Table of Contents

A Picture is Worth 1000 Minutiae

A case review of fingerprint identifications made in the photographs of child pornography

2014

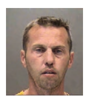
The Department of Homeland Security Investigates lead in Argentina

ICAC Internet Crimes Against Children Task Force

Sarasota Police Department receives a tip

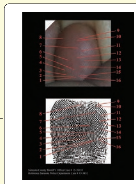
Suspect Developed: Dannie Ray Horner

2015



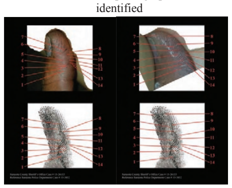
Suspect Arrested

Sarasota County Sheriff's Office Intelligence Unit submit photographs to AFIS Unit



Identification made for one photograph

Major Case Prints are taken: two additional photographs are identified



State vs Dannie Ray Horner in Sarasota County

Dannie Ray Horner was found guilty on twenty-six charges including: capital sexual battery, molestation, possession, distribution and transmission of child pornography

Sarasota Police Department Case # 15-3852
Sarasota County Sheriff's Office Case # 15-26153

What began in late 2014 as an investigation by Homeland Security into the distribution of child pornography ultimately led to a history making case for the agencies involved. A collaboration between the Sarasota Police Department and the Sarasota County Sheriff's Office would bring forth the arrest and conviction of Dannie Ray Horner on twenty-six charges including capital sexual battery, molestation, possession, distribution and transmission of child pornography.

In 2014 while The Department of Homeland Security was investigating a man from Argentina for the distribution of child pornography, new developments arose. During the investigation, several text messages and emails of disturbing graphic content were traced back to a subject possibly living in Sarasota County. This case was no longer about an individual trading and distributing child pornography, but possibly creating these images with a live victim. While working on a tip from the Internet Crimes Against Children (ICAC), the Sarasota Police Department developed a suspect, Dannie Ray Horner. Once the suspect was arrested, a thorough investigation of the digital media was performed by the Sarasota County Sheriff's Office Intelligence Digital Forensics team lead by Expert John McHenry. Through this investigation a unique discovery was made where friction ridge detail was visible in several photos of child pornography. This evidence was submitted to the AFIS unit for fingerprint examination.

While a suspect was known, confirmation of the identity was important. The photographs were taken with a Samsung Cell Phone, however at no time was there a face of the abuser in the photographs, only his hands. A Latent Print Examiner from the Sarasota County Sheriff's Office AFIS Unit was able to make an identification to one of the fingers in the photographs submitted.

After the initial identification was made, there was a possibility for more of the fingers in the photographs to be identified. With a court motion to compel prints from the suspect, the fingerprint examiner was able to take major case prints. These prints needed to be from the specific areas that were captured in the photographs. Even though fingerprints are recorded as part of the booking process, there are areas of friction ridge skin that is not captured during that time. These other areas on the sides of the fingers or extreme edges can be identified. After taking these more thorough known prints, two more fingers in the pictures of child pornography were identified. These identifications showed that the abuse was not just a one-time thing. Photographs taken with digital media devices have information stored within them called metadata. This information told the detectives that the pictures were taken on different days at different times. With three photographs, each comprised of a finger identified, a pattern was established.

For this case, the fingerprint identification was key to bringing the case together. This identification eliminated the defense from being able to say there was someone else in the photos creating the child pornography and abusing the child. This information solidified the case, for the child was too young to speak for himself. The email address that was associated with many of the transactions for distribution was a common email shared by his business partner at "Two Dans Painting". It would have been easy to use the "not me" card with both subjects being named Dan. The fingerprint identification allowed for the State Attorney's Office to move forward with the sexual battery as well as the molestation charges as there was no doubt as to which "Dan" was responsible.

This case was rather uncharted territory for all parties involved. There were several questions and challenges that arose from the state and the defense while preparing for this case. Although the suspect's face was never in the photos, having a positive identification to the hands that were causing harm to this child was the ultimate proof needed. Challenges to be discussed:

- Reversing the fingerprint image to mirror that of the traditional latent print
- Questioning the true motive behind taking on "a case like this"
- Visual color distinction when you are used to looking at "black and white"
- Taking major case prints and expressing why they are necessary

Even though this case was different from the typical workflow that examiners normally review, it was also similar in many ways. While these challenges at first may have posed questions, in the end, it was not as different as one may think. The challenges discussed will help to draw comparisons from what once may have seemed impossible to the reality of all possibilities.

Ultimately, this case demonstrates how still images of an offender's hand can be used to secure a conviction, but it also highlights how fingerprint detail in any form of digital media can be used in a wide variety of investigations. Furthermore, investigators should always be on the lookout for these opportunities of fingerprint detail in media and work in conjunction with the fingerprint examiners to determine if they are suitable for comparison.

Reversing the fingerprint images to mirror that of the traditional latent print

Challenge:
A photograph of a fingerprint does not look the way a traditional latent print does (see Figure A - Photographed vs Inked)

Figure A - Photograph vs Ink

Solution:
The photographed image can be flipped and rotated so that the image is more aesthetically pleasing to the eye.

Discussion:
When looking at a traditional latent print, one must think about the context in which it is being viewed. Latent prints are most commonly processed with powder, lifted with tape and attached to a card. The examiner would then look at the print as it was deposited onto the surface of the item in which it was lifted from. Even if the fingerprint on the surface of an item was photographed, it is still viewed in the same manner as a latent lift. The examiner is looking through the hand at the deposited print on a surface. A photograph of a physical fingerprint or the friction ridge skin while on the hand itself is the opposite of this. A clear thought process of this concept has to be on the forefront when examining physical friction ridge skin or photographs of friction ridge skin.

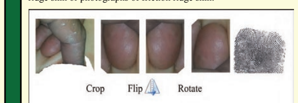


Figure B - Preparing the Photograph

Rotating and flipping the area of friction ridge skin will help in visual displays of the print. This may be beneficial when images are viewed by the jury or others that may not be accustomed to looking at fingerprint identifications (see Figure B – Preparing the Photograph).

There are other processing techniques that are used for the collection of friction ridge detail that examiners have to be mindful of. When examiners come into contact with latent prints that have been processed by Mikrosil, the same concept holds true. The image on the Mikrosil lift is the opposite of recorded known standards (See Figure C – Mikrosil vs Ink).

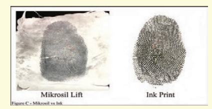


Figure C - Mikrosil vs Ink

Questioning the true motive behind taking on "a case like this"

Challenge
The defense will try to throw doubt wherever they can.

Solution
Have strong policies and procedures in place so that as an examiner, you know you followed protocol regardless of the type of case.

Discussion
One of the first questions that was asked during deposition from the defense was: Did you only take on this case because you knew it was about a victim of child abuse?

There have been many debates as to whether information about a case should be given to examiners. While some view information as knowledge is power, others may view it as information bias. In some instances, information can be very beneficial when it comes to location of a lift in the efforts to determine how someone may have handled an object. Some feel that information such as the suspect identity or other key players in the case may lead to false identifications from trying to "make the print fit". Ultimately, this battle should focus on how the information is used by the examiner.

In this particular case, a direct comparison was requested to who was believed to be the suspect. No other known standards were submitted or compared. However, that does not make the identification any less valuable than if it was an identification based on a subject from an Automated Fingerprint Identification System search. Even though this case was an identification using friction ridge skin that was photographed, the standard ACE-V method was utilized to make the identifications.

In a few concepts, this type of imagery was less challenging to work with than the traditional latent lift card. By having a photograph of the suspect's fingers, they could be viewed in their truest form. There are elements that examiners often have to work around or account for when analyzing a print. There could be bubbles in the tape, dust, dirt or other debris picked up in the tape from the surface of the item being processed. These artifacts can cause distortion or make prints more difficult to identify. Slippage, smudging and pressure all play a factor in prints when they are traditionally left on a surface of an item. However, in a photograph, different types of pressures are at work. The position of the hand itself and the manner in which the hand was photographed creates a different type of positional pressure.

Visual color distinction when you are used to looking at "black and white"

Challenge
The photograph of friction ridge skin does not have a high contrast difference between the ridges and furrows.

Solution
Look for anything that would provide contrast; dirt, oil or paint in the furrows (see Figure D - Photographed Friction Ridge Skin).

