Review Article

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Using Poroscopy as a Method of Personal Identification: A Review

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Abstract

Fingerprinting has played a massive role in establishing the identity of suspects in the legal arena. To help facilitate an accurate matching of two fingerprints, there are three levels of details that experts investigate. On the third level of those details, we see examination of pores and ridge characteristics. Poroscopy is the study of the size, shape, and arrangement of pores. Sweat pores have great individual differences and they are persistent throughout life, which makes them invaluable for individualization in crime scenes. In this review, we can see the evolution of poroscopy and how it can be implemented as a tool for personal identification as proved by various authors in their respective works .

Keywords: Fingerprinting; Poroscopy; Edgeoscopy; Ridges.

INTRODUCTION

One of the most prominent features found in the fingertips, palms and soles of feet is the folds formed by the outer layer of the skin which is known as the friction ridge skin. When the friction ridge skin comes in contact with another surface, it tends to leave an impression. This impression is known as fingerprint. Fingerprints are unique to each individual and can act as a distinguishing feature for individualization. No two individuals or fingertips can have the same fingerprint pattern. Though identical twins share the same DNA, they can never have the same fingerprint patterns. This is what makes the friction ridge skin one of the most unique features of the human body. The prints that are left behind are due to the body oils, sweat and dirt present on the surface of the skin. In 2015, a long-term study concluded that fingerprints of a person remain stable over their lifetime. In case of injuries, once the wound heals, the skin starts to grow back and so does the outer layer along with the friction ridge skin. The fingerprints remain intact without any altercation.

Dactyloscopy is the field of science which uses techniques for fingerprint identification. The techniques used in this field are incorporated in crime investigation to establish he identity of an unknown person.[9] Fingerprints are the most commonly encountered evidence in the crime

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arena. The unique nature of fingerprints makes them an important means to establish the identity of a suspect. Fingerprints can also be used to identify an unknown victim or link a person to a crime scene or with the crime itself. Police officers compare fingerprints found at the crime scene which is the 'unknown' fingerprint with a known print. Known prints are stored in a database known as Automated Fingerprint Identification System (AFIS) which contains millions of fingerprints from around the world. AFIS is a biometric identification system that collects, analyses and stores data pertaining to fingerprints. Primarily used by law enforcement agencies, AFIS assists in criminal investigation where the identity of the suspect is under question or when the police need to link a potential suspect to the scene of crime.[10] This database rapidly compares the unknown print with the library of the known fingerprints and provides a possible list of matches. But the comparison does not stop there. Experts later do further analysis to bring out a proper conclusion.

Fingerprints are unique, permanent, immutable, classifiable and a valuable form of evidence. Fingerprints are mainly classified by the patterns they form, namely: arch, loop, and whorl. The loop is the most commonly seen fingerprint. What makes a fingerprint unique are characteristics called 'minutiae' which is what is examined while comparing an unknown fingerprint with a known fingerprint. While fingerprint patterns are visible to the naked eye, minutiae characteristics are not perceptible to the naked eye. Minutiae encompasses specific plot points on a fingerprint that can be used as a marker to the fingerprint. Some examples of minutiae characteristics are ridge formation, ridge ending, bifurcation, enclosure, delta etc.

METHODOLOGY

For this study various studies conducted by scientists on the use and importance of poroscopy was taken into consideration. The initiation of poroscopy started with the study of epidermal ridges. Therefore, from the first scientifically documented case by Dr. Nehemiah Grew till the twenty first century the literature available was reviewed.

A total of sixteen literature articles available were taken into consideration and reviewed to the use of the scope of this study. All the articles were carefully investigated and the points relating to the use of poroscopy as a tool for personal identification was sought for.

ANALYSIS

British physician ***Dr. Nehemiah Grew*** (1684) studied the similarities between plant leaves and fingerprint striations. Dr. Nehemiah Grew was the first European scientist that did extensive research on the concept and the importance of fingerprints in distinguishing different human beings. He documented his findings on friction ridge skin.[1] He presented a paper "Philosophical Transactions" to the Royal Society explaining his observations of patterns on palms and fingers, sweat pores, epidermal ridges and their arrangements. He also published accurate drawings of finger ridge patterns.

