Evaluation of techniques to visualize fingerprints at different times on various soft surfaces

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Abstract:

Fingerprints on different surfaces can be visualized using forensic investigation techniques. The research focuses on using five samples which contain unique physical and chemical qualities. A thumbprint deposition was made on the samples allowing the use of procedures to determine whether the resolution of the fingerprint ridges can be seen with the techniques being analyzed. The purpose of the research allows forensic scientists to use other techniques to photograph fingerprints on materials not commonly found at crime scenes for better identification of the individual. These instruments can be used instead of regular photography if they function better with the qualities of the material. The techniques tested include: gel lifters and the Video Spectral Comparator. All of the fingerprints were visualized by the VSC (before and after 2 weeks) using different light sources. The duration of the research was approximately 3 weeks. This allowed time for the surfaces to undergo any changes they might be capable of. Using the gel lifters, only three of the five surfaces allowed the prints to be lifted. However, the other two surfaces were not capable of being lifted producing no photographs with the VSC. In conclusion, the Video Spectral Comparator is a helpful aid in forensic investigations because it allows prints to be visualized quite well even though the software is mostly used in document evaluations. The gel lifters can only be used on surfaces which retain moisture. If the surface undergoes significant drying, the gel lifters will not be able to lift the fingerprint. However, both methods have been determined to be good for the visualization of fingerprints on various soft surfaces due to the retention of ridge detail.

Keywords: alternating light sources, fingerprints, gel lifters, soft surfaces, Video Spectral Comparator (VSC), visualization

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Introduction

Limited research has been conducted on visualization of fingerprints on various soft surfaces. Soft surfaces all have very different chemical and physical qualities allowing for variation when being visualized by forensics methods.1 The variation is due to how surfaces react under different methods and reduce the bias in the evaluation. Thus, the surface which contains the fingerprint is very important because it can allow for faster and better methods to be used when a print is recovered from a crime scene in the future. The purpose of the research is to evaluate two different capacities and the reliability of their visualization efficiency on various soft surfaces which contain the right thumbprint of one specific individual. The surfaces chosen for the research include: caulk, clay, nail polish, paint and toothpaste. Since all the materials contain different properties they undergo different methods of visualization better.

The proficiencies evaluated in the research are: gel lifters (both black and white colours depending on the surface for better contrast) and the Video Spectral Comparator machine. The gel lifters were used to lift the fingerprints from the soft surfaces after two weeks. The duration of the two weeks allowed the surfaces to dry to their fullest potential in order to evaluate the accessibility of the gel lifters. This part of the research can give forensic investigators an idea of which surfaces will interact with the gel lifters for better visualization thus reducing the time of analysis. Gel lifters are most commonly used to lift forensic evidence such as fingerprints for easier transportation to the laboratory.2 The composition of the gel lifters (thick, non-aggressive, low-adhesive gelatin layer) allows for lifting from almost every surface encountered, even porous surfaces like paper or cardboard.2 Fingerprints lifted with gel lifters can be visualized using photography techniques for a more thorough examination.2 The gel lifters are protected by transparent polyester film which is removed when the print is to be lifted, however, the cover sheet may be placed back onto the lifter after photographs have been taken.2 Forensic investigators should avoid placing the cover sheet back on the print if air bubbles begin to form. The Video Spectral Comparator instrument was used to take photographs after the initial deposit of the thumbprint and after two weeks. The VSC is mostly used for document investigations when a questioned document is being examined. The instrument allows for the lighting examination of documents.3 The VSC views and records the responses of documents/inks when under examination to light of various wavelengths.3 This gives the VSC an upper hand in document (passports and driving licenses), and ink examinations.4 The machine also distinguishes between altered and non-altered entries.3 The Video Spectral Comparator uses many lighting resources which include: visible, infrared, UV, transmitted, coaxial and oblique light.3 However, the research uses the Video Spectral Comparator to take photographs under different wavelengths and is being evaluated for the quality of photographs it produces for fingerprint ridge visualization.