Figure D - Photographed Friction Ridge Skin

Discussion
From the three photographs that were identified in this case, two had color contrast in the furrows. This is the opposite from what general latent print lifts would be. In most prints, the color is on the friction ridge and the furrows are absent of color. In the third photograph, only flesh tones were visible. Even though the color contrast is not as desirable, the lighting from the photograph still allowed for a visual distinction between ridges and furrows.

There are other processing techniques that can be used where the latent print results are not "black and white". One example is when porous (example paper) items are processed with the chemical Ninhydrin. The chemical reaction occurs with the amino acids that are left behind by a fingerprint that has touched a porous surface. The friction ridge impression becomes a purple color that contrasts against the item it was processed on (see Figure E - Ninhydrin).

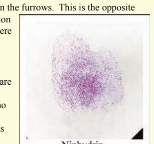


Figure E - Ninhydrin

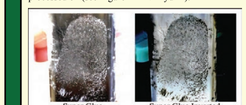


Figure F - Cyancrylate "Super Glue"

Another example is when cyancrylate fuming is used to process for latent prints. This process is often referred to as the super glue process. Super glue reacts with the traces of amino acids, fatty acids, and proteins in the latent fingerprint and the moisture in the air to produce a visible, sticky and white material that forms along the ridges of the fingerprint. The print can now be photographed with the ridges being white or further processed (see Figure F – Cyancrylate "Super Glue").

Taking major case prints and expressing why they are necessary

Challenge
Even with the best "nail to nail" rolled prints on file, there are still areas of friction ridge skin that is not captured.

Solution
Through communication with the State Attorney's Office have a motion to compel prints filed.

Discussion
Once a motion to compel prints has been granted, it may be the one and only opportunity to record all the friction ridge skin for a subject. During this time, it is important to either capture the recordings yourself as the examiner or be in proximity to witness the recording so that a prompt review of the captures can be done to ensure that all areas needed are recorded.

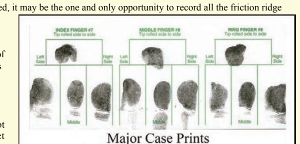


Figure G - Major Case Prints

The recording of all friction ridge skin is often referred to as major case prints (see Figure G – Major Case Prints). These recordings should not be rushed in any way, or hindered by the subject being handcuffed or shackled. The ability to get a clear recording could make a difference in whether a print is identified or inconclusive. Know the area that needs to be recorded. If possible beforehand familiarize yourself with the process of taking prints from different areas of the hands and/or fingers.

Author: Valerie Fulton, Forensic Print Anaylst, Hillsborourgh County Sheriff's Office

Dependence among randomly acquired characteristics on shoeprints and their features

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(4) Hadassah Academic College, Dept. of Computer Science, Jerusalem **(5)** Department of Statistics, Texas A&M University, TX

Israel Police

Introduction

Randomly acquired characteristics (RACs), are random markings on a shoe sole, such as scratches or holes, that are used by forensic experts to compare a suspect's shoe with a print found at the crime scene. This research investigates the relationships among three features of a RAC: its location, shape type and orientation.

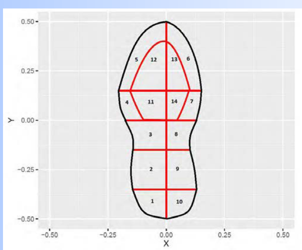
Previous studies assume that the features of a given RAC are independent of each other, as are the RACs themselves and therefore the Degree Of Rarity (DOR) of a single RAC is calculated by multiplying the probabilities of its features and the DOR of the entire shoe is calculated by multiplying the DOR of all RACs. If these features, as well as the RACs, are independent of each other, a simple probabilistic calculation could be used to evaluate the rarity of a RAC and hence the evidential value of the shoe and print comparison, whereas a correlation among the features would complicate the analysis.

The goal of this research is to statistically test the independence assumption using a database collected by the Israeli Police DIFS. It includes about 13,500 RACs from 380 test impressions.

Data

Three features of each RAC were defined as follows:

1. ***Location:*** The normalized shoe sole was divided into 14 subareas.



2. ***Orientation:*** Determined by the angle of the RAC with respect to the x axis of the shoe. The orientations were divided into 9 groups (20° each).

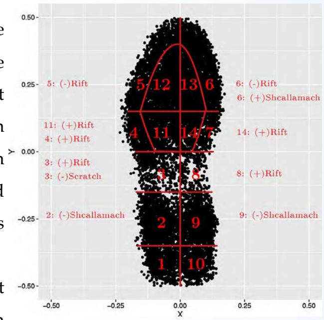
3. ***Shape type:*** Based on the definitions determined by the Israeli Police DIFS for classification purposes.

Dependence between orientation and location

The results indicate that the orientation and the location are not independent (p-value = 0.017), though the p-value is much larger than those obtained in the other two tests. The residual analysis does not reveal any interesting conclusions.

Dependence between shape type and location

The p-value of the Chi-square independence test indicates that the shape type and the sub-area are not independent (p-value < 0.001). In order to investigate for which categories the observed and expected differ the most, Pearson residuals were calculated.



The nature of the shoe sole element can explain the dependency between sub-location and shape type:

Schalamach RACs are micro tears of the boarders of elements (resulting from wear). Thus, it is reasonable that in areas where there is less pressure caused by the foot (2, 9) there will be less RACs of that type.

A possible explanation for the abundance of Rifts in areas 3 and 8 is that most shoes do not have a contact surface in these areas, and those shoes which do, have patterns that contain lines, the only elements in which the Rift type can appear.

Holes can occur on almost every element which may explain the small absolute value of its residuals.

Dependence between shape type and orientation

	Scratch	Hole	Cut-off corner	Rift	Schallamach
(-90,-70]	6.28	-2.18	-0.86	-1.23	-6.28
(-70,-50]	3.75	-0.39	-0.35	-0.39	-5.79
(-50,-30]	1.07	-1.50	3.14	0.57	-1.56
(-30,-10]	-4.55	3.53	0.83	0.29	1.20
(-10,10]	-10.53	2.22	-0.72	-0.07	16.02
(10,30]	-3.91	2.05	-0.76	0.25	3.78
(30,50]	0.74	-0.93	2.94	0.40	-1.78
(50,70]	5.35	-2.47	-1.44	-0.68	-4.02
(70,90]	3.30	-0.66	-2.54	0.92	-3.94

Further investigation of the shape type features

Two further analyses were conducted to examine whether the cause for dependence is the fact that the shape types were defined in relation to shoe-sole elements:

1. The analysis was repeated using only scratches and holes, shape types that do not involve elements of the shoe.
2. The dependence between the **size** of the RAC (not shape type) and its location and orientation was tested.

The first analysis did not reject the independence assumption between the two shapes and location (p-value 0.9), but found association between the two shapes and orientation (p-value < 0.001).

For the second analysis, the size of each RAC was calculated as the area in square pixels which is the product of the length and width of the tight bounding box that encloses the RAC. The size was divided into 20 groups, each containing 5% of the observations. A Chi-square test was used. An association was found between the size of the RAC and each of the features (location, shape and orientation) with p-value < 0.001 in each test. These analyses indicate that the independence assumption among the RAC features does not hold.

Association between sole patterns and RACs' features

The dependence among the features of a RAC may be caused by the differences among shoe soles. In order to test this assumption, Three relatively frequent patterns in he database: Nike Shox R4 (NSR4, n = 36), Nike Shox NZ (NSNZ, n = 27) and Classic Timberland (CT, n = 22) are presented. preliminary analysis was performed in order to test independence between RACs on similar shoes.

Three frequent shoe patterns; from left to right NSR4, NSNZ, and CT

Results:

1. Scratches are more likely to appear on CT shoes than on NSR4.
2. Shcallamach shapes appear more on NSR4 shoes and less on CT.
3. There are no shapes of type Rift in CT shoes, as would be expected since this pattern contains no thin lines.
4. Pattern NSR4 has less RACs in area 3 than would be expected under the independence assumption, and pattern NSNZ has more.
5. Pattern CT tends to have less RACs in area 9 and more in areas 11 and 12.
6. Orientation and pattern are found to be independent, that is, the distribution of orientation in these three patterns is similar.

