Palm Print Recognition

Introduction

Palm print recognition inherently implements many of the same matching characteristics that have allowed fingerprint recognition to be one of the most well-known and best publicized biometrics. Both palm and finger biometrics are represented by the information presented in a friction ridge impression. This information combines ridge flow, ridge characteristics, and ridge structure of the raised portion of the epidermis. The data represented by these friction ridge impressions allows a determination that corresponding areas of friction ridge impressions either originated from the same source or could not have been made by the same source. Because fingerprints and palms have both uniqueness and permanence, they have been used for over a century as a trusted form of identification. However, palm recognition has been slower in becoming automated due to some restraints in computing capabilities and live-scan technologies. This paper provides a brief overview of the historical progress of and future implications for palm print biometric recognition.

History

In many instances throughout history, examination of handprints was the only method of distinguishing one illiterate person from another since they could not write their own names. Accordingly, the hand impressions of those who could not record a name but could press an inked hand onto the back of a contract became an acceptable form of identification. In 1858, Sir William Herschel, working for the Civil Service of India, recorded a handprint on the back of a contract for each worker to distinguish employees from others who might claim to be employees when payday arrived. This was the first recorded systematic capture of hand and finger images that were uniformly taken for identification purposes.[1]

The first known AFIS system built to support palm prints is believed to have been built by a Hungarian company. In late 1994, latent experts from the United States benchmarked the palm system and invited the Hungarian company to the 1995 International Association for Identification (IAI) conference. The palm and fingerprint identification technology embedded in the palm system was subsequently bought by a US company in 1997.

In 2004, Connecticut, Rhode Island and California established statewide palm print databases that allowed law enforcement agencies in each state to submit unidentified latent palm prints to be searched against each other's database of known offenders.[2,3]

Australia currently houses the largest repository of palm prints in the world. The new Australian National Automated Fingerprint Identification System (NAFIS) includes 4.8 million palm prints. The new NAFIS complies with the ANSI/NIST international standard for fingerprint data exchange, making it easy for Australian police services to provide fingerprint records to overseas police forces such as Interpol or the FBI, when necessary.[4]

Over the past several years, most commercial companies that provide fingerprint capabilities have added the capability for storing and searching palm print records. While several state and local agencies within the US have implemented palm systems, a centralized national palm system has yet to be developed. Currently, the Federal Bureau of Investigation (FBI) Criminal Justice Information Services (CJIS) Division houses the largest collection of criminal history information in the world. This information primarily utilizes fingerprints as the biometric allowing identification services to federal, state, and local users through the Integrated Automated Fingerprint Identification System (IAFIS). The Federal Government has allowed maturation time for the standards relating to palm data and live-scan capture equipment prior to adding this capability to the current services offered by the CJIS Division. The FBI Laboratory Division has evaluated several different commercial palm AFIS systems to gain a better understanding of the capabilities of various vendors. Additionally, state and local law enforcement have deployed systems to compare latent palm prints against their own palm print databases. It is a goal to leverage those experiences and apply them towards the development of a National Palm Print Search System.

In April 2002, a Staff Paper on palm print technology and IAFIS palm print capabilities was submitted to the Identification Services (IS) Subcommittee, CJIS Advisory Policy Board (APB). The Joint Working Group then moved "for strong endorsement of the planning, costing, and development of an integrated latent print capability for palms at the CJIS Division of the FBI. This should proceed as an effort along the same parallel lines that IAFIS was developed and integrate this into the CJIS technical capabilities…."[5]

As a result of this endorsement and other changing business needs for law enforcement, the FBI announced the Next Generation IAFIS (NGI) initiative. A major component of the NGI initiative is the development of the requirements for and deployment of an integrated National Palm Print Service. Law enforcement agencies indicate that at least 30 percent of the prints lifted from crime scenes — from knife hilts, gun grips, steering wheels, and window panes — are of palms, not fingers.[6] For this reason, capturing and scanning latent palm prints is becoming an area of increasing interest among the law enforcement community. The National Palm Print Service is being developed on the basis of improving law enforcement's ability to exchange a more complete set of biometric information, making additional identifications, quickly aiding in solving crimes that formerly may have not been possible, and improving the overall accuracy of identification through the IAFIS criminal history records.

