LIBERTY UNIVERSITY

Analysis of Fingerprinting Techniques and Comparing the Fingerprints of Twins

Elijah DeYoung, Lydia Buxa, Allie Stacks and Dr. Chad Snyder

Abstract and/or Background

Fingerprinting has been used in China as early as 300 BC. The idea started to gain popularity in Europe during the 1800s, specifically in England and France, where they were used in place of signatures to prevent forgery. It spread to the United States during the 1900s where it was used for forensic identification methods. This investigative process of fingerprinting involves analyzing the individual ridges present in the skin on fingers, which are unique to each person. Although certain patterns are common across the world's population, including loops (approximately 50% of the population), whorls (about 30% of the population), or arches (approximately 15% of the population), the minutiae details of each fingerprint, including bifurcations, islands, crossovers, and other such identifiers create an infinite number of unique fingerprints. Fingerprints can be used in a forensic setting because the oils that are left on surfaces yield the same pattern as the finger ridges of each person's unique fingerprint. These oils can be visualized by a number of techniques. The purpose of this research was to analyze the most effective of these techniques, including finding the best mixture of inorganic solids that adhered to the fingerprint oils, as well as investigating the use of aqueous ninhydrin which reacts with the amino acids present in the oils of each print. The final step in this research was to compare the fingerprints of twins, both identical and fraternal, to see if these individuals shared some commonalities in fingerprints that are not found between random individuals.

Introduction and/or Research Question

There were two primary research questions asked in this study:

- What is the best technique/formulation for latent fingerprint development?
- Do twins share similarities in fingerprint patterns and minutiae that the average individual does not?

Methods

1. Validity of Lanconide Powder

To test for the validity of the lanconide powder, seven sets of white powders were created. First, the literature powder was created using 0.4g of each of the following compounds: zinc sulfide (ZnS), zinc oxide (ZnO), barium sulfate ($BaSO_4$), titanium dioxide (TiO_2), and bismuth oxychloride (BiOCl), as well as 0.2g of calcium carbonate ($CaCO_3$). The remaining six sets of powder were created by omitting one of the components. The compounds were weighed, placed into a mortar and pestle, and mixed for at least 90 seconds. A fingerprint was placed on a dark nonporous surface and a fiberglass fingerprinting brush was used to transfer the powder to the print. This was done by placing the brush in the powder, tapping off any excess, and slowly spinning the edges of the brush over the print, barely touching the surface to transfer the powder so as to not alter the print. The print was lifted using fingerprint lifting tape and placed onto black paper. The print was then photographed under a small magnifying glass to analyze the quality of the print and minutiae.

2. Twin Studies

The fingerprinting development strategy used for twin studies followed the same format as the testing of lanconide powder validity. To compare the fingerprints for similarities, a millimeter ruler was placed on both the vertical and horizontal axis of each fingerprint. The locations of six fingerprint minutiae were approximated for the first twin's fingerprint in each set, using the format of a cartesian coordinate system. Using the matching fingerprint of the second twin, the approximate locations in which minutiae were found in the first twin's fingerprint were analyzed and minutiae were marked on the second twin. Matching types of minutiae were marked first, but if there were no matching marks, any minutiae in the same location were recorded. If there were no minutiae in the same approximate location on the corresponding fingerprint, the location was left unmarked. The minutiae found in similar locations between twins were then compared for both minutiae type as well as direction.

3. Ninhydrin

In order to test for fingerprints on a porous surface (such as paper), a ninhydrin solution was prepared. This consisted of 1000 mL of acetone and 6 g of ninhydrin crystals. The solution was stirred well until the ninhydrin crystals dissolved. Two different methods were used in order to test for the prints: a spray bottle and a pipette. To spray for the prints, the solution was transferred to a spray bottle and 20 sprays of the solution were delivered onto each print. If using a pipette, 20 drops were delivered directly onto each print. Ninhydrin reacts with the alpha amino group of a primary amino acid in order to form Ruhemann's purple. In both methods, the paper was allowed to dry under a fume hood for 48 hours and a household steamer was used to accelerate the reaction and darken print results. Prints were then placed under a small magnifying glass to analyze the results.