Marcello Malpighi (1686) an Italian physician, was greatly inspired by Dr. Grew's findings. He studied the layers of the skin and mentioned the patterns of friction ridge skin. Malpighi gathered his observations and formally published about the function, form, and structure of friction ridge skin in an article entitled "Concerning the External Tactile Organs'. He had also noted in his treaties about spirals and loops in fingerprints but stated no explanation as to how they can be used for individualization.[15] The Malpighian layer a layer of the skin was later named after Marcello Malpighi, in honour of his contribution to the field of dactyloscopy.[1]

The first system of classification of fingerprints was introduced by ***Johan-Evangelist Purkinje***, a Czech physiologist. He was one of the pioneers who had majorly contributed to the fingerprinting community. Purkinje classified fingerprints into nine standard types based on their papillary lines and their geometric arrangement.[1] Purkinje (1823) published his most famous medical thesis, *"Commentatio de Examine Physiologico Organi Visus et Systematis Cutanei"* (A Commentary on the Physiological Examination of the Organs of Vision and the Cutaneous System). In this thesis, he described nine classifiable fingerprint patterns (Ashbaugh, 1999, p 40): (1) transverse curve, (2) central longitudinal stria, (3) oblique stripe, (4) oblique loop, (5) almond whorl, (6) spiral whorl, (7) ellipse, (8) circle, and (9) double whorl (Ashbaugh, 1999).[18] At that time, this was the only detailed description of fingerprint patterns to appear in the scientific record. He classified and named the fingerprint patterns; however, he did not associate those patterns with personal identification or how they can be utilized. (Faulds, 1905, p 33). Even though his classification system is not used today, Purkinje was the first to recognize and name these patterns and classify them into a system.[1] Although Dr. Purkinje went no further than naming the patterns, his contribution is significant because his nine pattern types were the basis to the Henry classification system.

Henry Faulds became interested in friction ridge skin after seeing ridge detail on pottery found on a Japanese beach (Faulds, 1880). Faulds conducted independent research by collecting prints of both monkeys and people. In a letter dated February 16, 1880, to the famed naturalist Charles Darwin, Faulds wrote that friction ridges were unique and classifiable, and alluded to their permanence (Lambourne, 1984, pp 34–35). In October 1880, Faulds submitted an article for publication to the journal Nature in order to inform other researchers of his findings (Faulds, 1880, p 605). In that article, Faulds proposed using friction ridge individualization at crime scenes and gave two practical examples In one example, a greasy print on a drinking glass revealed who had been drinking some distilled spirits.[19] In the other, sooty fingermarks on a white wall exonerated an accused individual (Faulds, 1880, p 605). Faulds was the first person to publish in a journal the value of friction ridge skin for individualization, especially its use as evidence. Faulds had also devised a method of using ink to record the fingerprint impressions of all 10 fingers on cards and soon had collected thousands of fingerprint cards.[1] His collection became invaluable when the police accused a member of his medical staff of attempted burglary, committed by scaling the hospital wall and entering through a window. He compared a latent print that had been found on the wall with the accused staff member's fingerprints in his collection and determined that the latent print had not been left by his staff member. Faulds developed a syllabic system for classifying fingerprints (Faulds, 1912, pp 83–100).[20] In his system, each hand was represented by five syllables, one syllable for each finger, with each syllable separated by a hyphen. Syllables were constructed from an established list of 21 consonants and 6 vowels representing set fingerprint pattern characteristics. This classification system has the potential to create nearly 17 trillion classifications.

Dr. Arthur Kollmann (1883) was the first researcher to address the formation of friction ridges on the fetus and the random physical stresses and tensions which may have played a part in their growth. He grouped the volar pads of humans and grouped the volar pads of many primates. Kollmann studied the embryological development of friction ridge skin, proposing that ridges are formed by lateral pressure between nascent ridges and that ridges are discernible in the fourth month of fetal life and are fully formed in the sixth (Galton, 1892, p 58) Kollmann is credited with establishing and naming ten volar pads in humans, and he was the first one to study epidermic markings in different races. His publication, The *Tactile Apparatus of the Hand of the Human Races and Apes in Its Development and Structure,* added to the research being conducted on friction ridge skin.

Francis Galton (1892) was the author of the first books on fingerprints (***Fingerprints*, *1892***) in which he established that fingerprints were unique and persistent. He further stated that fingerprints had no relation to the character of the individual. Because Galton was the first to define and name specific print minutiae, the minutiae became known as Galton details. His study of minutiae in prints provided the foundation for meaningful comparison of different prints, and he was able to construct a statistical proof of the uniqueness of minutiae in individual prints.[1] He classified fingerprint patterns into three main classes: arches, loops and whorls on the idea of degree of curvature.