Conclusions

- The assumption of independence among RACs and among the features of RACs was rejected.
- DOR cannot be calculated by a simple multiplication of the characteristics' probabilities.
- The dependence is caused by the shoe-sole pattern.
- In order to calculate the DOR, the mechanism of dependence is needed.

Shoeprint Lab Survey

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Israel Police

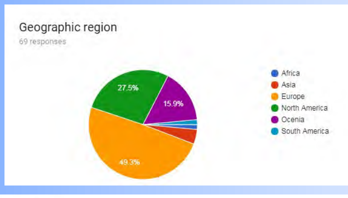
Introduction

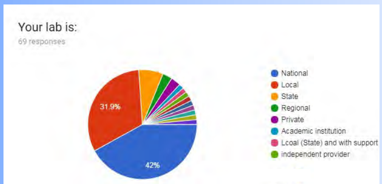
The 2009 NAS report (Strengthening forensic science in the United States: a path forward) which evaluated and set required standards for the various forensic fields, caused an earthquake in the forensic community. Its important recommendations include the standardization of the terminology used in reporting, lab accreditation and personal certification, including estimated probabilities and measures of uncertainty in reported results, minimizing potential bias and human error. Some of these aspects standards were addressed in the 2016 PCAST report (Forensic Science in Criminal Courts: Ensuring Scientific Validity of Feature-Comparison Methods) as well.

A survey concerning some of these aspects was distributed among shoeprint labs worldwide. The participating labs were contacted in several methods. A personal request was sent to experts with personal acquaintance with the authors. They were requested to forward the survey to other labs they are familiar with as well. In addition, a link to the survey was posted on a professional oriented social networking. Anonymousness of the answers was promised.

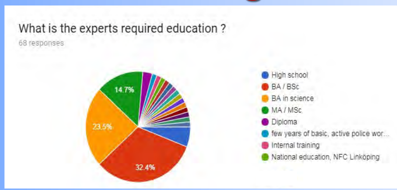
The distribution of responses for the various questions was analyzed.

Characteristics of participating

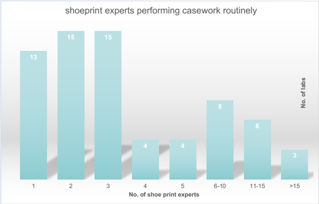


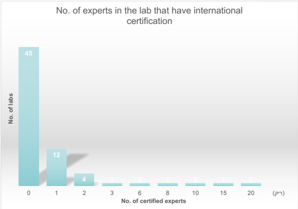


Training

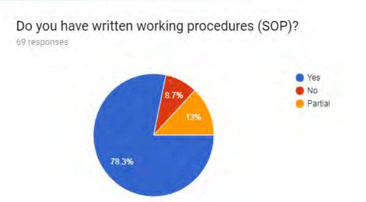


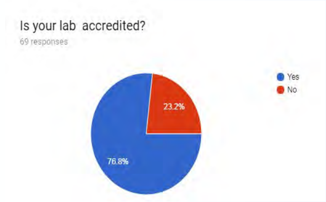
Man power & work load

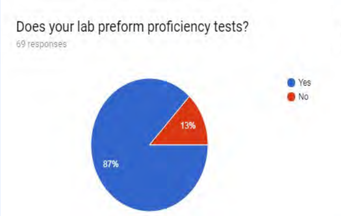


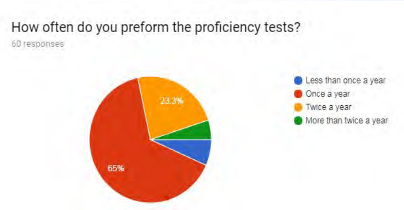


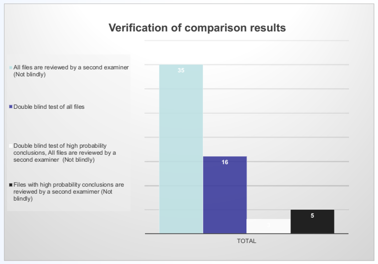
Accreditation and quality assurance



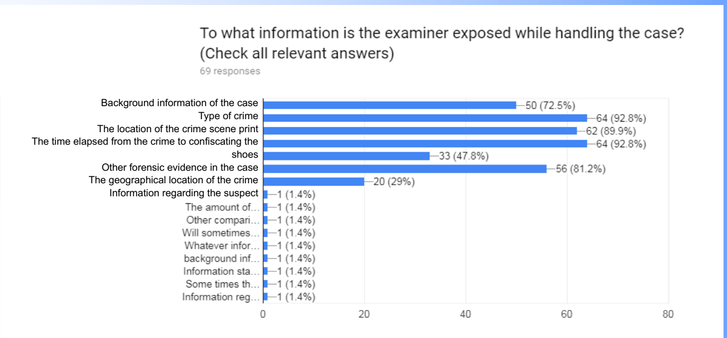




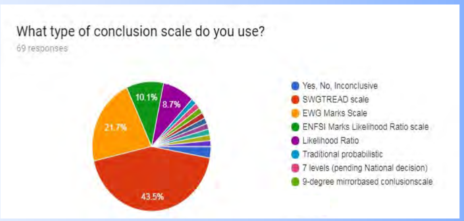




Exposure to bios information



Conclusion scale used



Conclusions

- The variability among the participating labs is great but the survey shows that most of them maintain high professional standards:
  - Much effort is invested by most labs in recruiting educated personal and training them. The personal recruited to most labs have at least a bachelors degree and the training is exceeds one year. On the other hand, most shoeprint experts didn't receive international certification.
  - Most labs have written working procedures and are accredited.
  - Most labs perform some kind of verification of the case work.
  - The vast majority of labs performs at least one proficiency test a year.
- Stricter rules should be set for the background information the examiner are exposed to in order to minimize bios.
- Only a minority of the labs participating in this survey use likelihood ratio to present the comparison results.

“How Old Are They?” A White Lines Case Study That Defies Expectations

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Baltimore Police Department

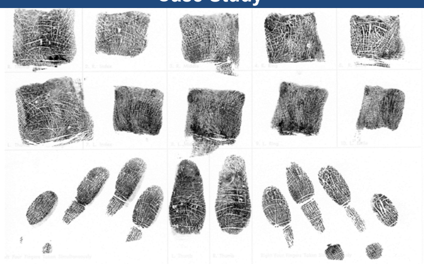
Baltimore, MD

Right Little Finger
December 12, 2017

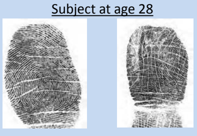
Background

In the fingerprint community, the common rule of “thumb” is the amount and severity of creases within the impression is directly correlated to the age of the subject. While increasing age does result in changes to the skin structure, this is not the only explanation for creases or “white lines” in the impression.

Case Study



Subject at age 28

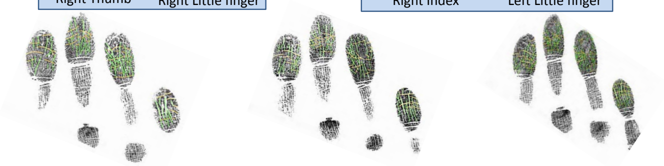


Least affected Right Thumb — Most affected Right Little finger

These records were both taken with LiveScan devices during an applicant background investigation.

Subject’s Mother at Age 56

Least affected Right Index — Most affected Left Little finger



Research Questions

- Quality of ridges vs. depth of creases
- Environmental Factors?
- Does this affect other members of the family?
- Is it worse with age?
- Correlation with season or weather?
- Is there a disease associated with this?

Initial Observations

- Ridges are still present but obscured by deep creases
- Acute dryness plays a part
- Yes, affects other female members (not males)
- Does not appear worse in older individuals
- Does not appear dramatically worse in winter
- No known disease explanation

Possible Causes

Biology of Subject	Environmental Factors	Genetic Factors
• Gender • Hormone Levels • Age • Stature • Collagen content	• Hand washing • Occupation • Chemical Exposure • Manual Labor • Ambient Humidity • Chemotherapy	• Diseases affecting skin • Unknown genetic factors

Gender (Badawi 2006)

White lines are more common in women.

Hormone Levels (Shuster 1975)

Collagen content decreases in women after menopause, resulting in increased wrinkling tendencies.

Age (Shuster 1975)

Increasing age results in thinner skin and increased wrinkling. Collagen content drops 1% per year.

Stature

Finer ridges apply to females and males equally in smaller individuals. Finer ridges are more difficult to see.

