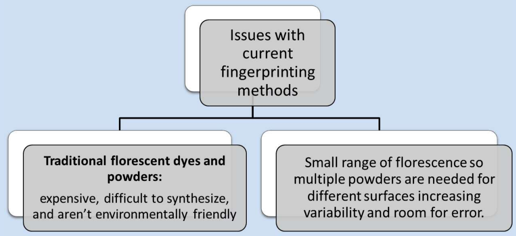
Introduction

01

This project focuses on creating a higher quality method of fingerprinting that reveals more visible minutiae.

Problem



Currently 22 known instances of incorrect court rulings based on fingerprint evidence and studies suggest there could be thousands more (abcnews.go.com).

Background

- **Carbon dots** are a carbon-based nanomaterial which are fluorescent and have a low toxicity, making them a good candidate for fingerprinting
- **Cyanoacrylate fuming** is one of many used methods of fingerprint analysis which involves using a cyanoacrylate glue to fume fingerprints
  - **1 step -** fluorescent dye/powder applied before fuming
  - 2 step - fluorescent dye/powder applied after fuming
- **Minutiae -** characteristics of fingerprints used to compare and classify fingerprints

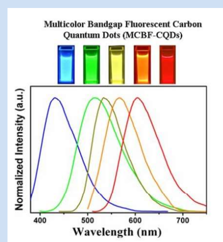


Image of carbon dot florescence spectrum taken from advancedsciencenews.com

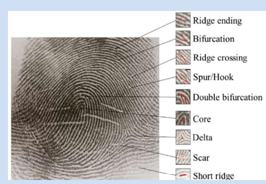


Figure of fingerprint minutiae taken from (Azman, Mahat, Wahab et al., 2019)

Goals

02

Research Question

How can using carbon dots in conjunction with cyanoacrylate fuming create higher quality latent fingerprints?

Engineering Goals

01 Create prints that fluoresce under 625nm, 530nm, and 465nm

02 Create prints with at least 5 more minutiae on average than just cyanoacrylate prints

03 Create prints with at least 5 more minutiae on average than just carbon dot dusted prints

Methods

03

1. Collect Control 1 Prints
2. Collect Control 2 Prints
3. Collect Experimental Prints
4. Collect Photos of Prints
5. Analyze under FpMV software & Preform T-Test

Variables

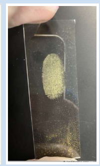
04

Control Group 1

Cyanoacrylate fuming followed by a florescent dye treatment (Cyanoblue spray)

Control Group 2

Only dusting with carbon dot powder



Expiermental Group

Carbon dot powder dusted on followed by cyanoacrylate fuming

all photos of me & my prints

Data Processing

05

FpMV software used to analyze fingerprints. Converted images into grayscale for more accurate results.

01 **Number of Minutiae**

Changed to only show minutiae with a quality of >0.2

02 **NFIQ Score**

1 – highest score
5 – lowest score (unusable prints)

Fingerprint Collection

06

Control Group 1

Control Group 2

Experimental Group

Photos of Control Group 1 and 2 prints and experimental prints. Fingerprints all deposited from **right index finger** onto glass slide. Fingerprints coated in sebaceous oils before to increase standardization between fingerprints.

Data

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Control Group 1

fingerprint	minutiae	NFIQ
1	45	4
2	12	1
3	51	1
4	74	2
5	64	1
6	12	3
7	146	2
8	48	3
9	64	5
10	24	5
average	54	2.7

Control Group 2

fingerprint	green minutiae	green NFIQ	blue minutiae	blue NFIQ	red minutiae	red NFIQ	Average minutiae	average NFIQ
1	43	5	88	5	63	1	64.6	3.7
2	49	2	85	3	55	3	63	2.7
3	148	1	16	1	96	1	86.6	1
4	141	1	107	2	74	1	107.3	1.3
5	120	1	136	1	56	2	104	1.3
6	68	1	110	4	60	5	79.3	3.3
7	101	3	66	3	129	1	98.7	2.3
8	147	1	86	2	67	1	100	1.3
9	135	1	136	4	116	2	129	2.3
10	116	2	79	2	113	1	102.7	1.7
average	106.8	1.8	90.9	2.7	82.9	1.8	93.5	2.1

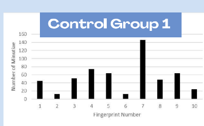
Experimental Group

fingerprint	green minutiae	green NFIQ	blue minutiae	blue NFIQ	red minutiae	red NFIQ	Average minutiae	average NFIQ
1	38	5	78	2	38	3	51.3	3.3
2	126	2	79	2	122	1	105.7	1.7
3	147	1	145	2	146	2	146	1.7
4	141	1	22	3	77	3	80	2.3
5	146	1	23	1	135	1	101.3	1
6	147	2	132	1	55	1	111.3	1.3
7	101	2	138	3	121	2	120	2.3
8	139	1	130	1	101	1	123.3	1
9	109	3	107	2	119	1	111.7	2
10	116	2	104	1	125	1	115	1.3
average	121	2	95.8	1.8	103.9	1.6	106.9	1.8

