The Use of Color Contrast to Detect Biological Sex Differences in a Small Population of Fingerprints

Ryan W. Vynalek*, BS; and Josep De Alcaraz-Fossoul, PhD
Henry C. Lee College of Criminal Justice and Forensic Science, Forensic Science Department,
University of New Haven. 300 Boston Post Rd - West Haven - Connecticut 06516
Rvyna1@unh.newhaven.edu and Jfossoul@newhaven.edu

University of New Haven

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Learning Overview/Impact Statement:

The end goal of this blind study is to determine whether color contrast analysis between ridges and furrows is sensitive enough to detect differences between fingerprints from different donors, developers and substrates.

Hypotheses:

- Gray scale color contrast is sensitive enough to reveal quantitative differences in male and female fingerprint images when exposed to different experimental variables such as substrate (plastic and tile), powder developer (black and white) and deposition type (inked and latent).
- Statistical analysis will detect a variance between biological sexes through mean color values (average color) and amplitude (color range) obtained from histogram profiles.
- Data will detect a "mirror image" of the white powder and black powder fingermark images on a grayscale color contrast histogram.
- Data will reveal that Generation 1 inked fingerprints will have a lower color intensity mean than Generation 2 inked fingerprints.

Methodologies:

- A small population of ten donors (five males and five females) deposited three fingerprints (index, middle, and ring fingers) of the non-dominant hand under eight different experimental conditions as shown:

	Fingerprint type							
Condition 1	Latent				Patent (inked prints)			
Condition 2	Black Powder		White Powder		Flat		Rolled	
Condition 3	Tile	Glass	Tile	Glass	Gen 1*	Gen 2**	Gen 1*	Gen 2**
# of prints	30 (x3)	30 (x3)	30 (x3)	30 (x3)	30 (x3)	30 (x3)	30 (x3)	30 (x3)

Table 1: Eight different experimental conditions used in this study. (conditions were not known until after data collection)
*Fingers were inked before deposition
**Fingers were not inked again before deposition

- The image was re-sized to 1:1 scale and cropped to a 1cm X 1cm
- To assure data accuracy across the eight different images of a single finger, each representing a different experimental condition, the area selected for each image was identical.

- Quantitative data on color contrast was then collected (average and amplitude).
- A total of 720 fingerprint images (240 per 3 blind trial runs) were edited using imaging software as follows:

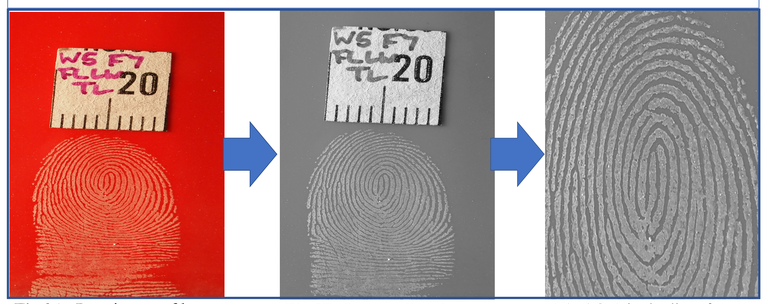

Fig 2A: Raw image of latent fingermark on tile with white powder

Fig 2B: Intermediate image (grayscale) of the same fingermark

Fig 2C: Final edits of mage of previous fingermark

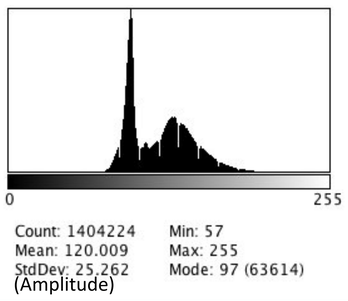

Fig. 2D: Grayscale color contrast histogram scale of fingermark used to collect quantitative data on color contrast. The Y axis is the amount of pixels. The X axis is the color intensity of each image (0-255)

- Mean and amplitude were statistically tested during this study but the color intensity mean of each fingerprint were the main focus in this poster
- In addition, every fingerprints visual qualities were rated on a scale from 0-4 as follows:

Quality Grading	Description of Grading
0	No print present
1	Print present but no visual indication that it is a fingerprint
2	General classification pattern present but no clear minutiae can be identified
3	Minutiae can be identified – suitable for identification
4	Very clear ridge edges, high contrast with background – suitable for identification

Table 2: Description of the 5 different levels of quality used to grade all fingerprint images used in this study.