Hand Washing

Drying action of repeated soap application dehydrates the skin.

Chemical Exposure

Can reduce hydration of the skin, can cause sloughing of epidermis or burns can damage the skin.

Manual Labor

Repeated handling of coarse objects (bricks, rocks, wooden tools) can affect ridge height and quality.

Ambient Humidity

Seasonal variations in humidity in air can cause dehydration of the skin. Increased lotion application and water intake may improve the condition.

Chemotherapy (Al-Ahwal 2012)

Can cause hyperpigmentation, blistering, desquamation and ulceration of skin and can cause loss of fingerprint detail. Divided into 3 levels of severity ranging from painless dermatitis to ulcerative dermatitis which affects daily living.

Hand Dermatitis (Lee 2013)

Additional 4 white lines

Mechanisms:

- Scaling/wrinkling
- Fissures
- Effacement of fine ridges

Control subjects had more prevalence of white lines, but were less disruptive to pattern details.

Celiac Disease (David 1970)

Ridge atrophy in 95% of untreated adults. Quality of ridge details directly related to adherence to gluten free diet. White lines appear when skin grows normally and disappear when atrophied. White lines are present with normal skin behavior.

Marfan’s Syndrome (David 1970)

Buckling of the skin and systemic collagen deficiencies lead to crease formation.

Eczema (Drahansky 2010)

Affects fingers individually or together, results in patches, cracks or fissures. Twice as common in women.

Psoriasis (Drahansky 2010)

Scaly Papules and plaques with thick brown scaling

Biometric System Challenges

As fingerprint technology is used more frequently, individuals with difficult skin face challenges in verifying their identity. White lines can cause artifacts in digital technology and obscure reliable ridge features. The broader and longer the white lines were, the worse the ability of the system to identify. (Lee 2013)

Certain fingers which have more clear ridge detail should be used when possible, but dry skin conditions may require a different biometric technology or numerical password as a backup.

Single Finger Environments

- Cellphone scanners
- Banking transactions
- Security
  - Computer Login Terminals
  - Exterior Door locks
  - Alarm Systems
  - Medical Record Systems

Multiple Finger Environments

- Airport Security Systems
- Background Checks
- Criminal Record Maintenance
- Immigration Documentation

Forensic Application

How does this condition affect Latent Print Examiners?

- Latent Print Quality
  - Prints left by these individuals would be frequently marked as “Not Sufficient for Comparison”
  - Individuals expressing this condition may be frequently unidentifiable
- Known Print Quality
  - Attempts to compare these individuals may result in frequent “Inconclusive” results
  - Additional known prints might or might not show similar levels of creasing defects
  - Multiple records should be gathered for these subjects, as the white lines in the latent may not resemble to newest record available

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Time Lapse

Barrier Penetration Characteristics of PolyCase Inceptor ARX Ammunition

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Jack Hietpas, Penn State University, PA; Xiao Shan Law, Penn State University, PA

ABSTRACT

PolyCase ammunition has some novel design features, specifically the construction and unique shape of their ARX bullet. Several studies have shown that traditional bullets have predictable interactions with many yielding and non-yielding intermediate substrates (Haag). The newly marketed ARX bullet behaves quite differently than previous bullet designs. Not only is the bullet lead free, it is comprised of copper spheres in a polymer matrix manufactured using an injection molding process. This manufacturing process does not lend itself to a traditional hollow point design, however the bulletsmiths at PolyCase have devised a unique alternative to a cavity in the form of three large "flutes" in the bullet's ogive. These flutes create characteristic triangular perforation holes in automobile sheet metal.

METHODS

Several calibers of PolyCase-brand ammunition were test-fired at various barriers, including drywall, paneling, windshield glass and sheet metal of different gauges. Automobile sheet metal provided the most characteristic bullet holes when perforated by the ARX bullets as compared to traditional hollow point or full metal jacket bullets. The results were replicated using firearm barrels with both left-hand and right-hand twists.

Fig 1. The cartridges tested: 380 ACP, 9mmL, 40 S&W, 45 ACP.

RESULTS

Fig 2. The components of a PolyCase Inceptor ARX bullet deconstructed, revealing copper spheres and polymer.

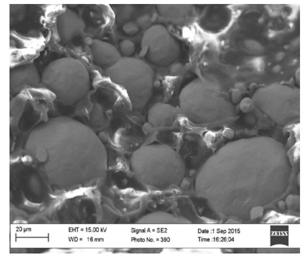

Fig 3. Interior of a PolyCase bullet, imaged with scanning electron microscope (SEM), showing matrix of copper spheres in polymer binder.

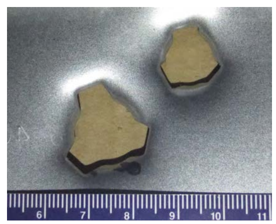

Fig 4. Holes in 22 gauge sheet metal (0.028" or 0.71mm) made by PolyCase Inceptor ARX bullets. Note triangular shape of holes. Caliber 45 ACP on left fired from Kimber 1911, 9mm L on right fired from S&W 5946.

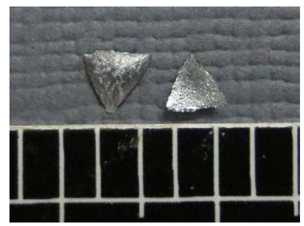

Fig 5. "Punchouts" recovered in ballistic gel from 22 gauge sheet metal perforated by PolyCase Inceptor ARX bullets.

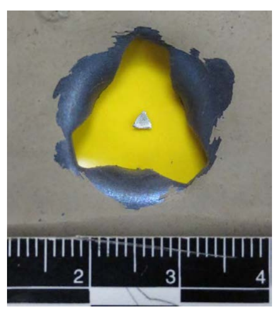

Fig 6. Entry hole in 22 gauge sheet metal made by 40 S&W PolyCase Inceptor ARX bullet fired from Glock 22. Punchout placed in center for size comparison.

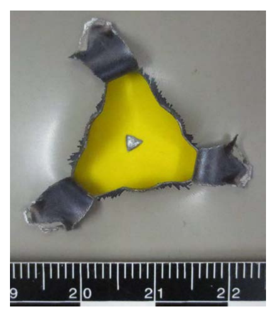

Fig 7. Exit hole in 22 gauge sheet metal made by 40 S&W PolyCase Inceptor ARX bullet fired from Glock 22. Punchout placed in center for size comparison.

CONCLUSION

Reproducible triangular holes were made in sheet metal by the PolyCase Inceptor ARX bullets. Traditional bullet designs from other manufacturers do not produce triangular shaped holes. Triangular "punchouts" were recovered from the recovery medium positioned directly downrange of the sheet metal, along with witness panels to keep track of secondary missiles and post-impact bullet fragments.

The fluted ogive of the PolyCase ARX bullets produces characteristic holes in sheet metal. The style of bullet hole morphology can be readily distinguished from traditional hollow point and full metal jacket bullet types. Recognition of this unique style of perforation may provide useful information for shooting scene reconstructions.

Fig 8. Side view of exit hole in 22 gauge sheet metal made by 40 S&W PolyCase ARX bullet. Note 3 sharp points and 3 peeled back petals.

ACKNOWLEDGEMENTS

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Mr. Paul Lemke, CEO of PolyCase Ammunition
IPTES 2018 Host Committee

REFERENCE

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U.S. Department of Homeland Security
United States Secret Service

Laterally Reversed Latent Prints Detected with Amino Acid Reagents

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Forensic Services Division

A laterally reversed latent print is a mirror image of a friction ridge skin impression from a finger, palm or foot.

The occurrence of laterally reversed friction ridge skin impressions detected on porous and nonporous substrates has been observed. As the ability of the chemical reagents used to develop latent print impressions becomes more sensitive, an observed increase in the development of latent prints will occur. Such is the case with the reagent 1,2-indanedione and its ability to develop numerous latent prints, some being laterally reversed. Therefore, due to the increased use of 1,2-indanedione in the field, issues regarding the recognition of potential laterally reversed latent print images needs to be addressed.

The two types of laterally reversed latent print images which have been observed are the "surface to surface" transfer and what we will refer to as the "bleed through" transfer. The "surface to surface" transfer occurs when two items come in contact with one another and the friction ridge skin impression transfers from one surface to the surface of the other item. The "bleed through" transfer occurs when the matrix passes through from one side of the porous item to the opposite side of that same item.

