Technical Note

The Fingerprint Disaster Victim Identification Toolkit: From Powder to Biometrics

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Abstract: For the past 25 years, the Disaster Victim Identification (DVI) Squad of the Institut de Recherche Criminelle de la Gendarmerie Nationale, the Forensic Laboratory of the French Gendarmerie, has been involved in more than 80 identification missions of various types including natural disasters, aircraft crashes, road traffic accidents, and terrorist attacks. Members of this DVI squad have sometimes operated in extreme conditions, forcing them to adapt their equipment.

This technical note explores the use of a fingerprint disaster victim identification toolkit, which is a portable kit that was developed through years of experience by fingerprint experts. This toolkit not only allows the use of traditional techniques to produce postmortem records but also includes a biometric sensor with a specific interface, combined with a portable automated fingerprint identification system. This operational toolkit offers an all-in-one system, devoted to disaster victim identification.

Introduction

On January 20, 1992, 87 people were killed in the crash of an Airbus A320 near Mont Sainte-Odile in France. A disaster victim identification team was set up for the first time to face this large-scale disaster, even though the French Gendarmerie

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Forensic Institute–Institut de Recherche Criminelle de la Gendarmerie Nationale (IRCGN)–had few specialists at that time.

This event marked the birth of the Disaster Victim Identification (DVI) Squad of the French Gendarmerie, named Unité Gendarmerie d'Identification de Victimes de Catastrophes (UGIVC). Since then, members of this team have been deployed on more than 80 identification missions in France and abroad [1].

Members of the DVI squad have to be able to execute traditional fingerprinting techniques (e.g., photography, powder, ink, injection, rehydration, dissection) [2–10] as well as more modern techniques (e.g., kettle) [11,12] at the scene of any disaster and compare the collected postmortem data to antemortem data via a portable AFIS system. This is done through the use of a complete, robust, easy-to-implement, and easy-to-transport toolkit called The Fingerprint DVI Toolkit.

The DVI squad aims to meet the natural expectations of the families of victims. The families want to be able to dispose of the bodies of the deceased and allow them to rest in peace. However, unlike in the past, expectations have become more significant as strong media coverage of these events heightens public awareness. The pace of work of DVI squads is therefore impacted by this new context.

Terrorists' acts have led to a French interministrial instruction regarding attention to victims of terrorist acts [13], aimed in particular at better addressing the needs of the victims through a faster identification process, using technological advances in fingerprints, DNA, and odontology.

Fingerprint experts have to be familiar with many techniques. In many cases, the powder technique provides high-quality print impressions. However, this is too time-consuming when a fast identification process is needed. This need was fullfilled by the creation of the Fingerprint DVI Toolkit.

The Fingerprint DVI Toolkit

The Fingerprint DVI Toolkit consists of a modular transportation unit, a photography stand, the equipment needed to perform traditional techniques for fingerprinting a corpse and for hand restructuring, photographic and computer equipment, a biometric sensor, and a portable AFIS system.

The unit is housed in an air-transportable box with wheels and is covered with stainless steel panels in order to ensure a clean work surface (Figure 1). The unit can be moved via the use of four retractable handles and four rotating wheels, which must be locked once the unit is positioned. The covers can be opened by unlocking the top and bottom locking devices. The front and back covers can be used as work benches, supported by folding stands that are adjustable to two possible working heights.

The storage area is accessed by the removal of external panels. There are four storage spaces intended for the appropriate equipment (Figures 2, 3):

- A photography stand: This is mounted on the central section of the unit.
- A data processing kit: This includes a camera (Nikon D500 digital camera, Nikkor, 18–105 mm lens and 60 mm macro lens), a computer, a touch tablet, and an Integrated Biometric sensor (Watson Mini). This device is equipped with an interface developed by the IRCGN.
- A comparison computer (Figure 3): This is equipped with the MorphoBis AFIS system. The postmortem collected data and the known prints of assumed victims are entered in the system. This ensures short-time identifications in situ.
- A restructuring kit (Figure 4): This contains all of the conventional equipment (e.g, fingerprint powder, brushes, labels, syringes, scalpals) that is necessary to work on degraded (e.g., decomposed, drowned, burned, mummified) bodies.

Figure 1

Front and side views of the Fingerprint DVI Toolkit.

Figure 2
The different components of the Fingerprint DVI toolkit.