In the first literature resource, the paper introduces a nondestructive technique for the collection and chemical identification of latent prints.5 The research included using two different types of lifting media which were analyzed by ATR-FT-IR spectroscopic imaging.5 This is the first paper to develop chemical images of latent fingerprints which were collected by gel lifters from different surfaces.5 The images were taken at different depths using ATR-FT-IR with a variable angle ATR accessory to reduce disturbance from the surface.5 The research shows great potential for forensic investigations of samples of interest.5

The research conducted in the literature resource is very different from the research conducted in this paper. Both papers analyze gel lifters and their lifting efficiency. However, the literature depends on a more chemical approach rather than visual. This research will identify gaps in timely forensic procedures. It will help determine which visualization technique should be used on various different surfaces, even if those surfaces are not found at crime scenes very often. It will bridge the time gap and will allow for faster and smarter analysis. This leads to the culprit being convicted on a timely basis.
In the second paper by Simon Bunter it discusses the amount of time an identifiable fingerprint can be retained on an exterior surface. The research indicates that some prints in materials from food and linseed oil can be retained well over 2 and a half years on a non-porous surface. This idea has been developed under different UK weather conditions in an external environment. The fingerprints were able to be visualized without fingerprint powder enhancements indicating good quality and suitability for identification. The results indicate various fingerprints can be visualized despite the weather and environmental conditions they undergo.

**Materials and Methods**

(i) **Surfaces**

The research began by choosing five different soft surfaces. All five of these soft surfaces contain special chemical and physical characteristics allowing for variation in between samples and reducing bias. Some of the samples contain more moisture than other samples, while other samples undergo drying more rapidly thus, not capable of being subjected to techniques important in the forensic science field. Most of the surfaces chosen are usually not found at crime scenes often. This allows for further information to be discovered when these materials are found in the future. Most but not all of the surfaces have a liquid component when distributed, however, over time the samples dry depending on their specific chemical constituents. The only surface which was a solid when distributed was the modelling clay but with enough time it dries as well.

(ii) **Experiment Setup**

All of the samples were distributed upon the translucent sheet on the same day so they could be subjected to the same time interval. They were distributed as uniformly as possible using clean popsicle sticks (for each surface to avoid plausible contamination). Once the materials were spread onto the translucent sheet as a thin layer, they were allowed sufficient drying time in order for the surfaces to retain the thumbprint. Once dry, the right thumbprint of one individual was deposited onto each surface. In between deposits, the right thumb was washed and dried for no interference for the next deposit. For example, when the thumbprint was laid in the paint sample, it was washed and dried and then laid onto the upcoming sample. A control thumbprint was developed with ink on blank paper and a photograph was taken using the individual’s iPhone 5s camera for comparison between the alternating light sources.

(iii) **Video Spectral Comparator**

After all of the samples had been prepared, the samples were then taken and analyzed by the Video Spectral Comparator. The VSC was used to take photographs of the thumbprints and to indicate whether the ridge details can be seen on those particular surfaces. After the initial deposit, the photographs were taken using alternating light sources available on the software (Group 1). When finished, the samples were left in the laboratory fume hood without any disruption for approximately 2 weeks. The time should have allowed some changes to occur within the material which may have altered the thumbprint ridge details. In the mean time, after the 2 weeks passed the materials were once again subjected to the VSC machine allowing a second set of pictures to be taken known as Group 2.

(iv) **Gel lifters**

Then the thumbprints were proceeded to be lifted with either black or white gel lifters according to the best contrast undertaken. Hence, if the surface with the thumbprint contained a white colour, then the gel lifter used would be black and so forth. Subsequently, the gel lifters with the thumbprints were then subjected to visualization by the VSC software allowing a third set of photographs to be taken indicated as Group 3. The
methods evaluated include: gel lifters and the Video Spectral Comparator. The research focused on whether or not they will be a visualization aid to forensic investigators if they ever encounter these types of materials at a crime scene in the distant future.