Salil Kumar Chatterjee (1962) published a book called '***Finger, Palm, and Sole Prints***' in 1953 and an article called ***'Edgeoscopy'***, in 1962, which he became well known for. In his article, he described how one could use specific ridge shapes and it's characteristics to aid in fingerprint individualization and hence, establish the identity of the person. He stated that the edges of ridges are also unique and are persistent like ridges and pores. He defined ridge shapes including straight, convex, peak, table, pocket, concave, and angle.[1] He contributed to the field of dactyloscopy by bringing awareness to the edges and pores of the ridges, in other words – the third-level details and how they can be put to use. Chatterjee's idea revolved around using the patterns of friction ridge skin and the arrangement of the minutiae, in conjunction with variability in the edge formations for personal identification and individualization.

Chatterjee encountered some shapes on the friction ridge edges that tended to reappear frequently, so he gave them specific names. He used the following terms to describe the characteristics encountered: (1) Straight edge, (2) Convex edge, (3) Peak-the edge which protrudes, and the protrusion has a broad base and pointed top, (4) Table-the edge has a protrusion with a narrow base and broad flat, top (5) Pocket-the edge looks like a pocket with a narrow opening, (6) Concave edge, (7) Angle and, (8) Infinite other characteristics other than the ones mentioned.[1] Subsequent research into edgeoscopy found that all characteristics encountered along the friction ridges can be placed into one of these characteristics.

In 1952, ***Dr. Alfred R. Hale***, of Tulane University, published a thesis titled ***"Morphogenesis of the Volar Skin within the Human Foetus"***. Hale's paper describes the formation of friction ridge skin patterns. He studied and observed the developmental stages of friction ridge growth in foetuses and described their process of formation in his thesis.[22] Hale examined thin slices of skin, cut in cross-section to friction ridges, from the fingers of foetuses at different stages of development. Various stages of friction ridge development were then examined and revealed. Dr. Hale is most likely the first researcher to delve into how minutiae develop. Dr. Hale states, "minutiae are products of the interaction between stress (mechanical factors) and the ability of ridges to multiply (genetic factors)." His study went on to become a major foundation for friction ridge identification.[22]

David Ashbaugh (1982) is a Canadian police officer who coined the term ridgeology. By Ashbaugh's definition, *ridgeology* was the process of friction ridge identification based on quantitative-qualitative analysis (Ashbaugh, 1982). Ashbaugh studies sweat pores and proposed two methods for comparing pore locations and it's individualization uses. In 1999, Ashbaugh wrote and published ***"Quantitative - Qualitative Friction Ridge Analysis: An Introduction to Basic and Advanced Ridgeology"***, a book considered to be an essential resource for latent print examiners. The book gives a summary and an overview of the history of friction ridge identification, along with detailed discussions of ridgeology methods, including poroscopy, edgeoscopy, pressure distortion, and problem print analysis.[11]

Ashbaugh extensively studied and researched friction ridge identification. He also created the terms ***level 1, level 2 and level 3 details*** which is now widespread in the finger printing community. He introduced to the field of finger printing the ACE-V methodology for fingerprint identification, where ACE-V stands for Analysis, Comparison, Evaluation, and Verification.

Bindra et al., (2000) "A method of personal identification" conducted a study on one hundred individuals. They developed both inked and latent prints from porous as well as non-porous surfaces. They studied the microscopic nature of sweat pores and expressed that the identification with the help of poroscopy is as reliable and accurate as ridge characteristics.[2]

O.P Jasuja studied "Poroscopy; A method of personal identification 2000" by obtaining rolled and plain fingerprints of one hundred individuals along with their palm prints to find the shape, size, position, inter-spacing and number per unit area of pores etc. The findings were compared with findings obtained from the latent prints of same number of people to ascertain the sensible feasibility of poroscopy in personal identification. It was then found that the study of pores thanks to their microscopic nature is somewhat difficult as compared to the study of ridge characteristics.[4] However, the results achieved within the present study indicate that identification with the assistance of poroscopy is as reliable and accurate as ridge characteristics and may be compared with the results obtained through the study of ridge characteristics.

Krzysztof et al., (2004) on their paper, ***"Study of the Distinctiveness of Level 2 and Level 3 Features in Fragmentary Fingerprint Comparison"*** studied the problems that would come with studying fingerprints and their level 2 and level 3 details using fingerprint fragments. They inferred that, using small fragments to assess level 2 and 3 details can bring out more clear-cut results especially, in cases where the fingerprints might have been corrupted and the undistorted parts can be extracted.[5] They also proposed that there should be proper measuring techniques or score matching techniques for studying level 2 and level 3 details in fingerprint fragments. They found that with the decrease in the size of test fingerprint fragment, the correlation score increases, if the two prints are from the same source (Gupta, 2008). They concluded in their paper that, "the use of level 3 features can offer at least a comparable recognition potential from a small area fingerprint fragment, as the level 2 features offer for fragments of larger area" (Krzysztof, 2004).[5] They explained the benefit of using pores in fragmentary fingerprint recognition and that the chance of success increases when the fragmentary fingerprint size decreases.