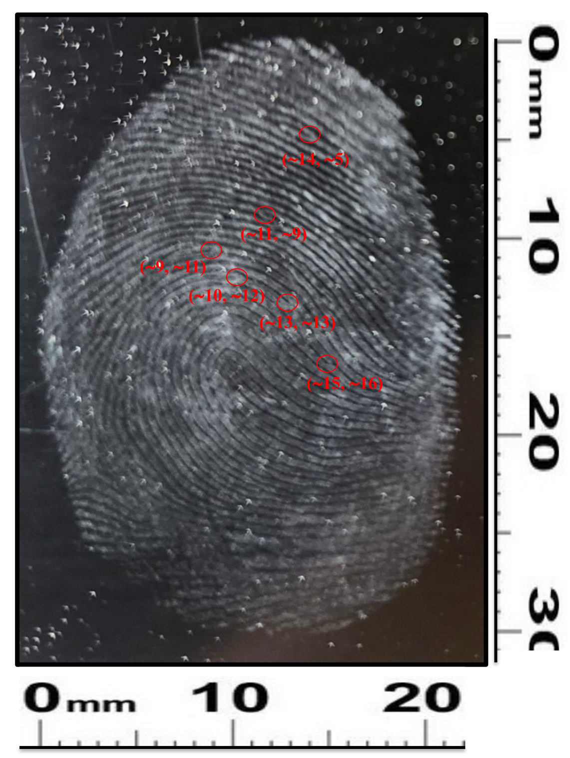

Figure 1. Identical Twin 1 Right Thumbprint

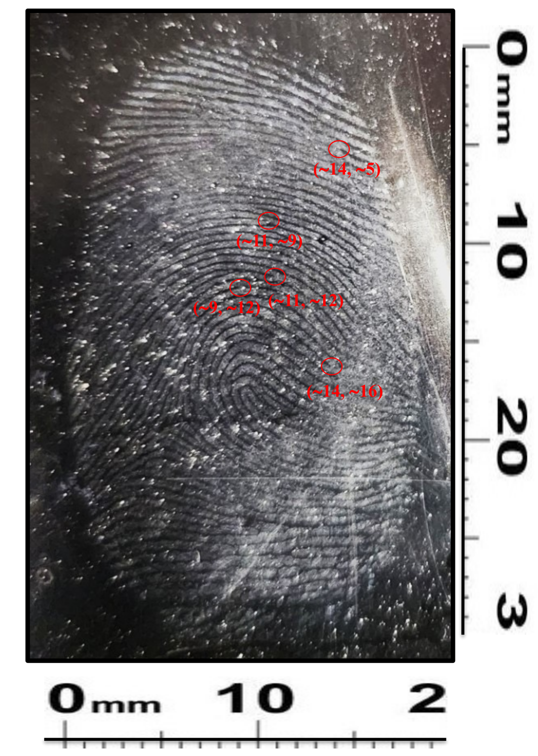

Figure 2. Identical Twin 2 Right Thumbprint

Figure 3. Fraternal Twin 1 Right Thumbprint

Figure 4. Fraternal Twin 2 Right Thumbprint

Figure 5. Identical Twin 1 Left Thumbprint

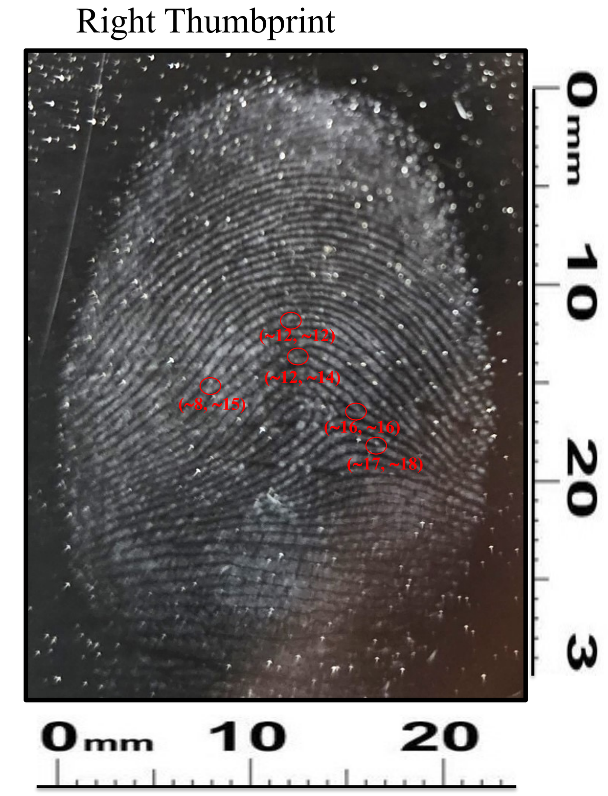

Figure 6. Identical Twin 2 Left Thumbprint