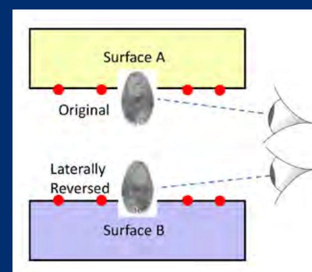
This poster presentation demonstrates and discusses the two types of laterally reversed prints; the "surface to surface" transfer and the "bleed through" transfer.

Synopsis

Recognition of laterally reversed prints should be included in training modules and procedural protocols for examiners, photographers, technicians, and others involved in the examination or documentation of latent print impressions. Research and Quality Assurance Measures should also be addressed regarding the recognition, frequency and mechanics of these types of prints.

- Education
  - Hodge Podge podcast [3]
  - NIST Error Management Symposium
  - NIJ Impression, Pattern and Trace Evidence Symposium
  - Articles in professional journals [4]
- Training
  - Need to include examples of "bleed through" prints in ACE training To examiners, technicians, photographers and others involved in latent print detection
- Research
  - How often does this happen?
  - Why does this happen?
    - Almog et al. examined the Fingerprints' Third Dimension: Depth and Shape of Fingerprint Penetration into Paper – Cross Section Examination by Fluorescence Microscopy
- Quality Assurance Measures
  - Should prints be searched in two positions when using amino acid reagents?
  - Competency/proficiency testing?
  - Re-examine unidentified latent prints in unsolved cases?

Surface to Surface Transfer



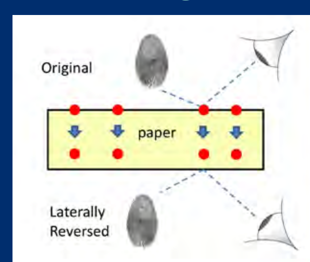
Example 1[1]

Superglue on plastic bag

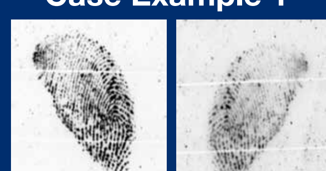
Example 2[2]

Ninhydrin on transparent tape adhesive side

Bleed Through Transfer

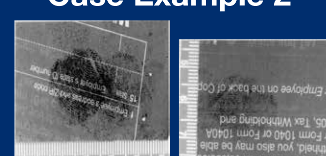


Case Example 1*



1,2-indanedione

Case Example 2*



1,2-indanedione

* The two case examples consisted of different types and weights of paper which were processed with the reagent 1, 2-indanedione. The items were processed using standard protocol and were visualized with either an alternate light source or laser with proper filtration. Latent prints were developed and upon further examination, it was observed that some of the latent prints had bled through to the backs of the papers creating laterally reversed images. Although 1,2-indanedione was used in these cited cases, it should be noted that laterally reversed latent prints have also been developed with DFO and ninhydrin reagents and superglue.

Notes:

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2 – Czarnecki, Eugene R. Laterally Inverted Fingerprints, J. Forensic Ident., 2005,55(6), 702-706
3 – Hodge Podge podcast – Episode 117, #6
4 – Articles in professional journals – manuscript under review for publication

Identifying Human Touched Objects by Reverse Fingerprint Lifting Suitable for Microbiome-Based Forensic Applications

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Abstract

Latent fingerprint lifting has been carried out on objects to identify and classify the human touched objects within a workplace, which can be readily applied for both traditional (fingerprint analysis) and microbiome-based forensic identification. Several objects in a work place environment, such as keyboard, mouse, cell phone, office phone, stapler, cabinet handle, and door knob were selected for this study. Dusting the print in an office set up is not healthy, due to possibility of the fine microscopic dust particles moving around the whole area. Secondly it may disturb microbiome-based forensic analysis. An attempt has been made for lifting the print and then developing through dust lifting and chemical methods, called "reverse lifting". Alternate light source (ALS) has been used to enhance the observation and to locate the latent print. Visible fingerprints are photographed and traditional methods of dusting with suitable powders have been used to lift the print. The results showed that the reverse lifting method worked well with glazed/smooth surfaces, which will allow investigators to use the microbiome-based analysis as well as the fingerprint lifting on the same object in a crime scene.

Objectives

- To develop a non-invasive fingerprint lifting method that may not affect other forensic analyses including the microbiome-based analysis
- To compare the newly developed "Reverse Lifting" method with the traditional lifting method
- To identify objects that are feasible for the reverse lifting method

Hypothesis

- It may be possible to lift fingerprints first from objects and develop and identify fingerprints later, so the same object can be used for the microbiome-based forensic analysis
- The results from the new method, "Reverse Lifting" can be comparable to those of the traditional lifting on the objects in an office setting
- Some objects commonly found in an office can be readily used for the reverse lifting method

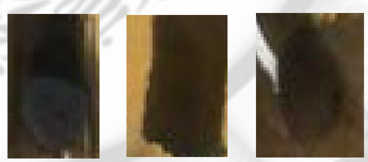
Methods

1. Traditional fingerprint lifting methods were used to lift the fingerprint using magnetic, red, and black powders on objects such as mouse, keyboard, door knob, and computer screen.
2. Reverse fingerprint lifting was developed to lift fingerprints from the objects before the dusting or chemical treatment. This approach may avoid dusting or chemical treatment directly to objects, so the same objects can be used for further analyses including microbiome-based applications.

Table 1. Reverse Fingerprint lifting: object vs. lifting parameters

	Mouse	Keyboard	Door knob	Computer screen
Packing Tape w/ red powder	Visible print ridge detail (Figure 5)	No print	No print	No print
Duct Tape w/ red powder	No print	No print	No print	No print
Masking Tape w/ red powder	No print	No print	No print	No print
Fingerprint Lifting Tape w/ red powder	No print	No print	No print	No print
Adhesive-side developer w/ masking tape	Visible print ridge detail (Figure 2a)	Visible print (Figure 1b)	Visible print ridge detail (Figure 1a)	Visible print ridge detail (Figure 1c)

Figure 1.. Reverse lifting from different objects

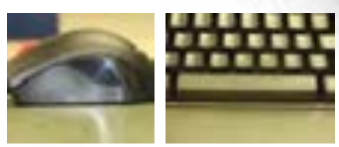


a) Door knob b) Keyboard c) Computer screen

Figure 2. Compare reverse lifting and Forensic light source

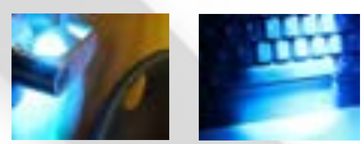
a) Mouse ALS b) Mouse R -Lifting

Figure 3. Fingerprints identified by human eye



a) Mouse b)Keyboard

Figure 4. Fingerprints under a forensic light source



a) Door knob b) Keyboard

Results

1. Traditional Lifting Method

- The smooth surface (Figure 2a) presented a more visible print than the rough surface (Figure 4b) because the rough surface on a microscopic level have high and low areas, like hills and valleys that makes the surface uneven, thus causing the ridges in the print to not show fully
- The Forensic light source (Figure 2a, 4) worked better than the human eye (Figure 3) observation because the light source enhanced the detection of the latent print through the fluorescents of the light magnifying the oils and natural sweats of the fingerprint.

2. Reverse Lifting

- The fingerprints recovered from the smooth surface using the reverse lifting method can be compared to the fingerprint observed by the forensic light source. (Figure 2)
- The method of reverse lifting using adhesive-side developer worked well for a mouse, and more work is still in progress.

Figure 5. Reverse lifting from a mouse

Conclusions

- Forensic light sources (luma light) enhanced the detection of a latent print using the "Reverse Lifting" method.
- The newly developed "Reverse Lifting" method is promising on the objects with glazed/smooth surfaces.
- In future – plans to use various types of tapes, Reverse Lifting powder technique on various objects.

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Acknowledgements

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The Evidentiary Significance of Automotive Paint from the Northeast: A Study of Red Paint

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Abstract

The populations of automotive paints are constantly changing, and thus need to be thoroughly monitored. By investigating these populations, forensic scientists can begin to understand what significance each individual automotive paint may hold. In order to do this, the physical appearance, layer structure and layer chemistry can be analyzed to provide a forensic examiner with more detail, which can be used to give strength to a conclusion made during an automotive paint examination. This population study involved the microscopic analysis of 200 automotive paint samples and the discrimination of red automotive paints using a comparative analysis approach and data analysis.