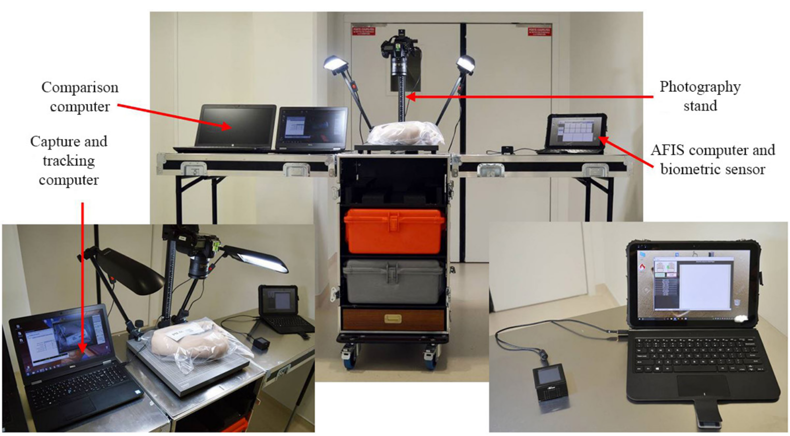

Figure 3
The Fingerprint DVI Toolkit deployed.

Figure 4

Restructuring kit.

Testing of Sensors

Aware of the necessity to adapt our methods to operational demands and needs, we tested the new electroluminescent sensor technology from Integrated Biometrics (Spartanburg, SC). This new technology used an electroluminescent film that creates the fingerprint image [14]. These sensors were designed to work under extreme conditions, similar to DVI situations. Traditional, optical, capacitive, or ultrasonic sensors were discarded because their ergonomics and their low efficiency on soiled fingers did not fit with a use on a postmortem chain of identification. Therefore, we tested three models of sensors distributed by Intergrated Biometrics: Kojak (Figure 5), Watson Mini (Figure 6), and Sherlock (Figure 7). All of the three sensors are FBI Appendix F certified and work with the same picture capture software. This software allows the user to choose the type of record: flat, rolled, or simultaneous impressions. The real-time display helps the user to obtain the best possible quality of the print. Data can be saved in different file formats: BMP, TIFF, JPG, or WSQ.

The Kojak sensor (135 mm x 90 mm x 115 mm) is very intuitive and enables image acquisition of four flat fingers and one rolled finger (thumb).

The Watson Mini sensor is smaller (60 mm x 60 mm x 30 mm). It enables image acquisition of one finger at a time (flat or rolled fingers).

The Sherlock sensor (80 mm x 75 mm x 20 mm) enables image acquisition of one finger at a time (flat or rolled fingers) and of two flat fingers.

A short experimentation was therefore conducted to estimate the benefit or the loss that this technology could represent, in comparison to traditional methods.

Besides experience-related dexterity, these techniques generally require hand processing and several steps, sometimes repeated, so as to obtain the wanted result. In the context of our tests, four corpses (Figures 8–11) were studied within the forensic examination laboratory of the IRCGN. First, we proceeded to postmortem fingerprinting using electroluminescent sensors from Integrated Biometrics: Kojak, Watson Mini, and Sherlock sensors. Second, we followed the traditional protocol adapted to each of the four corpses.

The time of execution for each of these techniques was measured, and print quality was assessed on a 3-point scale by the fingerprint experts of our unit (1: poor quality, 2: average quality, 3: good quality).

Figure 5

Kojak sensor - Integrated Biometrics.

Figure 6

Watson Mini sensor - Integrated Biometrics.

Figure 7

Sherlock sensor - Integrated Biometrics.

Figure 8
Corpse PM1.

Figure 9
Corpse PM2.

Figure 10
Corpse PM3.

Figure 11
Corpse PM4.

Results

Corpse PM1

All of the four fingerprint records were of very good quality. There was substantial contrast between the papillary ridges and furrows, and the pattern formed by the ridges was clearly legible (Figure 12). The processing times for fingerprinting were similar for the three sensors. The Watson Mini and the Sherlock sensors provided slightly faster results. A significant difference in time was observed when using the traditional method (Table 1).

