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Analyzing Palm Print Shapes with Pressure and Distortion

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ANALYZING PALM PRINT SHAPES WITH PRESSURE AND DISTORTION

by

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Abstract

While much research exists on latent fingerprints, there is a lack of research on palm prints. This study aims to discover how the variable of pressure affects the distortion of latent palm prints recovered from a crime scene. This study used various development techniques to extract prints from aluminum Coca-Cola cans, white copy paper, and household steak knives. The collected prints were scanned into the AFIX Tracker system and an auto-extract number, based on the number of minutiae points, was generated automatically from the system. These auto-extract numbers were then compared to a baseline, which consisted of an average of 400 perfectly rolled unknown palm prints. There was a significantly lower number of minutiae points from the partial prints that were lifted than the average of the 400 that were perfectly rolled. The analysis of the collected data revealed that, for the most part, when a medium amount of pressure is applied to an object, it yields a higher auto-extract number than when a low or high amount of pressure is applied.

Key Words: latent palm prints, pressure, distortion, minutiae, auto-extract number, AFIX Tracker.

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List of Abbreviations

AFIS	Automated Fingerprint Identification System
EGA	Estimated Gestational Age
CA	Cyanoacrylate
FBI	Federal Bureau of Investigation

Chapter I: Introduction

Although much research has focused on latent fingerprinting, my investigation of the literature revealed that little of value has been published regarding latent palm print examination. In order to identify a latent print, one must first be familiar with the three regions of the palm from which such prints originate: thenar, hypothenar, and interdigital (Kolb, 1979). When a palm print impression is transferred to an object, it leaves a shape, which can easily be distorted depending on the amount of pressure originally applied. Within these shapes, ridges and other unique markings (i.e., minutiae) create a palm print identifiably-unique when comparing it to suspect prints found at a crime scene. By examining such latent print minutiae, it is possible to determine if the print was created as a result of light, medium, or heavy amounts of pressure. The goal of this study is to aid investigations involving latent palm prints and provide a teaching tool for fingerprint/palm print examiner certification courses.

Pressure affects the general shape of the palm when it comes in contact with a surface. As pressure increases, the size of the shape expands, and the friction skin ridges become darker in color and therefore more pronounced (Barros, Faria, & Kuckelhaus, 2011). Different minutiae points also become more visible or they can clump together. It is impossible to pinpoint the exact amount of pressure cast to a latent palm print since it is unique to the individual. However, by applying different levels of pressure to various actions, it is possible to obtain a general range of light pressure to high pressure and attribute general palm print shapes based on that scale.

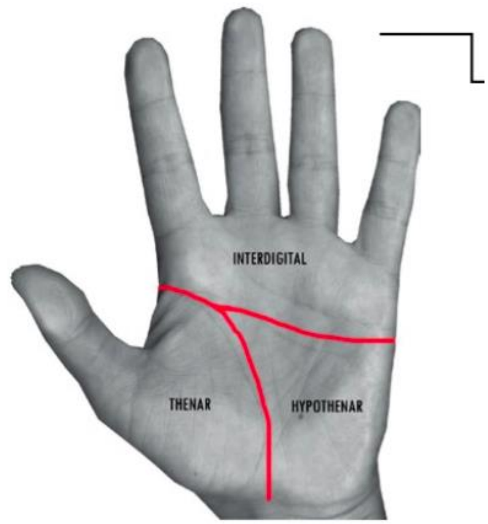
Latent print examiners can use software to scan latent prints and analyze them. For this study, a system called the AFIX Tracker System will be used to scan in the latent palm prints and will locate minutiae points and generate an auto-extract number. Minutiae points are the irregular endings or bifurcations manifested in ridges of the skin (Holder, Robinson, & Laub, 2011). These markings play a significant role in the unique character of palm prints. An auto-extract number is the number of those minutiae points located automatically by an Automated Fingerprint Identification Software (AFIS), specifically the AFIX Tracker software for this study. Certified latent print examiners often locate minutiae points by visual analysis. However, for the sake of consistency, an auto-extract number of each print was generated by the AFIX system. About four hundred latent palm prints collected by an agency were used in order to create a baseline for an average number of minutiae points. This baseline was utilized to compare results of the minutiae points of the prints that were created by the researcher.

Mr. Kelly Counts, a certified latent print examiner from the company Ron Smith and Associates, was interviewed to get a professional perspective on this topic and how the success of this study could be beneficial to other certified latent print examiners. The information that was discovered can be utilized as teaching topics in forensics classes or even in latent print examination certification classes. This research may also assist investigators where latent palm prints were discovered to prove or disprove that a specific event occurred.

