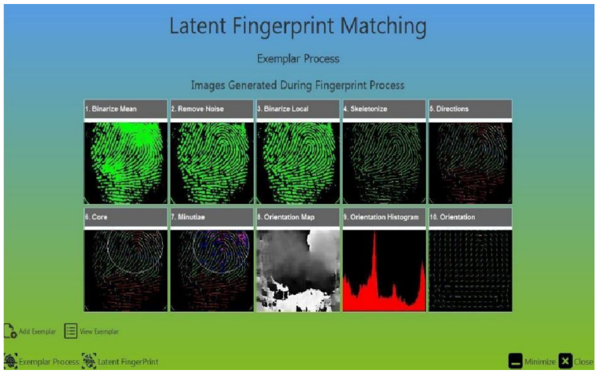
Available End Points: 81:18, 87:3, 94:98, 97:43

Available Intersections: 109:106, 119:2, 127:18, 133:18

Selected End Points: 81:18, 87:3, 94:98, 97:43

Selected Intersections: 109:106, 119:2, 127:18, 133:18

View processed image



VIII. CONCLUSION

Despite the significant advancements in automatic fingerprint recognition technology over the past forty years, fingerprint matching remains a challenging problem. Experts agree that current state-of-the-art fingerprint recognition systems still fall short compared to the capabilities of human fingerprint examiners, especially when dealing with low-quality latent fingerprints. Consequently, manual annotation of various features, such as minutiae, in latent prints remains a standard practice in forensic work. There is increasing interest in enhancing automatic latent fingerprint encoding and matching capabilities, with law enforcement agencies supporting the development of "lights-out" latent identification techniques. Government-sponsored evaluations by NIST have been conducted to assess automatic latent feature extraction and matching algorithms. To markedly improve automatic systems, it is crucial to identify which specific capabilities of fingerprint examiners are missing in these systems. It is believed that the extensive experience of fingerprint examiners, gained through examining numerous fingerprints, provides them with an advantage in accurately identifying features in poor-quality latent prints. However, incorporating such prior knowledge into fingerprint recognition algorithms has been attempted only a few times in the literature. Inspired by spelling correction methods used in natural language processing, we have developed a robust algorithm for estimating the orientation field in latent fingerprint enhancement. Our approach involves a local estimation method to create an initial orientation field for the latent fingerprint. We then match each patch in this initial field with candidate patches from an orientation patch dictionary, which is trained on genuine fingerprint orientation fields. The final orientation field is determined by selecting the combination of candidates that minimizes an energy function. Experimental results on the challenging NIST SD27 latent fingerprint database demonstrated that our algorithm outperformed two well-known orientation field estimation techniques. With a minor adjustment, our algorithm can also estimate the orientation field of overlapped latent fingerprints, achieving performance comparable to leading specialized algorithms.

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