(v) Materials

The materials used include:

I. Kwik Seal - Kitchen & Bath Adhesive Caulk
II. Crafts - Modelling Clay
III. L’Oreal Nail Color - Hit the Slopes (712)
IV. DecoArt Crafter’s Acrylic - Cherry Blossom Pink
V. Colgate Fluoride Toothpaste

Results

All of the surfaces containing thumbprints were able to be visualized using the Video Spectral Comparator. Every surface was visualized using various alternating light sources thus, a wide range of photographs was taken. This is a benefit for the software because not only does it examine documents at a high resolution rate, it allows photographs of fingerprint ridges to be taken using the different alternating light sources contained. The alternating light sources the software contains helps in the evolution of new techniques to visualize fingerprints on materials not commonly found at crime scenes. The VSC machine contains different types of light such as: normal flood light, UV light, transmitted light, oblique and many other types. Due to the various selection of light, fingerprints on unique surfaces can be photographed at high resolution images showing all or most of the ridge detail.

For Group 1 photographs, the thumbprints were visualized using the VSC after the initial deposit. Firstly, the caulking surface was visualized using the VSC machine. The caulking material was not significantly uniform as the drying time was difficult to estimate before depositing the thumbprint. The colour of the caulking was white and the texture was very thick which was difficult to distribute evenly. The caulking was visualized the best under both oblique and transmitted light. The oblique light allowed for better enhancement of the fingerprint ridges while transmitted light gave more depth to the core of the fingerprint (Fig. 1, 2). Secondly, the clay surface thumbprint was best seen using oblique left light after the initial deposit. The fingerprint ridges are best seen in the clay material compared to others. The ridges are clear and contain better resolution for identification purposes (Fig. 3). Thirdly, the nail polish was also visualized with the software. The nail polish had a white colour and contained reflective properties which made it difficult to capture a good photograph. The nail polish was captured with ultraviolet light. Fourthly, the paint had a cherry blossom pink colour and was also not uniform when distributed due to the physicality of the material. The paint was best visualized under normal flood light unlike the rest of the surfaces. However, the colours were changed in order for better contrast allowing the thumbprint on the paint surface to be photographed in black and white for better resolution and depth perception (Fig. 4). Lastly, the toothpaste will be discussed. The toothpaste had a dark blue colour containing crystals which can be seen in the photographs. The toothpaste was easy to place on the translucent sheet because of its physical nature and it was distributed as a thin layer. The best light for the visualization of the thumbprints was transmitted. The transmitted light gave the ridges good quality for
comparison especially the outer sides of the fingerprint. The core of the fingerprint was somewhat difficult to see using this surface (Fig. 5). The contrast levels were also adjusted to account for better visualization.