Chapter II: Literature Review

“A palm print is an impression of the friction ridges of all or any part of the palmar surface of the hand. A friction ridge is a raised portion of the epidermis on the palmar or plantar skin, consisting of one or more connected ridge units” (Holder et al., 2011 (425-426)). The palm of a human hand is divided into three regions: the hypothenar, thenar, and interdigital area. Four creases separate these areas: the radial longitudinal crease, the metacarpophalangeal crease, the distal transverse crease, and the carpal crease. The hypothenar area is the largest of the three areas and is the region located on the ulnar (pinky) side of the palm. The distal transverse crease is located above the hypothenar area. The radial longitudinal crease is located on the radial side of the hypotenar area. The carpal crease is located below the hypothenar area. The thenar region is on the radial (thumb) side of the palm and is separated on the ulnar side by the radial longitudinal crease, which surrounds the entire thenar area. It is separated on the bottom by the carpal crease. Finally, the interdigital area is located under the fingers with the metacarpophalangeal crease above and the distal transverse crease below it (Kolb, 1979).

Figure 1: A figure showing the different areas of the palm separated by the different creases from the Fingerprint Sourcebook, chapter 5



Around six weeks after fertilization, the human hands develop volar pads, which are elevations of connective tissue called mesenchyme tissue under the epidermis layer of skin on the palmar side of hands (Seidenberg-Kajabova, Pospisilova, & Vranakova, 2010). Latent palm print shapes found at a crime scene come from these volar pads located in the three different areas of the palm. They first appear in the interdigital region of the palm around the sixth week of estimated gestational age (EGA). Then, they form on the palmar side of the fingers at approximately 7-8 weeks EGA. Around 8 weeks EGA, the creases in the palms begin to form along with the resulting volar pads in those regions, and shortly thereafter in the thenar and hypothenar regions (Holder et al., 2011).

As the hand grows rapidly, it seems as if the volar pads are shrinking; however, they are actually just growing at a slower rate. This process is called regression (Seidenberg-Kajabova et al., 2010). During this process, ridges form horizontally, while the growth of the hand is longitudinal. This causes stress, which can influence volar pad height causing the shape of the palm patterns and the size of each of the three areas of the palm to vary among individuals. Regression can begin around 11 weeks EGA and by 16 weeks EGA the volar pads are completely formed and merged with the contour of the hands (Holder et al., 2011).

On the volar pads of the hands, there are patterns. These patterns are also found in fingerprints. There are three types: loops, whorls, and arches. Within those types of patterns, there are subsections of each. A loop is a type of pattern that enters from one side and makes a circle, or loop, around and exits back to that same side. There are two types of loops: a radial loop (flowing in the direction of the thumb) and an ulnar loop (flowing in the direction of the pinky finger). A whorl can be described exactly as it sounds; the ridges flow in a circle in one direction like a spiral. There are four types of whorls: a plain loop (the spiral pattern consisting of concentric circles that take up the entire pattern area), a central pocket whorl (the spiral pattern is concentrated in the center and is smaller than the plain whorl), a double loop whorl (two loop patterns going in opposite directions to make a circular flow), and an accidental whorl (no specific structure, it is almost a mixture of all the whorls mentioned). Finally, an arch is a pattern that enters from one side and makes a “hill” shape then exits to the opposite side. There are two types of arches: a plain arch (consisting of the described pattern with a smooth, even amount of ridge flow) and a tented arch (consisting of the described pattern but with a thrusting ridge flow up the middle of the pattern) (Saferstein, 2011).

In addition to patterns within the palm print, there are also points that a latent print examiner will analyze to make a positive identification. These points are called minutiae. Minutiae is defined in the Fingerprint Sourcebook as “events along a ridge path, including bifurcations, ending ridges, and dots” (Holder et al., 2011 (426)). Furthermore, an ending ridge is defined as “a single friction ridge that terminates within the friction ridge structure,” and a bifurcation is “the point at which one friction ridge divides into two friction ridges” (Holder et al., 2011 (423-424). These points are what make a print unique to an individual. When examining latent prints, forensic experts take note of what kind of minutiae points are present, the location of the minutiae, and the orientation of the points. If two prints have the same type of minutiae points in the same locations, it is said to be a match.