Figure 7. Fraternal Twin 1 Left Thumbprint

Figure 8. Fraternal Twin 2 Left Thumbprint

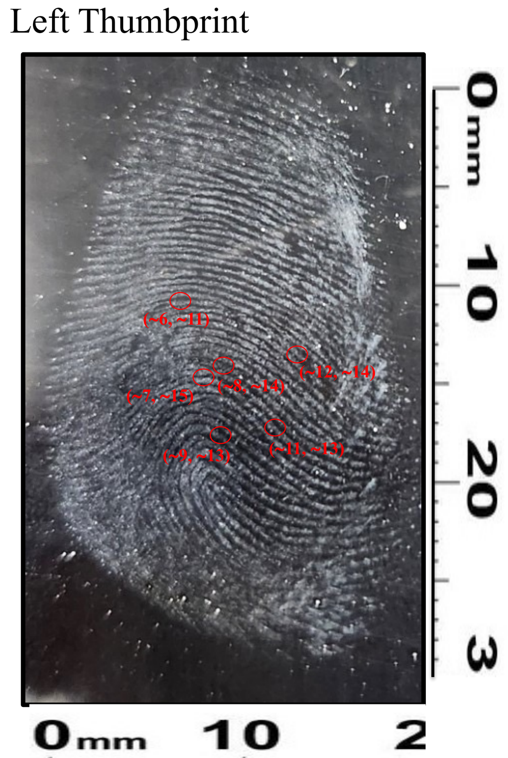

Figure 9. Control Right Thumbprint

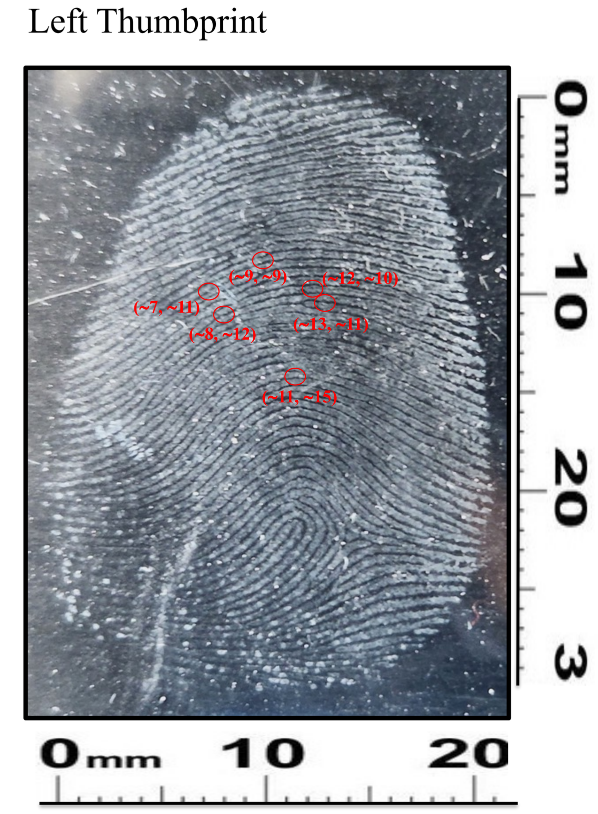

Figure 10. Control Left Thumbprint

Figure 11. Identical Twin 1 Left Pointer Fingerprint (using ninhydrin)

Figure 12. Identical Twin 2 Left Pointer Fingerprint (using ninhydrin)