The red samples were chosen as a target group from the larger automotive paint population based on popularity among consumers and manufacturers; there were 26 red samples within the entire sample population. This comparative analysis approach helped to determine the differentiating power of the analytical sequence as well as analyze the chemical properties of similarly colored paints. Current laboratory methods were used to analyze the red automotive paints, and included ultra-violet-visible microspectrophotometry (UV-Vis MSP) and Fourier-transform infrared (FT-IR) microspectroscopy. In addition, this research used Raman microspectroscopy, an emerging technique for automotive paint analysis that has been demonstrated to provide valuable pigment information (1).

This study was conducted to highlight the significance of automotive paint comparisons and the characteristics each sample possesses. The frequency data and the degree of differentiation is important information as it can provide a foundation for determining the significance of indistinguishable samples.

Materials and Methods

The entire population (200 samples) was analyzed with stereomicroscopy (color and surface characteristics), brightfield and polarized light microscopy of cross-sections and thin peals (number of layers, layer thickness and color, presence/absence of effect pigments, effect pigment size and type, extinction and birefringence).

The red automotive paint samples were additionally analyzed with FT-IR and Raman microspectroscopy, and UV-Visible microspectrophotometry. FT-IR microspectroscopy was used to obtain chemical information about all of the layers of each sample. Raman microspectroscopy was used to obtain pigment information about the red color coats. Lastly, UV-Vis microspectrophotometry was used to help differentiate between metamers and was also used to obtain absorption information about the clear coat layers.

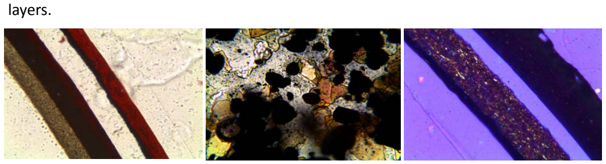

Figure 1: Photomicrographs (400 X) of: (left) a cross section of a 7-layered red paint (brightfield), (middle) a thin peal of a silver paint showing the presence of effect pigments (brightfield), and (right) a cross section of a 7-layered blue paint with a birefringent internal primer layer (PLM, XP with full wave plate compensation).

Results

Results from Entire Population:

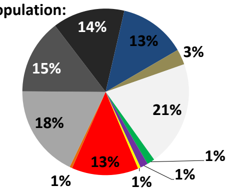

Figure 2 : Color Frequency Data from January 2017 - October 2017

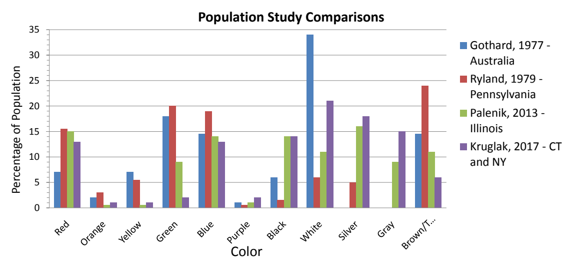

Figure 3: Comparison of four different automotive paint population studies

Results from the Red Automotive Paints:

Microscopy:

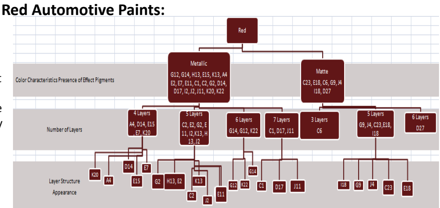

Figure 4: 1 pair out of 325 (0.3%) possible pairs were undifferentiated by microscopy alone.

Raman Microspectroscopy:

13 out of 26 resulted in fluorescence of the color coat.

8 identified as having Red Pigment 254 α present.

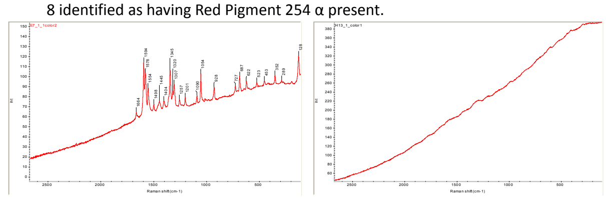

Figure 5: Raman spectra of (left) a sample which contained Red Pigment 254 α, and (right) a sample that exhibited fluorescence.

Results Continued

UV-Vis Microspectrophotometry:

3 pairs and 1 triplet were undifferentiated using only spectra of top coats

All pairs differentiated using spectra of color and top coats

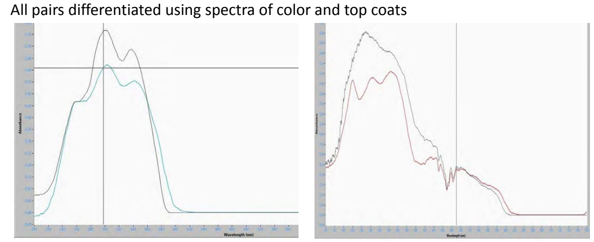

Figure 6: UV-Vis MSP spectra of (left) two samples with similar top coats, and (right) the same two samples which were differentiated by their color coats.

FT-IR Microspectroscopy:

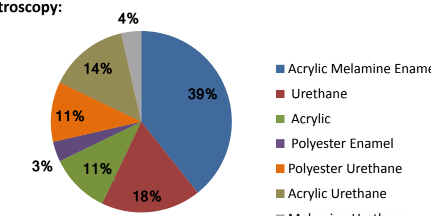

Figure 7: Chemical Composition Frequency of Clear Coats

Conclusions

This research concluded that after using both microscopical and analytical methods, all red automotive paints from this population were able to be differentiated from each other.

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Handling Situation-based Evidence in Identity Cases

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Advisor: Albert Esterline

Abstract

- This poster reports on an effort that is formulating a computational framework for identity that is useable in forensic and other contexts.
- Current work focuses on physical crime scenes, but the focus is expanding to cyber space.
- This work captures how evidence in a case involving a crime scene conspires to support various identity judgments.
- Ontologies are being developed to capture a case as a constellation of situations where info is recorded or applied.
- Dempster-Shafer theory is adapted to provide the framework for manipulating and combining information regarded as evidence.

Introduction

The criminal justice system relies heavily on evidence
- Dempster-Shafer theory provides powerful mechanisms for determining what confidence one may have in evidence combined from several sources and possibly modified

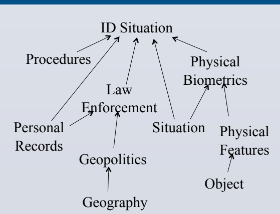
There is considerable structure in a legal case that makes available information in which we may have various levels of confidence
- We capture this structure using a family of ontologies
- We adapt Dempster-Shafer theory to exploit this structure

Situation Theory (cf. Barwise & Perry, Devlin)

- A *situation* supports information, may carry info about another situation
- A basic item of info supported by a situation is an *infon*, involving an *n*-place relation *R*, *n* objects to fill the roles in *R*, a location, and a time
- Situation semantics (situation theory applied to language) sees the meaning of an expression as a relation between an *utterance situation* and a *described situation*
- There are also *resource situations* to fill out references
- One situation carries information about another by virtue of *constraints*, e.g., "Smoke means fire"
- The constraints by which an utterance situation carries information about a described situation are the conventions of natural language
- We consider making an identity judgment (as in a CSI) to be an utterance situation (called *an id-situation*), part of a constellation of situations making up a case (an *id-case*)
  - The crime scene is the described situation
  - Resource situations include, e.g., where a fingerprint was filed, where one took a facial image to train a classifier

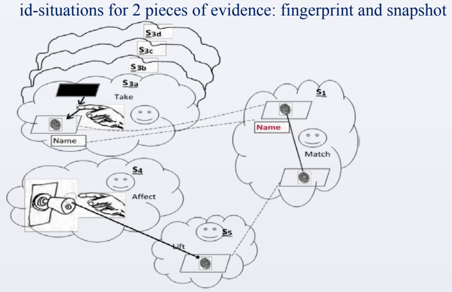
Ontologies

We define concepts used in representing id-cases in OWL ontologies

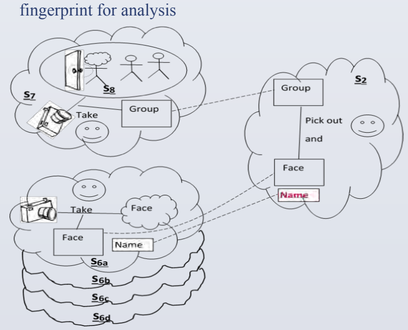


Example

- A theft has occurred during a party. We have a list of possible suspects in the form of a guest list. We have
  - a group photograph from a security camera with 1guest with their hand on the door to the valuables
  - a fingerprint from that same door.
- This scenario is a constellation of situations, centering around 2 id-situations for 2 pieces of evidence: fingerprint and snapshot