Approach

Concept

Palm identification, just like fingerprint identification, is based on the aggregate of information presented in a friction ridge impression. This information includes the flow of the friction ridges (Level 1 Detail), the presence or absence of features along the individual friction ridge paths and their sequences (Level 2 Detail), and the intricate detail of a single ridge (Level 3 detail). To understand this recognition concept, one must first understand the physiology of the ridges and valleys of a fingerprint or palm. When recorded, a fingerprint or palm print appears as a series of dark lines and represents the high, peaking portion of the friction ridged skin while the valley between these ridges appears as a white space and is the low, shallow portion of the friction ridged skin. This is shown in Figure 1.

Figure 1: Fingerprint Ridges (Dark Lines) vs. Fingerprint Valleys (White Lines).

Palm recognition technology exploits some of these palm features. Friction ridges do not always flow continuously throughout a pattern and often result in specific characteristics such as ending ridges or dividing ridges and dots. A palm recognition system is designed to interpret the flow of the overall ridges to assign a classification and then extract the minutiae detail — a subset of the total amount of information available, yet enough information to effectively search a large repository of palm prints. Minutiae are limited to the location, direction, and orientation of the ridge endings and bifurcations (splits) along a ridge path. The images in Figure 2 present a pictorial representation of the regions of the palm, two types of minutiae, and examples of other detailed characteristics used during the automatic classification and minutiae extraction processes.

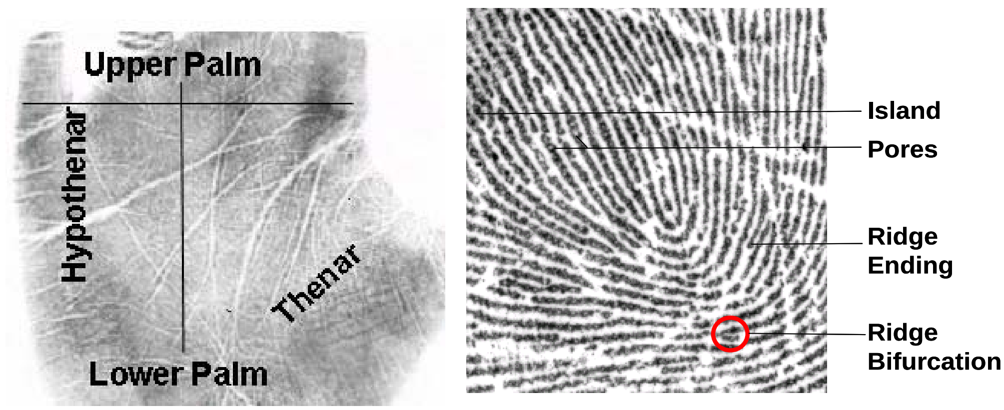

Figure 2: Palm Print and Close-up Showing Two Types of Minutiae and Other Characteristics.

Hardware

A variety of sensor types — capacitive, optical, ultrasound, and thermal — can be used for collecting the digital image of a palm surface; however, traditional live-scan methodologies have been slow to adapt to the larger capture areas required for digitizing palm prints. Challenges for sensors attempting to attain high-resolution palm images are still being dealt with today. One of the most common approaches, which employs the capacitive sensor, determines each pixel value based on the capacitance measured, made possible because an area of air (valley) has significantly less capacitance than an area of palm (ridge). Other palm sensors capture images by employing high frequency ultrasound or optical devices that use prisms to detect the change

in light reflectance related to the palm. Thermal scanners require a swipe of a palm across a surface to measure the difference in temperature over time to create a digital image. Capacitive, optical, and ultrasound sensors require only placement of a palm.