Volar pads react to pressure in different ways due to the way the skin stretches and compresses. For instance, skin is less flexible in the direction of ridge flow than it is perpendicular to it (Hicklin & Kalka, 2014). Therefore, minutiae points and other key features of the print respond to pressure differently than other aspects of the print such as the regular parallel ridges, and the different pattern types as well.

Due to regression and pressure, palm prints can easily be distorted. This has made the lifting, collection, and identification of palm prints difficult for latent print examiners. A latent print is a print left on a surface that is invisible to the naked eye. They are produced when the compounds of sweat and sebaceous glands are transferred which forms a deposit known as the latent print (Barros et al., 2011). Usually, when latent palm prints are found on a surface at a crime scene, only a partial print is discovered. The clarity, definition of ridges, and shape of a particular partial print are a result of a certain amount of pressure applied by an individual on a surface. Knowing how much pressure was applied to achieve the shape of a print would be an excellent tool for investigators.

When either fingerprints or palm prints are deposited, there are variations of both pressure and skin elasticity which cause distortions of the ridges within the print. Distortion can be caused by the substrate, matrix, development medium, and both the pressure and direction of deposition (Hicklin, 2014). The downward deposition pressure can change the width of the ridges and alter the shape of the minutiae. Another type of pressure is called "shearing" (Hicklin, 2014 (1)), which is lateral pressure that causes elongation of the print. This creates line differences and alters the location of the minutiae points. A third type of pressure is known as torque, which is twisting pressure. This causes non-linear distortion, which can cause significant changes in the patterns within the print, making it difficult to be analyzed and identified (Hicklin, 2014).

A perfectly rolled print is considered to be in its best condition and therefore has more defined minutiae points than a partial print. This is because the amount of pressure being applied has been perfectly balanced in order to produce the best results. There are different ways to lift a print found at a scene and experts are trained to know the most effective ways to lift a print from a particular surface at a scene. Three common ways are cyanoacrylate (super glue) fuming, the Ninhydrin technique, and lifting using magnetic black powder, which will all be used in this research.

Cyanoacrylate (CA) or super glue fuming is the common method for developing prints lifted from aluminum cans, like the Coca-Cola can used in this project. Chemically, it follows a process of creating many ester monomers, which eventually form polymers and the fingerprint residue reacts with these monomers. When the prints on the substance are fully developed they appear as a white three-dimensional matrix and can be seen by the naked eye (Holder et al., 2011).

Ninhydrin is a compound discovered in 1910. It turns a purple color when it is reacted with primary amine groups and is used to test for the presence of amino acids. Fingerprints are often created from the depositing of sweat from the fingers. The sweat from the fingers contains aqueous substances and amino acids. Ninhydrin detects the amino acids and will turn them purple. This purple color is the product that is formed called diketohydrindylidene-diketohydrindamine, known as Ruhemann's Purple (Holder et al., 2011).

Powders are the oldest method of fingerprint development techniques. Magnetic powder, which will be used to develop prints from the knives and the Coke cans allows for application with a magnetic rod brush that has no bristles. "This type of powder can be light, dark, or fluorescent and utilizes the ferromagnetic properties of iron powder mixed with pigment powders" (Holder et al., 2011 (167)). The magnetized rod is dipped in the powder and collects the iron particle mixture, which forms its own "brush" and develops the prints when wiped over them. The next step is to lift the developed prints from the surface and transfer them onto a material that can be scanned into a computer system. The most common and simplest method of doing this is by using transparent tape. The tape is placed over the print and removed slowly to extract the print and transferred to paper or other material.

An Automated Fingerprint Identification System (AFIS) can be used to automatically analyze latent prints and give information regarding the number of minutiae. The AFIX Tracker system is an AFIS system that offers biometric identification. This capability resulted from the request of the Federal Bureau of Investigation (FBI) to have an automated fingerprint identification system with several algorithms to mimic the work of forensic experts and aid in the identification/matching of latent prints. For this research project, all prints will utilize a feature of the system called SmartExtract, which provides a number derived from the automated extraction of latent prints (AFIX Technologies, 2018). This number is called an auto extract number. This study will attempt to determine if there is any correlation between the number of minutiae points and amount of pressure applied when creating the print. The number of minutiae points called from the SmartExtract feature is a reflection of how distorted the print is due to the amount of pressure applied.