- In situation s_1 (an id-situation), the analysts compare fingerprints of each suspect with fingerprints from the crime scene to get similarity measures
- This requires (by convention) resource situations s_{3a}, s_{3b}, s_{3c}, s_{3d} where officers collected the fingerprints on file
- In s_4 (part of the crime scene, the described situation), the culprit leaves their fingerprint on the doorknob
- In s_5 (a resource situation), the investigators make a copy of the fingerprint for analysis



- In s_2 (an id-situation), the analysts compare the photograph from the security camera with mugshots of the suspects to get similarity measures
- s_1 and s_2 are coordinated id-situations (supporting the same id-judgment)
- This requires (by convention) resource situations $s_{6a\text{-}d}$ where officers took those mugshots
- In s_7 (a resource situation that includes the described situation, s_8), the security camera takes the picture of the crime used in s_2
- Situation s_8 is the described situation for id-situation s_2 and also described (as dictated by situation theory) by s_7. s_8 contains s_4
- This is encoded in RDF triples stores using the concept/ defined in our ontologies. Query the triple stores with SPARQL

Dempster-Shafer (DS) Theory

- DS theory provides a numerical measure of confidence in our identities . It assigns *mass* to sets of elements, with the total mass summing to 1.0
- Any set of elements, including singletons, with some non-zero mass is a *focal element*
- Mass associated with a non-singleton set represents evidence for some element or other in that set. Unlike with probability theory, mass/probability associated with a non-singleton cannot be distributed to its elements
- The set of all possible elements is the *frame of discernment*. Uncertainty is preserved by assigning mass to the entire frame
- Frames of discernment can be analyzed to create new, *refined* frames in refinements
- The *belief* associated with a set is a lower bound on its likelihood and is determined by adding the masses of all of its subsets
- The *plausibility* of a set is an upper bound on its likelihood and is the sum of the masses of all sets that overlap with it
- DS theory provides a number of rules to combine mass functions while maintaining uncertainty
- We consider each id-situation and its associated situations to result in its own mass function and provide evidence for the likelihood that each suspect was the criminal
- Our scenario provides a numerical similarity measure between each suspect and the crime scene for each piece of evidence (fingerprint and mugshot)
  - These are turned into a mass function and combined to provide a single mass function for all evidence

Combining Mass Functions

- We use Dempster's rule for combining mass functions
  - It divides conflict between the different mass functions evenly among the focal elements and does not assign it to uncertainty
  - It works reasonably well for our scenario because conflict among different pieces of evidence is likely not indicating that the suspect is unknown
- Yager's rule applies all conflict directly to uncertainty,
  - It would be fitting, e.g., in a scenario where we believed evidence was planted to blame an innocent
- One existing combination rule, Zhang's center combination rule, takes in evidence from two separate frames of discernment

Constraints and Refinements

- Every piece of evidence used in the id-situation was collected in some other situation following appropriate legal procedures and preserved so as to maintain a chain of custody
- These protocols are conventions that establish constraints between the id-situation and these other, resource situations
- Numerically, there are 3 possible interpretations of constraints

1. Each (set of) situation(s) is a separate mass function
2. Each resource situation is considered a refinement of the frame of discernment created in the id-situation
3. A resource situation modifies the mass function of the id-situation

Implementation and Results

- Info on the various situations was retrieved from the RDF triple stores with SPARQL using the Jena Semantic-Web framework
- DS theory implemented in Python
- Matches originally expressed as distances were converted to masses with an inverting signmoid function (smaller distance gives greater mass) and normalizing

Mass values obtained from fingerprint evidence, along each step of their determination

- Final mass includes 0.228 for the frame of discernment to bring the sum to 1.0

Suspect ID	Fingerprint Distance	Initial Mass	Analyst reliability	FP taker reliability	Final Mass
201	0.430	0.373	0.800	0.980	0.292
202	0.660	0.000	0.800	0.860	0.000
203	0.490	0.342	0.910	0.810	0.252
204	0.570	0.286	0.800	0.860	0.197

Mass, belief, and plausibility measures for the 3 mass functions created by our 2 id-situations and their combination using Dempster's rule

Fingerprint Evidence			
Suspect	Mass	Belief	Plaus
201	0.292	0.292	0.551
202	0.000	0.000	0.259
203	0.252	0.252	0.511
204	0.197	0.197	0.456
All	0.259	1	1
Photographic Evidence			
Suspect	Mass	Belief	Plaus
201	0.503	0.503	0.678
202	0	0	0.175
203	0.322	0.322	0.497
204	0	0	0.175
All	0.175	1	1
Combined Evidence			
Suspect	Mass	Belief	Plaus
201	0.532	0.532	0.605
202	0	0	0.073
203	0.338	0.338	0.411
204	0.056	0.056	0.129
All	0.073	1	1

Conclusion and Future Work

- We present a framework of identity based on situation theory that considers id-cases, where a number of situations conspire to support a judgment of identity
- These situations are represented using semantic web resources
- Each id-case provides evidence for forming a mass function as described by Dempster-Shafer theory
- The id-situation gives us an initial mass function, which is modified based on the resource situations
- Future work will consider different combination rules and applications of Dempster-Shafer theory, look at weighting evidence
- Increase our set of scenarios, particularly ones with vague evidence pointing to non-singleton sets
- Our software will be web-accessible, used by students in the Criminal Justice Program at A&T

Acknowledgments

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Duct Tape Physical Matching by Various Separation Methods Using Quantitative Analysis

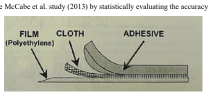
Michelle Bartley Marx

BACKGROUND

Physical matching is defined by AFTE as the "examination of two or more objects … through physical, optical, or photographic means which permits one to conclude whether the objects were either one entity or were held or bonded together in a unique arrangement." Physical matching is the strongest association in forensic science comparative examinations and has significantly high evidentiary value.

Duct tape is often associated with criminal activity, such as binding victims, abductions, rapes, and murders as well as the wrapping of drug parcels and construction of explosive devices. Duct tape can be used as an evidentiary link between the suspect and victim, suspect and crime, and the suspect and multiple crimes.

This study intended to further the results obtained from the McCabe et al. study (2013) by statistically evaluating the accuracy and error rates association with physical matching of industrial strength duct tape.



Minnesota Department of Public Safety: Bureau of Criminal Apprehension. (n.d.). *Tape*. Retrieved from https://dps.mn.gov/divisions/bca/bca-divisions/forensic-science/Pages/trace-tape.aspx. (above)
Ahonen, M.A. (2012). *Admissibility package for tape all wrapped up* [PDF document]. Retrieved from http://projects.nfstc.org/trace/2009/presentations/6-ahonen-tape.pdf. (left)

MATERIALS

- Nashua 357 Premium Grade Duct Tape
- 3M 3939 Heavy Duty Tape
- Pro Duct 120 Industrial Grade Duct Tape
- Intertape Polymer Group 9600/AC 29 Utility Duct Tape
- Duck Brand Maximum Strength Industrial Grade Duct Tape

METHODS

Blind study observing four methods of separation
- Hand torn (800 pairs)
- Scissor cut (300 pairs)
- Box cutter cut (200 pairs)
- Paper cutter cut (200 pairs)

STEPS
- Create duct tape pairs for each brand and for each separation method
- Assign numbers to matching pairs
- Assign envelopes to exemplars
- Create matching and non-matching pairs

Determine match, non-match, or inconclusive by
- Observing overlaps and gaps
- Observing edge alignment
- Observing scrim alignment

Accuracy rate
- Percentage of correctly reported matches and non-matches (excluding inconclusive)