Ray et al., (2005) in their paper A Novel Approach to Fingerprint Pore Extraction proposed a means to extract the location of sweat pores from grayscale images. They proposed this method to overcome the inability of Automated Fingerprint Identification Systems (AFIS) to provide discriminatory information of large collections of fingerprint images.[8] The experiment was conducted on both inked impressions and live scan images. The pore information was extracted from images obtained from a 500dpi scanner. The study also suggested that as sensors or scanners which produce even higher quality images come into the picture, pore information should be considered as an essential feature to fingerprint identification.[8]

Chen and Jain (2007) ***"Pores and ridges; Fingerprint matching using level 3"*** studied the reliability of other third level features in personal identification. They made a successful plan to extract level 3 features (dots and incipient ridges) in partial prints and evaluated its benefits in Next Generation Identification systems.[14] They proposed an algorithm to extract these level 3 features. Dots and incipient ridges are isolated features, and they show slightly higher local symmetry than fingerprint ridges.[3] They found that these third level features are often automatically extracted and are used as extended set features in matching to improve the matching performance. It was observed that matching results based on Level 3 features alone is very comparable to that of Level 2 features.

Stosz and Alyea (1994) have significantly contributed to sweat pore modelling. In their paper ***Automated system for fingerprint authentication using pores and ridge structure*** proposed a novel technique for pore extraction which can help in automated fingerprint authentication. The pore extraction was done from live scanned images. The technique had an advantage over many other multi-level systems which only utilized ridge formation. They also wrote that adding pore information while authentication will result in an added level of security.[12] Their work demonstrated the viability of pore formation along with minutiae and ridge formation. The Automated Fingerprint Recognition System (AFRS) they proposed, was the first to use both minutiae pores in identification. They gathered statistics to prove the power of pores in identifying a person and also to establish the individuality of pores on fingerprints.[12]

Zhao et al., (2009) in their paper ***Direct Pore Matching for Fingerprint Recognition*** explained how minutiae based pore matching methods matches the pores based on the minutiae matching results and how it was a problem that the pore matching was dependent on the minutiae matching scores.[16] They proceeded to propose a pore-matching method which was independent of the minutiae based matching. With the help of their experiment, they were able to prove that the method they proposed could improve the accuracy of fingerprint recognition. They stated that the recognition accuracy can be improved more than 30% if the proposed matching process which used only pores was equipped in fingerprint recognition.[16] However, the method had one shortcoming which was its complexity in accurately describing the pores.

Partial fingerprint matching based on SIFT Features (2010) by ***Dr. C. Meena and Ms. S.Malathi*** demonstrated the use of SIFT (Scale Invariant Feature Transform) for partial fingerprint matching. SIFT is a technique used to detect salient features and local points in an image. In their study, SIFT was used for fingerprint feature extraction. The matching of the SIFT key points with the fingerprints was done using a modified point matching process.[7] The matching score showed that the technique works better than the usual minutiae matching process. The algorithm overcame the drawbacks of the conventional minutiae based matching systems that were used for partial fingerprint matching. The results showed that SIFT can be used to accurately detect key points in the images.[7] With evidence, they were able to support the proposition that SIFT features are more sufficient for matching partial fingerprint against full fingerprint image.

Biological Variability of Sweat Gland Pores in the Fingerprints of a Fars Iranian Family from Khorasan Razavi Province is an Iran study done by Mariam Tafazoli et al. 2013. This study enrolled 100 Iranian males from the Fars family who resided in Khorasan Razavi Province. The average age of the subjects were 20 years. Photographs of their fingertips and tri-linear A positions of both hands were taken using an advanced microscope and a software. The numbers of pore ducts of the sweat glands that occurred in these given areas were counted. The results were analysed by Minitab Statistical Software. The size, number, position and relative distance of the pores on the fingers and toes were examined. After evaluating the qualitative results and comparing it with the findings obtained from other studies, they were able to conclude that there was a morphological variety within the sweat pores of the Fars family of the Iranian population.[21]

CONCLUSION

From the review of the articles, it can be clearly seen that poroscopy as a study has evolved considerably since the 17th century. From the time when Dr. Nehemiah Grew identified and described pores and the field of poroscopy till date, there has been a decent investigation and research done in order to incorporate the techniques of poroscopy as an essential part of fingerprinting or even palm print analysis. The study done by Mariam Tafazoli et al. in 2013 itself demonstrates that poroscopy as a technique can be used digitally and can be developed to be a more efficient technique of personal identification. Their study using Minitab Statistical Software showed the identification of morphological characteristics of pores present on the skin and the palm. Therefore, from this literature review it can be concluded that poroscopy can be a supportive technique for personal identification when the techniques of fingerprint analysis don't seem to give one hundred percent accurate results and thus making it an essential technique in the third level of identification.