PM1	**Sex: Male**		**Cause of Death: Firearm Suicide**			
Date of Death: 12/05/2016			**Date of Fingerprinting: 12/07/2016**			
Description: Left hand with a good state of preservation, close to living. The fingers are flexible and the epidermis is present, except on the index where the distal part is degraded.						
	Quality Assessment					
Sensor/Method	Thumb	Index	Middle	Ring	Little	Measured Time (minutes, seconds)
Kojak	3	3	3	3	3	1,40
Sherlock	3	3	3	3	3	1,30
Watson Mini	3	3	3	3	3	1,30
Traditional Method	3	3	3	3	3	8,00

Table 1

Comparison of the techniques for PM1.

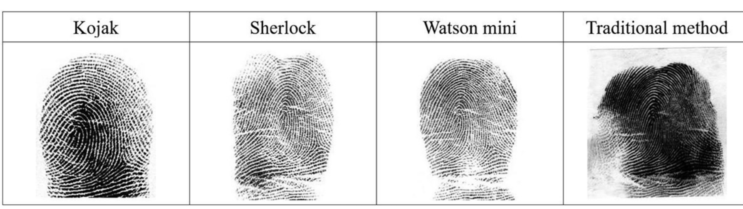

Figure 12

PM1 left middle finger impressions.

Corpse PM2

A restructuring process with subcutaneous injection was needed to perform the traditional technique because of the state of deterioration. Hot water rehydration was unsuccessful. The three images provided by the sensors were considered as average quality images. The lack of density and consistency on the finger surface generated dark areas on the images. The contrast between the papillary ridges and furrows was correct on the rest of the pattern (Figure 13). The processing times for fingerprinting were similar for the three sensors, although the Watson Mini sensor provided slightly faster results. However, a very significant difference in time was observed when using the traditional method, because of the need to use several techniques to get a good result (Table 2).

PM2	**Sex: Male**		**Cause of Death: Drowning**			
Date of Death: 12/28/2016			**Date of Fingerprinting: 1/02/2017**			
Description: Left hand showing that maceration stage has already begun. Wrinkles and crevices of various depth on palmar and finger surfaces. Some epidermis areas are about to peel off the dermis.						
	Quality Assessment					
Sensor/Method	Thumb	Index	Middle	Ring	Little	Measured Time (minutes, seconds)
Kojak	2	2	2	2	2	1,40
Sherlock	2	2	2	2	2	1,40
Watson Mini	2	2	2	2	2	1,30
Traditional Method	2	2	2	2	2	18,00

Table 2

Comparison of the techniques for PM2.

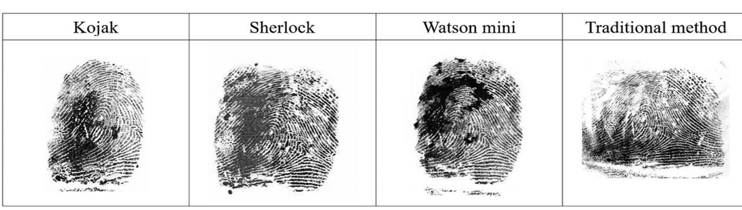

Figure 13

PM2 left middle finger impressions.

Corpse PM3

All of the four fingerprint records were of very good quality. There was substantial contrast between the papillary ridges and furrows, and the pattern formed by the ridges was clearly legible (Figure 14). The processing times for fingerprinting were similar for the three sensors, although the Watson Mini sensor provided slightly faster results. A significant difference in time was observed when using the traditional method (Table 3).

PM3	**Sex: Male**		**Cause of Death: Hospital Death**			
Date of Death: 1/31/2017			**Date of Fingerprinting: 3/02/2017**			
Description: Right hand with a good state of preservation, close to living. The epidermis is present. The fingers are flexible but wrinkles are already formed on distal areas.						
	Quality Assessment					
Sensor/Method	Thumb	Index	Middle	Ring	Little	Measured Time (minutes, seconds)
Kojak	3	3	3	3	3	1, 20
Sherlock	3	3	3	3	3	1, 20
Watson Mini	3	3	3	3	3	1, 10
Traditional Method	3	3	3	3	3	6, 00

Table 3

Comparison of the techniques for PM3.

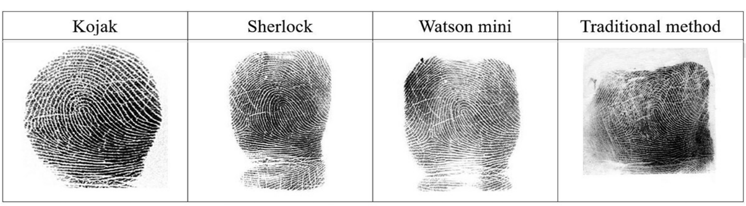

Figure 14

PM3 left middle finger impressions.