Software

Some palm recognition systems scan the entire palm, while others require the palms to be segmented into smaller areas to optimize performance. Maximizing reliability within either a fingerprint or palm print system can be greatly improved by searching smaller data sets. While fingerprint systems often partition repositories based upon finger number or pattern classification, palm systems partition their repositories based upon the location of a friction ridge area. Latent examiners are very skilled in recognizing the portion of the hand from which a piece of evidence or latent lift has been acquired. Searching only this region of a palm repository rather than the entire database maximizes the reliability of a latent palm search.

Like fingerprints, the three main categories of palm matching techniques are minutiae-based matching, correlation-based matching, and ridge-based matching. Minutiae-based matching, the most widely used technique, relies on the minutiae points described above, specifically the location, direction, and orientation of each point. Correlation-based matching involves simply lining up the palm images and subtracting them to determine if the ridges in the two palm images correspond. Ridge-based matching uses ridge pattern landmark features such as sweat pores, spatial attributes, and geometric characteristics of the ridges, and/or local texture analysis, all of which are alternates to minutiae characteristic extraction. This method is a faster method of matching and overcomes some of the difficulties associated with extracting minutiae from poor quality images.

The advantages and disadvantages of each approach vary based on the algorithm used and the sensor implemented. Minutiae-based matching typically attains higher recognition accuracy, although it performs poorly with low quality images and does not take advantage of textural or visual features of the palm. Processing using minutiae-based techniques may also be time consuming because of the time associated with minutiae extraction. Correlation-based matching is often quicker to process but is less tolerant to elastic, rotational, and translational variances and noise within the image. Some ridge-based matching characteristics are unstable or require a high-resolution sensor to

obtain quality images. The distinctiveness of the ridge-based characteristics is significantly lower than the minutiae characteristics.

United States Government Evaluations

Unlike several other biometrics, a large-scale Government-sponsored evaluation has not been performed for palm recognition. The amount of data currently available for test purposes has hindered the ability for not only the Federal Government but also the vendors in efficiently testing and benchmarking commercial palm systems. The FBI Laboratory is currently encoding its hard-copy palm records into three of the most popular commercial palm recognition systems. This activity, along with other parallel activities needed for establishing a National Palm Print Service, will address these limitations and potentially provide benchmark data for US Government evaluations of palm systems.

Standards Overview

Just as with fingerprints, standards development is an essential element in palm recognition because of the vast variety of algorithms and sensors available on the market. Interoperability is a crucial aspect of product implementation, meaning that images obtained by one device must be capable of being interpreted by a computer using another device. Major standards efforts for palm prints currently underway are the revision to the ANSI NIST ITL-2000 Type-15 record. Many, if not all, commercial palm AFIS systems comply with the ANSI NIST ITL-2000 Type-15 record for storing palm print data. Several recommendations to enhance the record type are currently being “vetted” through workshops facilitated by the National Institute for Standards and Technology. Specifically, enhancements to allow the proper encoding and storage of Major Case Prints, essentially any and all friction ridge data located on the hand, are being endorsed to support the National Palm Print Service initiative of NGI.

Summary

Even though total error rates are decreasing when comparing live scan enrollment data with live-scan verification data, improvements in matches between live-scan and latent print data are still needed. Data indicates that fully integrated palm print and fingerprint multi-biometric systems are widely used for identification and verification of criminal subjects as well as in security access applications. But there are still significant challenges in balancing accuracy with system cost. Image matching accuracy may be improved by building and using larger databases and by employing more processing power, but then purchase and maintenance costs will most certainly rise as the systems become larger and more sophisticated. Future challenges require balancing the need for more processing power with more improvements in algorithm technology to produce systems that are affordable to all levels of law enforcement.

Document References

[4] Joe Bonino, Advisory Policy Board Joint Working Group Meeting. 24 April 2002

[1] Peter Komarinski, "Automated Fingerprint Identification Systems": (any publisher info?) 29.

[2] "NEC Solutions America Customer Honored By California's Center for Digital Government," NEC Press Release, December 16, 2004 <http://www.necus.com/companies/20/NECSAMCustomerAwardByCalifCenterDigitalGovt.pdf#search='first%20automated%20palm%20system>.