Chapter III: Methods

A. Creating a Baseline

In order to conduct the research, a baseline was created to know how many average minutiae points are present in a perfectly rolled palm print. This baseline was created by scanning 400 rolled latent prints into the AFIX Tracker System. These prints were previously rolled with ink and donated by Ron Smith and Associates, a forensic services provider. The minutiae points were found through the SmartExtract feature in AFIX. Minutiae points can be detected manually, however in an effort to maintain uniformity and generate consistent results, the automatic feature of AFIX was the only source of detection utilized.

B. Assessing Pressure

The researcher created latent prints of her own while applying different relative amounts of pressure: light, medium, and heavy. These amounts of pressure were created solely subjectively to the researcher. A perfectly rolled print using ink was also created by the researcher to serve as a comparison to the minutiae of when the print is in perfect condition compared to when it is partially lifted. This is because the perfectly rolled print of the researcher may have a significantly different number of minutiae points than that of the baseline from the average of the 400 latent prints. Three different materials were used to apply these different pressures: standard copy paper, a Coca-Cola can, and a household steak knife. These materials were chosen for the project because they are common objects often used and collected as evidence at a crime scene.

C. Lifting Techniques

Each object required a different lifting technique due to what the objects are made of. Three techniques were used to lift the prints: cyanoacrylate (super glue) fuming, a ninhydrin technique, and visualizing with magnetic black powder and lifting with tape. The cyanoacrylate was used to lift prints from the Coke cans, ninhydrin was used for the paper, and magnetic black powder was used for the knives. These methods were chosen because they are considered to be the lifting methods that yield the best results for those types of materials according to both the fingerprint sourcebook manual (Holder et. al, 2011) and certified latent print examiner Kelly Counts.

D. Analysis and Interpretation

After scanning the four hundred unknown latent prints into AFIX and performing three trials of each method for each object, data analysis was performed. Once again, the SmartExtract feature was used to identify the number of minutiae that are found in each print created by the researcher. Once the auto-extract number was found for each print, the numbers were recorded and the researcher looked to see if there were any trends regarding how the numbers of minutiae points present increased or decreased based on the amount of pressure applied to each object.

Chapter IV: Results

Four hundred perfectly rolled latent palm prints were scanned into AFIX to get an auto-extract number of the minutiae points found in the print. All of these numbers were put into an Excel spreadsheet and the average number of minutiae points was found. Next, a perfectly rolled palm print of the researcher was created using ink and was scanned into AFIX to get the number of minutiae points (see Figure 2). This was done due to the possibility that the researcher's number of minutiae points is higher or lower than the average of the 400 prints that were rolled the same way. These two sets of numbers are shown in Table 1 below and served as the baseline for this project.

Figure 2: Perfectly Rolled Ink Print of the Researcher

Table 1: Baseline Minutiae

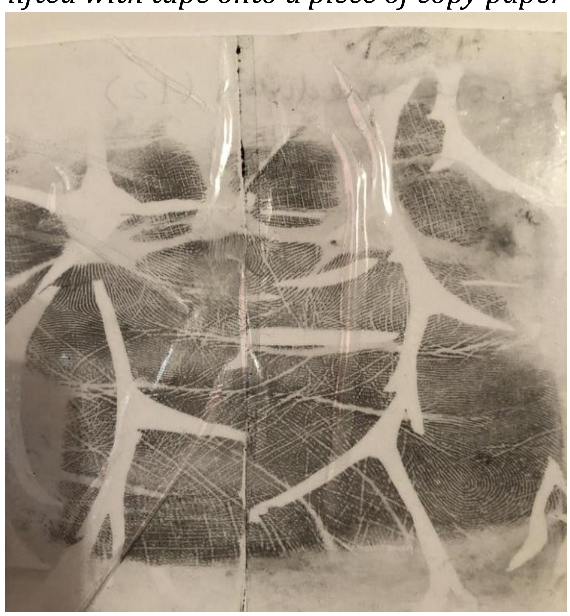
Average number of minutiae from 400 prints	Number of minutiae points of perfectly rolled print from the researcher
339	186

The researcher created three partial palm prints on the following objects: a piece of copy paper, a Coke can, and a kitchen knife. The first partial print was created using a light amount of pressure; the second with a medium amount of pressure; and the third with a high amount of pressure. Three trials of each were performed on each object. These prints were then developed. The ninhydrin technique was used to develop the prints from the copy paper (see Figure 3), the cyanoacrylate method was used to develop the prints from the Coke can (see Figure 4), and magnetic powder was used to develop the prints from the knife (see Figure 5).