Next, Group 2 photographs will be discussed. Group 2 photographs include the surfaces after not being disturbed for 2 weeks. The surfaces were once again visualized using the Video Spectral Comparator. Firstly, the caulking was visualized under three different sets of lights. The first alternating light source used was normal flood light. The normal flood light gave some resolution to the fingerprint ridges but the overall photograph remained blurry and not in focus (Fig. 6). This could be compared to an image that was taken by a regular camera or any mobile phone. The next light used was ultraviolet light (312nm). This light gave the overall image a blue background which enhanced the contrast of the white caulking. When looking at the fingerprint ridges, the outer edges can be interpreted quite heavily while the core of the fingerprint cannot be visualized as well. This could also be due to the surface not being constant which is the most likely in forensic cases. Out of all of the wavelengths on the ultraviolet spectrum, the best was 312nm as depicted. However, the fingerprint ridges on the caulking cannot be clearly determined using ultraviolet light. The last alternating light source used on the caulking after two weeks was oblique left lighting. This light was the best out of the three because it allowed the ridges to be seen clearly in detail and gave the print sufficient lighting from the left side (Fig. 7). The left side was chosen over the right side because of the amount of details which could be seen. This type of light will certainly help forensic investigators in cases which encounter a caulking surface. The oblique left light is the best for caulking while normal flood light is the worst choice. Secondly, the clay surface was then visualized using both oblique light and visible light. The visible lighting did not enhance the thumbprint ridge details to its fullest potential. The outer ridge details can be seen with some perspective but the core of the thumbprint is not noticeable making it more difficult for fingerprint examiners to determine the type of primary pattern. The visible light made the clay colour background blue which allowed for the visualization of thumbprint ridges to be a white colour. The depth of the fingerprint could still be noticed just by observing the photograph. The second light source used was oblique left light. Once again, the oblique left light is a good match for the clay surface as it was for the caulking. The light allows the ridge details to be seen with great depth and the ridge details can be individualized into their separate categories such as bifurcations, ridge endings, islands, etc. This is very helpful when the thumbprints are being compared to known databases. The thumbprint is significantly enhanced with oblique lighting and does not cause a big reflection on the surface. Thirdly, the nail polish surface was visualized again using the VSC. The nail polish was visualized using two different sets of light including: coaxial and transmitted light. When using coaxial light at 3%, which is light coming from all sides of the instrument, the details can be seen somewhat but very hard to decipher the minutiae details. The entire thumbprint is blurry using coaxial light and does not do a good job enhancing the technicalities (Fig. 8). The other light used was transmitted light. The thumbprint ridges are hidden due to the developed cloudiness of the light which could have been produced due to the reflective qualities. The minutiae can be seen in various parts of the fingerprint such as the outer sides and the core. The core of the fingerprint is visualized the best using the nail polish surface because the photograph indicates the individual who deposited the print has a primary pattern known as a loop (Fig. 9). Most of the other surfaces which have been discussed early on have no clear indication of a primary loop. Therefore, if a nail polish pattern is ever found in the future, this will aid investigators in reducing the suspect pool to only people with the same primary pattern found on the surface. Fourthly, the paint was visualized after two weeks using three different alternating light sources. The three include: normal flood light (3% and 8%), ultraviolet light, and transmitted light. Using normal light at 3% can help visualize the ridges but at a very low resolution. Fingerprint ridges are very hard to see because they seem to blend into each other which could be a result of the surface not being uniform physically. In the first group, the surface was visualized using normal light however the photograph was converted to black and white for better contrast. If this was done with Group 2 paint photographs, the ridges would have developed more. Next, the surface was visualized with normal flood light but using 8%. Normal flood lighting at
8% was even worse than the initial one because it made the photograph too bright thus distorting the minutiae (Fig. 10). The minutiae look disrupted due to the fact the thumbprint looks doubled which produces overlapping ridge content. Lastly, the tooth paste was visualized under transmitted and oblique lighting. The transmitted light allowed for partial viewing of the outside thumbprint. The entire core of the fingerprint cannot be seen on the tooth paste surface. However, using transmitted light on the tooth paste surface allowed for a cool analysis (Fig. 11). The second alternating light source includes oblique left lighting. This allowed for a better visual of the thumbprint ridges on the outside. However, once again the core of the fingerprint could not be indicated because it was non-existent. This is most likely due to the surface itself and how well it retains indented details. The two photographs are quite different from each other allowing scientists to understand the differences between the alternating light sources commonly used in the forensic science field (Fig. 12).

Lastly, Group 3 photographs were taken after the surfaces were attempted to be lifted with gel lifters and then visualized by the VSC machine. Three out of the five surfaces used were able to be lifted with the provided gel lifters. Those surfaces include: Crafts - Modelling Clay, L’Oreal Nail Color - Hit the Slopes (712), and Colgate Fluoride Toothpaste. The lifter colours included both black and white to correlate for the colour of the surface. However, two of the five surfaces were unable to be lifted due to their properties. The surfaces which retained moisture were the ones which were capable of being lifted unlike the really dry surfaces. The clay surface was lifted easily due to the moisture it retained even after two weeks. The thumbprint ridges are clear and can be interpreted using secondary patterns (Fig. 13). The photograph was taken with coaxial light allowing good contrast and brightness. The reflectiveness of the gel lifter combined with the light produced big spots of light in various regions on the lifted thumbprint. This produced large areas of invisible minutiae which is useful to forensic scientists. The second photograph taken had adjusted contrast. This did not help much because the outer ridges of the fingerprint were not visible (Fig. 14). Only the middle area of the fingerprint is visible clearly. This area can be used for identification and comparison. Thus, the gel lifter is very helpful in investigations which contain clay as a surface but the VSC combined with the gel lifter is not as useful due to qualities the techniques contain. The tooth paste surface was the second easiest to lift out of the three. The texture of the tooth paste was very soft and contained moisture allowing for better lifting technique. The VSC was used with coaxial light. This helped light the entire print and show the fingerprint ridges. The ridges are very difficult to identify because the surface is not constant (Fig. 15). Using the gel lifters works for tooth paste but it distorts the actual ridge details making it hard to distinguish between secondary patterns on the print (Fig. 15). The next surface lifted was nail polish. The nail polish surface was the only surface which was lifted entirely (meaning the actual material was lifted). This is most commonly due to the physical aspect of the surface being very thin and plastic-like. When the nail polish surface was being lifted, a quarter of the print ripped and later on it was difficult to place the pieces back together onto the gel lifter. The best way to lift the nail polish would be to lift in one go. Using coaxial light, the thumbprint ridges are visible, however they are very distorted due to the viscosity of the surface. The lifting of the fingerprint produces bubbles on the surface which is not useful for forensic identification officers (Fig. 16). In Group 3, the two surfaces which were not lifted included: caulkking and paint. The caulking surface was too dry to be lifted properly while everything on the paint surface would lift except the thumbprint itself. This research goes to show gel lifters are useful on some materials and not on others.
Figures
Not all of the photographs taken with the Video Spectral Comparator are depicted in the research paper (only the pictures showing different pros and cons of the techniques).