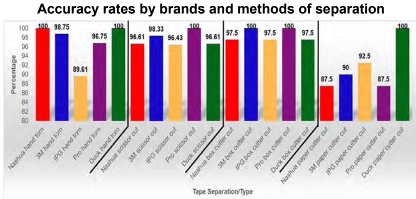
Inconclusive rate
- Percentage of inconclusive results out of all true matching and non-matching pairs

False-positive rate
- Percentage of incorrectly reported matches out of true non-matching pairs

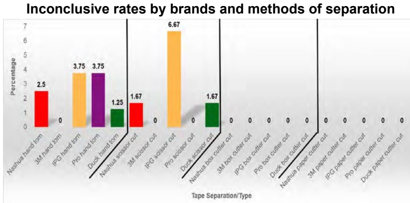
False-negative rate
- Percentage of incorrectly reported non-matches out of true matching pairs

RESULTS

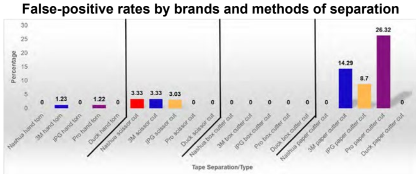
Accuracy rates by brands and methods of separation



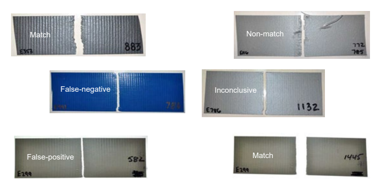
Inconclusive rates by brands and methods of separation



False-positive rates by brands and methods of separation

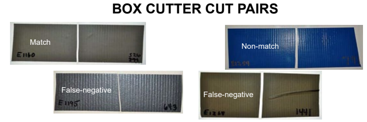


HAND TORN PAIRS

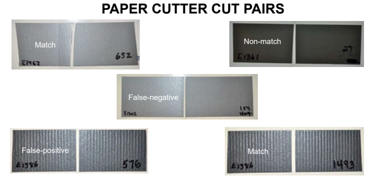


SCISSOR CUT PAIRS

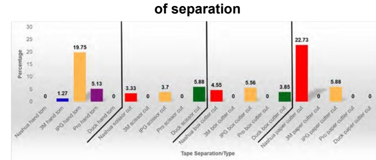
BOX CUTTER CUT PAIRS



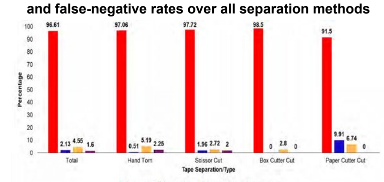
PAPER CUTTER CUT PAIRS



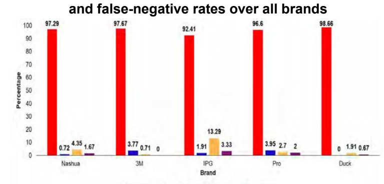
False-negative rates by brands and methods of separation



Accuracy rates, inconclusive rates, false-positive rates, and false-negative rates over all separation methods



Accuracy rates, inconclusive rates, false-positive rates, and false-negative rates over all brands



CONCLUSIONS

This study showed a high degree of accuracy associated with the physical matching technique.
- Accuracy rates ranged from 91.50% to 98.50% (96.61% overall)
- Misidentifications ranged from 1.50% to 8.50% (3.39% overall)

This study showed that stronger grades are less prone to distortion and stretch upon separation.
- Less distortion: increased false-positive identifications
- More distortion: increased false-negative identifications and inconclusive results

This study showed that tape grade affects the analyst's ability to correctly identify duct tape physical matches.
- Weaker grades: highest number of misidentifications
- Stronger grades: least number of misidentifications

This study showed that the method of separation affects the analyst's ability to identify duct tape physical matches.

This study showed that when an analyst is uncertain whether the pair is a match or non-match it should be reported as inconclusive to avoid false-positive and false-negative results.

Non-matches would still undergo further testing.

A relatively untrained analyst can achieve a high accuracy rate utilizing the physical matching technique.

This study can also be used to examine the evidentiary value of an individual analyst's testimony when declaring a duct tape pair a match or non-match although these values have not yet been calculated.

FUTURE RESEARCH

Further exploration on the interactions between brand and grade on error rates is necessary.

Ensure that all brands have similar strength.

Look at the opposite grades (stronger/weaker) of duct tapes used in the study.

Continue to examine more samples to fully understand error rates on duct tape physical matching,

Have other analysts examine the 1500 pairs (peer review).

It would also be advantageous to add more brands of industrial and general grades strengths to continue evaluation whether brand, grade, or separation method has a greater effect on an analyst's accuracy and error rates.

It is also necessary to continue to increase the sample size in order to show the reliability of the physical matching technique.

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Fingerprints on Clothing: Evidence About Fingerprint Visualization on Distinct Types of Fabrics

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INTRODUCTION

- Fingerprints are one of the most common evidence found at crime scenes and can help to get an identification or exclusion of suspects;
- The knowledge on the development of fingerprints in different surfaces (porous and non-porous) is increasing;
- There are few techniques to visualize fingerprints on clothing.

METHODS

- 13 different types of fabrics were tested: cotton, linen, silk, satin silk, wool, polyester, acetate, viscose, nylon, cotton(40%)-polyester(60%),cotton(60%)-polyester (40%), lycra-elastane and cotton(97%)-elastane(3%);
- 5 black samples and 5 white samples of each type of fabric;
- Authenticity of samples was confirmed using Fourier Transform Infrared Spectroscopy (FTIR) and microscope visualization;
- 2 different techniques were used: Ninhydrin and Lumyciano.

RESULTS

- Ninhydrin developed naked-eye fingerprints in white samples but not in black samples (table 1);
- Quality of fingerprints was classified from 0 to 4 as in previous studies, with 4 representing good and detailed marks (Fraser *et al.*, 2011);
- Some samples had better quality fingerprints after 8 days (→), this happened because Ninhydrin is a liquid solution that only develops fingerprints when it is dried and some fabrics take more time to do dry. On the other hand some samples lose quality of visualization due to the spread of Ninhydrin into the fabric.

Fabric Type - Color	Detail White light
Cotton - black	0
Cotton - white	1→2
Wool - black	0
Wool - white	1
Linen - black	0
Linen - white	1→2
Silk - black	0
Silk - white	1
Satin silk - black	0
Satin silk - white	1
Polyester - black	0
Polyester - white	1
Nylon - black	0
Nylon - white	0→1
Cotton-elastane - black	0
Cotton-elastane - white	1
Cotton(40%) -polyester(60%) -black	0
Cotton(40%) -polyester(60%) - white	1
Cotton(60%) -polyester(40%) - black	0
Cotton(60%) -polyester(40%) - white	1
Lycra-elastane - black	0
Lycra-elastane - white	0
Acetate - black	0
Acetate - white	2→3
Visoce - black	0
Viscose - white	1

Table 1— Results with Ninhydrin technique

- Lumicyano developed fingerprints in almost all black samples and in a few white samples (but when visualized using fluorescent light) - table 2;
- Lumicyano manufacturers reported that ultraviolet light was the most suitable for the development of fingerprints, but in fact, this research suggests that higher wavelengths were more efficient.

Fabric Type - Color	Detail - White light	Detail - UV
Cotton - black	0	1
Cotton - white	0	0
Wool - black	0	0
Wool - white	0	0
Linen - black	0	0
Linen - white	0	0
Silk - black	2	1
Silk - white	0	0
Satin silk - black	2	1
Satin silk - white	0	0
Polyester - black	3	1
Polyester - white	0	0
Nylon - black	3	3
Nylon - white	0	3
Cotton-elastane - black	1	0
Cotton-elastane - white	0	0
Cotton(40%) -polyester(60%) - black	2	1
Cotton(40%) -polyester(60%) - white	0	1
Cotton(60%) -polyester(40%) - black	3	1
Cotton(60%) -polyester(40%) - white	0	3
Lycra-elastane - black	2	2
Lycra-elastane - white	0	0
Acetate - black	2	2
Acetate - white	0	0
Visoce - black	0	0
Viscose - white	0	0

Table 2— Results with Lumicyano technique

CONCLUSIONS

- With these techniques it was possible to visualize fingerprints on clothes with some level of detail of patterns and features;
- Ninhydrin developed fingerprints only in white fabrics and Lumicyano developed better results in black than in white samples;
- With these two chemicals, positive results were obtained, which means that these techniques are suitable to be used on fabrics to help criminal investigations.

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