Figure 3: Ninhydrin technique used to develop a print created on white copy paper

Figure 4: Cyanoacrylate technique used to develop a print on a Coke can

Figure 5: Magnetic powder technique used to develop a print from a steak knife and lifted with tape onto a piece of copy paper



These developed prints were then lifted and transferred to paper to be scanned into AFIX. In the same manner used to create data in the baseline, the SmartExtract feature was once again used to generate the number of minutiae points found in these partial prints. The data obtained can be found in Table 2.

Table 2: Experimental Minutiae

Pressure	Trial Number	Paper	Coke Cans	Knives
Light	1,2,3	1,5,2	5,4,1	1,2,6
Medium	1,2,3	26, 15, 8	12,1,8	1,5,1
Heavy	1,2,3	5,1,3	8,2,5	1,1,1

The partial prints yielded much lower auto-extract numbers than the baseline. This is due to the fact that they are partial prints and not perfectly rolled but also because the different amounts of pressure have distorted the prints. It is known that this happened because the different amounts of pressure caused different numbers of minutiae points. It is also noted from Table 1 that to even begin with, the auto-extract number found from the perfectly rolled print of the researcher is much smaller than the average auto-extract number found from the baseline of the 400 points. With only 3 exceptions, the most minutiae points are found when there is a medium amount of pressure applied to the object. This statement is only untrue for trial 2 with medium pressure on the coke can, trial 1 with medium pressure on the knives, and trial 3 of medium pressure with the knives. This margin of discrepancy accounts for approximately eleven percent of the data. The reason numbers were not assigned for this project is because it is impossible to assign a specific number to the amount of pressure being applied as it would be subjective to each individual. These results simply show general trends for what a print would look like and how many minutiae points would be found if someone were doing different tasks that require different amounts of force such as picking up a piece of paper or picking up a television.

Chapter V: Conclusion

This study illustrates how different amounts of pressure impact the distortion and number of minutiae points that can be identified in palm prints. No prior research has been conducted in this area so there are not any other results for comparison. However, there was a consistent result found throughout the study in that the most minutiae points were found when using medium amounts of pressure for each object. Even though the number of minutiae points found for the partial prints was low, this trend was still present. This means that, even though the prints were distorted from their regular perfectly rolled appearance, there was still some type of consistency with the results in regards to the quality of the print based on the fact that the number of minutiae found was greatest when a medium amount of pressure, unique to the researcher, was applied.

Although conclusive results were reached, there were still some limitations present for this study. The greatest limitation within this project is that only one person's palm prints were used to create the partial prints. This means the researcher's version of light, medium, and heavy pressure is unique to her and could be different for someone else. Also, only three trials of each method were performed and only three different objects were used for the trials. It would have improved this study if more participants would have been used, more trials would have been performed, and more objects would have been used. Due to time constraints, these did not occur.

Because this research was the first of its kind, future research could be conducted to further support the theory of medium pressure producing the best results. If validated, this data could be used as a teaching tool for forensic courses and training purposes. It could also aid in investigations when determining what happened or did not happen at a crime scene. Another suggestion would be to perform this study by allowing certified latent print examiners to locate the minutiae points manually and see if the results were similar to those in this study.

Literature Cited

AFIX Technologies. *About us.* Kansas: AFIX Technologies, 2018. Web.

Barros, R.M, Faria, B.E., & Kuckelhaus, S.A. (2011). Morphometry of latent prints as a function of time. *Science and Justice*. 53(4). 402-408.

Counts, K. Telephone Interview. 21 September 2017.

Hicklin, R.A., Kalka, N.D. (2014). On relative distortion in fingerprint comparison. *Forensic Science International*. *244.* 78-84.

Holder, E. H., Robinson L.O., & Laub, J.H. *The fingerprint sourcebook*. Washington, DC: U.S. Department of Justice, Office of Justice Programs, National Institute of Justice.

Kolb, P.A., *H.I.T. (Hypothenar, Interdigital Area, Thenar)- A manual for the classification, filing, and retrieval of palmprints*. Springfield: Charles C. Thomas.

Saferstein, Richard. (2010). *Criminalistics: An Introduction to Forensic Science.* Upper Saddle River, New Jersey: Prentice Hall.

Seidenberg-Kajabova, H., Pospisilova, V., & Vranakova, V. (2010). An original histological method for studying the volar skin of the fetal hands and feet. *Biomed Pap Med Fac Univ Palacky Olomouc Czech Republic. 154(3).* 211-218.