Fig. 1: Group 1: Caulking visualized using oblique lighting

Fig. 2: Group 1: Caulking visualized using transmitted light

Fig. 3: Group 1: Modelling clay visualized using oblique left light

Fig. 4: Group 1: Paint visualized under normal flood light (with adjusted contrasts)

Fig. 5: Group 1: Tooth paste visualized using transmitted light (with adjusted contrasts)

Fig. 6: Group 2: Caulking visualized using normal flood light
Fig. 7: Group 2: Caulking visualized using oblique left light

Fig. 8: Group 2: Nail polish visualized using coaxial light (3%)

Fig. 9: Group 2: Nail polish visualized using transmitted light

Fig. 10: Group 2: Paint visualized using normal flood light (8%)

Fig. 11: Group 2: Tooth paste visualized using transmitted light

Fig. 12: Group 2: Tooth paste visualized using oblique left light
Discussion

All of the surfaces used can be visualized using the Video Spectral Comparator machine. This machine is mostly used for document examinations in forensic science however this research has indicated the machine can be used to visualize fingerprints on various soft surfaces using many of the alternating light sources it pertains. This will be of great use when forensic investigators find a fingerprint on a surface which is not commonly seen at crime scenes. It will allow for better comparison and identification of unknown to known prints. For Group 1 and 2 photographs, the best alternating light source for the surfaces was oblique lighting (most frequently mentioned in the Results section). This is due to oblique lighting allowing for better resolution of the thumbprint ridges on most of the surfaces. Some other surfaces were visualized better using different lights but the majority were best seen with oblique lighting. Even if the surfaces were not uniform, the minutiae could be determined to some extent for exclusions but not concrete identifications. For Group 3 photographs, the gel lifter was seen to be helpful for three out of the five materials used. As mentioned in the Results section above, the surfaces must contain some moisture in order to be properly lifted. This is shown in the case of the modelling clay. The clay surface retained the best fingerprint after two weeks of no disturbance because it was able to lock in moisture and did not dry out as quickly such as the caulking surface. The chemical formula of both surfaces is different thus allowing for variability in the data. The clay surface was the easiest to lift and retained the fingerprint quite well. However, two out of the five surfaces did not lift as expected. These surfaces include: caulking and paint. The worst surface to lift was the caulking because the material would not bind to the gel lifter no matter how much pressure was applied.
Conclusion

This allows for interpretation that materials which undergo drying quickly will most likely not be able to be visualized with this technique. Unlike the VSC which works on all the surfaces tested, the gel lifters will only work on certain surfaces which contain moisture. Since not much research has been done using these techniques on fingerprints, the results cannot be interpreted using similarities or differences. The evaluation of these techniques depends on the materials being used and their composition. There has been limited research done on this topic thus allowing complete new introduction of techniques used to visualize fingerprints on various materials. If this research was taken one step further, many more surfaces could be experimentally tested to develop a better understanding. Then it can be subjected to further research using the CSIpix Matcher software to indicate any alterations in ridge details over various times however, it will take a much longer period of time to complete.

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