Figure 13. Control Lanconide Fingerprint

Figure 14. ZnS Omission Fingerprint

Figure 15. ZnO Omission Fingerprint

Figure 16. $BaSO_4$ Omission Fingerprint

Figure 17. TiO_2 Omission Fingerprint

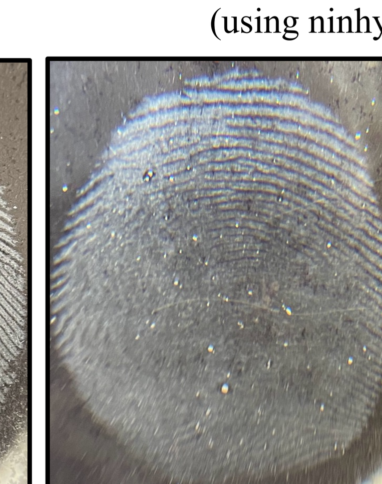

Figure 18. BiOCl Omission Fingerprint

Figure 19. $CaCO_3$ Omission Fingerprint

Results and/or Conclusion

1. Validity of Lanconide Powder

Of the seven prints, two powders yielded excellent results. These were the powders that omitted $BaSO_4$ and TiO_2. Both powders yielded bright, clear prints with clear features visible. The TiO_2 was the better-quality print and even allowed for the visualization of pores present on the fingerprint. The original literature lanconide powder did yield decent results, however, prints tended to be fainter, not as defined, and more difficult to distinguish minutiae. Omitting ZnO, ZnS, and $CaCO_3$ led to similar results as the original powder. Finally, omitting BiOCl led to a powder that barely adhered to the print with faint and indistinguishable results. Overall, the omission of $BaSO_4$ or TiO_2 yielded not only clear fingerprints but also enough detail to distinguish the general pattern and many points of minutiae. This is critical in the development of a successful fingerprint and allows for proper fingerprint identification in forensic settings.

2. Twin Studies

At the first glance, the results of the twin testing appeared as if there were similarities between the twins. For example, every matching fingerprint from each twin had the same general pattern, specifically in the core. However, when comparing the twin fingerprints to the control group, all fingerprints matched in the core pattern, showing no individuality or similarity between the twins. The results were then left up to the minutiae, which proved once more that there were no significant similarities shared only among twins. Although each set of twin prints had certain minutiae in similar spots, when the location was aligned, often the minutiae would be different. For example, when comparing the fraternal twins' right thumbprints, both had an identifier at (~7, ~15). However, twin 1 had a crossover, whereas twin 2 had a bifurcation. Other locations had the same minutiae but faced a different direction. The identical twins shared a bifurcation at point (~12, ~14), however, the bifurcation of twin 1 pointed left, whereas the bifurcation of twin 2 pointed right. Overall, the minutiae comparison appeared to be random across all accounts, not showing any particular similarity between the twins' fingerprints.

3. Ninhydrin

The work with the ninhydrin method yielded decent results. The general pattern of the fingerprints was clearly seen, however, developing finer minutiae was not as successful, which may have been due to the uneven distribution of amino acids in the prints. Some points could be seen, but certainly not all of them. Gaps in the prints could lead to incorrect identification of minutiae or the inability to see features present. The number of minutae from the ninhydrin prints was far less than the more successful forms of the lanconide powders.

Future Work

- Additional trials with different powder combinations could be done, using different ratios of each of the components to form the lanconide powder. Further testing could also be done with colored or black powders, which would allow for a greater range of surfaces for which these powders could be used. Powder composition and methods could also be altered to allow for better fingerprinting results on textured surfaces.
- To improve upon the twin research, the method used for comparison was very crude. Therefore, using a much more robust, mathematical procedure for comparison would greatly enhance the reliability of the results, as well as testing more sets of fraternal and identical twins, as well as control groups, for more statistically reliable data.
- For the ninhydrin research, reproducing more prints and modifying the amounts and/or application method of the reagents in order to get clearer prints would be useful.

References and/or Acknowledgments

1. Barnes, J.G. History. In *The Fingerprint Sourcebook;* McRoberts, A., Ed.; National Institute of Justice: Washington, DC, 2012; pp 1-7 – 1-22
2. Shrestha, I. Banshi, K.M. Study of Fingerprint Patterns in Population of a Community. *Journal of Nepal Medical Association.* **2019**, 57, 293-296
3. Alqadi, Z. Abuzalata, M. Eltous, Y. Qaryouti, G. M. Analysis of Fingerprint Minutiae to Form Fingerprint Identifier. *International Journal on Informatics Visualization.* **2020**, 4, 10-15
4. Prabhakara, S. Jainb, A.K. Pankantic, S. Learning Fingerprint Minutiae Location and Type. *Pattern Recognition.* **2003**, 36, 1847-1857