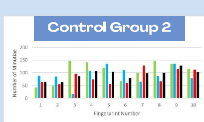
Data tables all created in Excel

Data Analysis

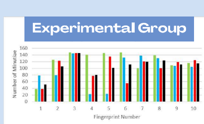
08



Number of minutiae for **Control Group 1** prints viewed under UV light (365 nm). Revealed an **average of 54 minutiae** between all 10 prints with an **average NFIQ score of 2.7.**



Number of minutiae for **Control Group 2** prints viewed under 625, 530, and 465nm. Revealed an **average of 93.5 minutiae** between all 10 prints (and 30 images) with an **average NFIQ score of 2.1.**



Number of minutiae for **Experimental** prints viewed under 625, 530, and 465nm. Revealed an **average of 106.9 minutiae** between all 10 prints (and 30 images) with an **average NFIQ score of 1.8.**

01 **F-Test:**

- compares variance between groups
  - found unequal variance

02 **T-Test:**

- two sample with unequal variance
- compared the average number of minutiae between groups

Control Group 1 vs. Experimental

F-Test Two-Sample for Variances

	Variable 1	Variable 2
Mean	54	106.56
Variance	1513.111	658.2227
Observations	10	10
df	9	9
F	2.298783	
P(F<=f) one-tail	0.11545	
F Critical one-tail	3.178893	

Control Group 2 vs. Experimental

F-Test Two-Sample for Variances

	Variable 1	Variable 2
Mean	83.82	106.56
Variance	1058.262	658.2227
Observations	10	10
df	9	9
F	1.607757	
P(F<=f) one-tail	0.245202	
F Critical one-tail	3.178893	

Control Group 1 vs. 2

t-Test: Two-Sample Assuming Unequal Variances

	Variable 1	Variable 2
Mean	54	83.82
Variance	1513.111	1058.262
Observations	10	10
Hypothesized Mean Difference	0	
df	17	
t Stat	-1.85962	
P(T<=t) one-tail	0.040167	
t Critical one-tail	1.739607	
P(T<=t) two-tail	0.080334	
t Critical two-tail	2.109816	

Control Group 1 vs. Experimental

t-Test: Two-Sample Assuming Unequal Variances

	Variable 1	Variable 2
Mean	54	106.56
Variance	1513.111	658.2227
Observations	10	10
Hypothesized Mean Difference	0	
df	16	
t Stat	-3.56691	
P(T<=t) one-tail	0.001286	
t Critical one-tail	1.745884	
P(T<=t) two-tail	0.002573	
t Critical two-tail	2.119905	

Control Group 2 vs. Experimental

t-Test: Two-Sample Assuming Unequal Variances

	Variable 1	Variable 2
Mean	83.82	106.56
Variance	1058.262	658.2227
Observations	10	10
Hypothesized Mean Difference	0	
df	17	
t Stat	-1.73568	
P(T<=t) one-tail	0.050354	
t Critical one-tail	1.739607	
P(T<=t) two-tail	0.100708	
t Critical two-tail	2.109816	

Control Group 1 vs. 2

t-Test: Two-Sample Assuming Unequal Variances

	Variable 1	Variable 2
Mean	54	83.82
Variance	1513.111	1058.262
Observations	10	10
Hypothesized Mean Difference	0	
df	17	
t Stat	-1.85962	
P(T<=t) one-tail	0.040167	
t Critical one-tail	1.739607	
P(T<=t) two-tail	0.080334	
t Critical two-tail	2.109816	

Graphics & data tables all created in Excel

Conclusion

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P-Value = 0.0026 Between Control Group 1 and Experimental Group.

52 more minutiae on average.

Discussion

- Between control Group 2 & the Experimental Group the novel procedure still produced more than 13 visible minutiae on average **exceeding my engineering goal** of 5 or more visible minutiae
- 39.5 more visible minutiae on average between Control Group 1 vs 2
- The NFIQ score for my novel prints was higher on average than both control groups.
  - Higher under red and blue light when compared to Control Group 2

image of my fingerprint under FpMV software

Limitations

- Camera quality & angle of photo
- Pressure of fingerprint deposit
- Substances available to test (couldn't test tunability) & amount of carbon dots limited
  - limited materials carbon dots were tested on

Future Application

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01 **Test under a wider range of wavelengths using a florescent microscope**
- Test between wavelengths of 450-650 nm

02 **Apply on a larger scale among forensic scientists**
- Reach out to Washington State crime lab

03 **Test florescence tunability**
- Coat fingerprints in different substances and test for patterns in quantum yield of florescence

04 **Run through AFIS program**
- Automated Fingerprint Identification System

Florescent Tunability

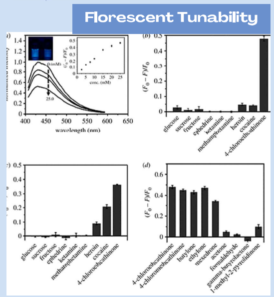

Image of florescent quenching of carbon dots by a range of compounds taken from Verhagen and Kelarakis 2020.

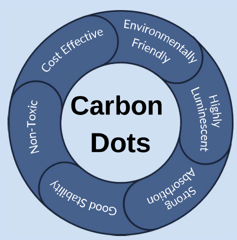

Image of carbon dot capabilities created based on graphics from (Liu and Yang 2020) and (Sabashini, Panja, Nandini 2021)

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