Results:

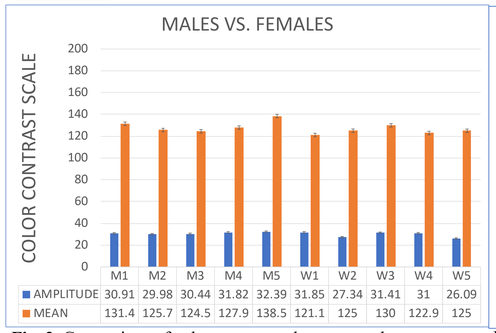

Fig. 3. Comparison of color contrast values across the population of donors (no differences observed between males and females)

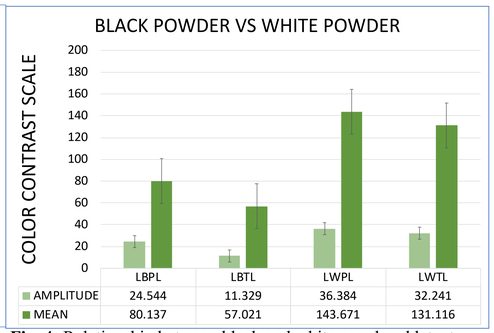

Fig. 4: Relationship between black and white powdered latent fingermarks on tile and plastic substrate.

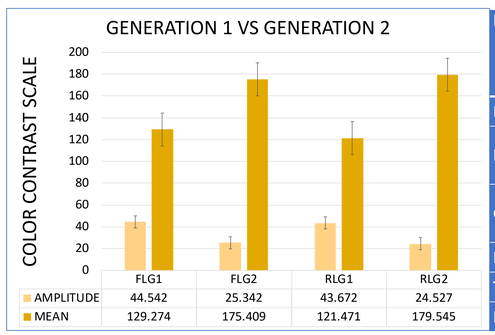

Fig 5: Relationship between generation 1 and generation 2 fingerprints, rolled and flat onto substrate

Experimental conditions	P values of average color intensity
Males vs Females	P= 0.149
Black powder vs. White powder	P= 3.09E-08
Generation 1 vs. Generation 2	P= 1.28E-06
Flat vs. Rolled	P= 5.21E-32
Tile vs. Plastic	P= 2.96E-05
Latent vs. Patent	P= 2.17E-08

Table 3: A statistical table showing the P values between different experimental conditions
Level of significance = 0.05

Discussion:

This research was conducted as a blind study to corroborate previous data and prove that anyone with proper training can repeat this study. Throughout three trial runs, the data computed results within the same range of each other, proving repeatability. This is crucial because it shows that this method can be repeated multiple times and still be robust. As shown in Figures 3, 4, and 5, and corroborated through P values in table 3, the experimental conditions have variance while males and females have no variance and can not be identified from each other. The reason why color contrast was able to distinguish between environmental conditions and not biological sex is simple, it is not sensitive enough to identify biological sex. This method detects differences through the average color intensity in the pixels of the fingerprint image so that's why it was able to detect differences in environmental conditions and not biological sex. Generation 1 fingerprints and generation 2 fingerprints were distinguished because generation 2 had less ink deposited, meaning a lighter color intensity throughout the pixels. Fingermarks on tile and plastic substrates were also distinguishable.

Conclusion:

- Preliminary results show no differences in the mean color values and amplitude (range of colors) between male and female fingerprints of the same experimental conditions as well as P values showing them to have a variance larger than 0.05 in Table 3.
- Differences in the mean and amplitude between Generation 1 and Generation 2 of inked fingerprints for flat and rolled depositions have also been detected
- Latent fingerprints visualized with black powder appear to mirror those developed with white powder on opposite sides of the grayscale color histogram.
- It has also proven that the repeatability of the method is valid and can be used on a larger population.

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