REFERENCES

1. Ashbaugh, D. R. Quantitative-qualitative friction ridge analysis: an introduction to basic and advanced ridgeology. CRC press, 1999.
2. Bindra, B., Jasuja, O. P., & Singla, A. K. Poroscopy: A method of personal identification revisited. Anil Aggrawal's Internet Journal of Forensic Medicine and Toxicology, 1(1), 2000.
3. Chen, Y., & Jain, A. K.Dots and incipients: extended features for partial fingerprint matching. In 2007 Biometrics Symposium (pp. 1-6). IEEE, 2007, September.
4. Jasuja, O. P., Singh, G. D., & Sodhi, G. S. Development of latent fingerprints on compact disc and its effect on subsequent data recovery. Forensic science international, 156(2-3), 237-241, 2006.
5. Kryszczuk, K. M., Morier, P., & Drygajlo, A. Study of the distinctiveness of level 2 and level 3 features in fragmentary fingerprint comparison. In International Workshop on Biometric Authentication (pp. 124-133). Springer, Berlin, Heidelberg, 2004, May.
6. Roddy, A.R., Stosz, J.D.: Fingerprint Features. Statistical Analysis and System Performance Estimates. Proceedings of the IEEE 85(9), 1390–1421, 1997.
7. S.Malathi, Dr.C.Meena "An Efficient Method for Partial Fingerprint Recognition based on Local Binary Pattern" IEEE International Conference on Communication Control and Computing Technologies, pages: 569-572, Oct 2010.
8. Ray, M., Meenen, P., & Adhami, R. A novel approach to fingerprint pore extraction. In Proceedings of the Thirty-Seventh Southeastern Symposium on System Theory, 2005. SSST'05. (pp. 282-286). IEEE, 2005, March.
9. Moenssens, A.A. Fingerprint techniques. Radnor, Pennsylvania: Chilton Book Co. , 1971.
10. Lennard, C. The detection and enhancement of latent fingerprints. In 13th INTERPOL Forensic Science Symposium, Lyon, France (pp. D2-88). US Department of Justice, 2001, October.
11. Kuhn, K. E. The Fingerprint Science and Ridgeology. The Print, 10(7), pp.1-3.
12. Stosz, J. D., & Alyea, L. A. Automated system for fingerprint authentication using pores and ridge structure. In Automatic systems for the identification and inspection of humans (Vol. 2277, pp. 210-223). International Society for Optics and Photonics, 1994, October.
13. Locard, E. Les pores et l'identification des criminels. Biologica: Revue Scientifique de Medicine, 2, 357-365 , 1912.
14. Jain, A., Chen, Y., & Demirkus, M. Pores and ridges: Fingerprint matching using level 3 features. In 18th International Conference on Pattern Recognition (ICPR'06) (Vol. 4, pp. 477-480). IEEE , 2006, August.
15. Malpighi, M. De externo tactus organo anatomica observatio. Apud Aegidium Longum.
16. Zhao, Q., Zhang, L., Zhang, D., & Luo, N. Direct pore matching for fingerprint recognition. In International conference on biometrics (pp. 597-606). Springer, Berlin, Heidelberg, 2009,june.
17. Holder, E. H., Robinson, L. O., & Laub, J. H. The fingerprint sourcebook. US Department. of Justice, Office of Justice Programs, National Institute of Justice, 2011.
18. Purkyne, J. Commentatio de examine physiologico organi visus et systematis cutanei. Spolek ceskych lékaru, 1819.
19. Faulds, H. On the skin-furrows of the hand. Nature, 22(574), 605-605, 1880.
20. Faulds, H. On the identification of habitual criminals by fingerprints. Nature, 50(1301), 548-548, 1894.
21. Tafazoli, M., Mahdavi Shahri, N., Ejtehadi, H., Haddad, F., Jabbari Nooghabi, H., Mahdavi Shahri, M., & Naderi, S. (2013). Biological variability of sweat gland pores in the fingerprints of a Fars Iranian family from Khorasan Razavi province, Iran. Anatomical Sciences Journal, 10(2), 99-104.
22. Hale, A. R. Morphogenesis of volar skin in the human fetus. American Journal of anatomy, 91(1), 147-181, 1952.