[3] "Cogent Systems has just received a contract to provide an Advanced Integrated Cogent Automated Palm and Fingerprint Identification System (CAPFIS) for the States of Connecticut and Rhode Island," Cogent Systems Press Release <http://cogt.client.shareholder.com/ReleaseDetail.cfm?ReleaseID=145765>.

[4] CrimTrak, "Fingerprints," Commonwealth of Australia, 2005.

[5] Joe Bonino, Advisory Policy Board Joint Working Group Meeting. 24 April 2002

[6] Shaila K. Dewan, "Elementary, Watson: Scan a Palm, Find a Clue," The New York Times, 21 November 2003.

About the National Science and Technology Council

The National Science and Technology Council (NSTC) was established by Executive Order on November 23, 1993. This Cabinet-level Council is the principal means within the executive branch to coordinate science and technology policy across the diverse entities that make up the Federal research and development enterprise. Chaired by the President, the membership of the NSTC is made up of the Vice President, the Director of the Office of Science and Technology Policy, Cabinet Secretaries and Agency Heads with significant science and technology responsibilities, and other White House officials.

A primary objective of the NSTC is the establishment of clear national goals for Federal science and technology investments in a broad array of areas spanning virtually all the mission areas of the executive branch. The Council prepares research and development strategies that are coordinated across Federal agencies to form investment packages aimed at accomplishing multiple national goals. The work of the NSTC is organized under four primary committees; Science, Technology, Environment and Natural Resources and Homeland and National Security. Each of these committees oversees a number of sub-committees and interagency working groups focused on different aspects of science and technology and working to coordinate the various agencies across the federal government. Additional information is available at http://ostp.gov/nstc.

About the Subcommittee on Biometrics

Biometrics is a technology that is rapidly becoming a useful security, cost-savings and convenience tool for the Federal Government. Although the Federal Government is using the technology for many applications now, further development and assessment is required to improve the technology's utility. To address these issues, the Office of Science & Technology Policy (OSTP) created the NSTC Subcommittee on Biometrics, reporting to the National Science & Technology Council (NSTC) Committees on Technology and Homeland & National Security. Additional information is available at http://www.biometricscatalog.org/NSTCSubcommittee.

Subcommittee on Biometrics

Co-chair: Duane Blackburn (OSTP)

Co-chair: Chris Miles (DOJ)

Co-chair: Brad Wing (DHS)

Executive Secretary: Kim Shepard (FBI Contractor)

<u>Department Leads</u>

Mr. Jon Atkins (DOS)

Dr. Sankar Basu (NSF)

Mr. Duane Blackburn (EOP)

Ms. Zaida Candelario (Treasury)

Dr. Joseph Guzman (DoD)

Dr. Martin Herman (DOC)

Ms. Usha Karne (SSA)

Dr. Michael King (IC)

Mr. Chris Miles (DOJ)

Mr. David Temoshok (GSA)

Mr. Brad Wing (DHS)

Mr. Jim Zok (DOT)

<u>Communications ICP Team</u>

Champion: Duane Blackburn (OSTP)

Members & Support Staff:

Mr. Richard Bailey (NSA Contractor)

Mr. Jeffrey Dunn (NSA)

Ms. Valerie Lively (DHS S&T)

Mr. John Mayer-Splain (DHS US-VISIT Contractor)

Ms. Susan Sexton (FAA)

Ms. Kim Shepard (FBI Contractor)

Mr. Scott Swann (FBI)

Ms. Kimberly Weissman (DHS US-VISIT)

Mr. Brad Wing (DHS US-VISIT)

Mr. David Young (FAA)

Mr. Jim Zok (DOT)

Special Acknowledgements

The Communications ICP Team wishes to thank the following external contributors for their assistance in developing this document:

- B. Scott Swann, FBI/CJIS, for performing background research and writing the first draft
- Ed German, Stephen Meagher, Ron Smith, and the Standards ICP Team for reviewing the document and providing numerous helpful comments

Document Source

This document, and others developed by the NSTC Subcommittee on Biometrics, can be found at http://www.biometricscatalog.org/NSTCSubcommittee.