Corpse PM4

All of the four fingerprint records were of very good quality. The processing times for fingerprinting were similar for the three sensors, although the Watson Mini sensor provided slightly faster results. There was substantial contrast between the papillary ridges and furrows, and the pattern formed by the ridges was clearly legible (Figure 15). More time needed to be spent when using the traditional technique (Table 4).

PM4	Sex: Female		Cause of Death: Hospital Death			
Date of Death: 3/29/2017			Date of Fingerprinting: 3/30/2017			
Description: Left hand with a good state of preservation, close to living. The epidermis is present. The fingers are slightly stiff.						
	Quality Assessment					
Sensor/Method	Thumb	Index	Middle	Ring	Little	Measured Time (minutes, seconds)
Kojak	3	3	3	3	3	1,30
Sherlock	3	3	3	3	3	1,30
Watson Mini	3	3	3	3	3	1,20
Traditional Method	3	3	3	3	3	7,00

Table 4

Comparison of the techniques for PM4.

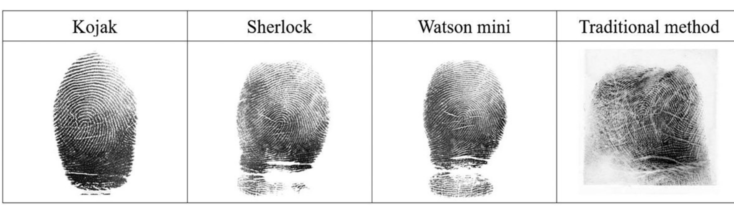

Figure 15

PM4 left middle finger impressions.

Discussion

Even though we are aware that these four cases do not reflect extreme examples of dehydrated or burned bodies, the study conducted on real cases demonstrates that electroluminescent sensors are of great interest. They not only offer a sufficient quality image but they also significantly reduce the processing time (Figure 16). Among the three tested sensors, the Watson Mini sensor was the quickest at getting the postmortem data. This difference is explained by the shape and the ergonomics of this device, making it easier for the expert who feels much more comfortable while taking the fingerprints. More importantly, the use of any sensor resulted in significant time savings while ensuring sufficient results to perform identifications [15].

In this study, Corpse PM2 was a special case for various reasons. First, this case was more complex than the three others in terms of finger deterioration. The results on this example show the advantage of the electroluminescent sensor but also reminds us that the use of the sensor might not be sufficient in extreme cases. We were able to successfully search the left middle finger from this corpse against the national database because this person was known to the national automated fingerprint database. The scores provided by the AFIS system (SAGEM Metamorpho) are given in Table 5.

Sensor/Method	Finger	Number of Minutiae Detected	Score	Rank
Kojak	Left middle	67	18392	1
Sherlock	Left middle	104	19407	1
Watson Mini	Left middle	80	22463	1
Traditional Method	Left middle	112	25934	1

Table 5

Number of minutiae detected, score, and rank for PM2 tested in the AFIS.

With a fingerprint expert approach, we determined that the traditional method offered more information, but was time-consuming. Actually, the best time-to-quality ratio was reached with the Watson Mini sensor. The Watson Mini sensor provided a higher AFIS score compared to Kojak and Sherlock, despite the detection of less minutiae than the Sherlock sensor (Figure 17). The Watson Mini sensor also provided the best ratio in terms of AFIS score and number of minutiae.

Even though only four corpses were studied and we are aware of the limits of such an experiment, we observed some convinc-

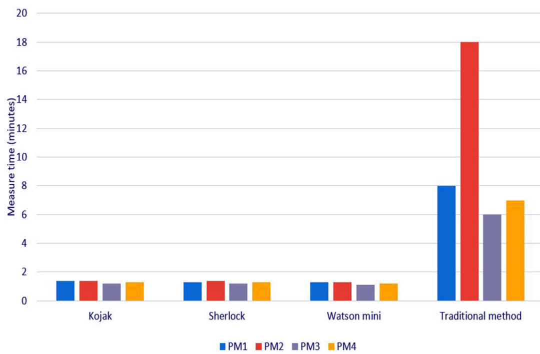

Figure 16

Time needed to fingerprint PM1 to PM4.

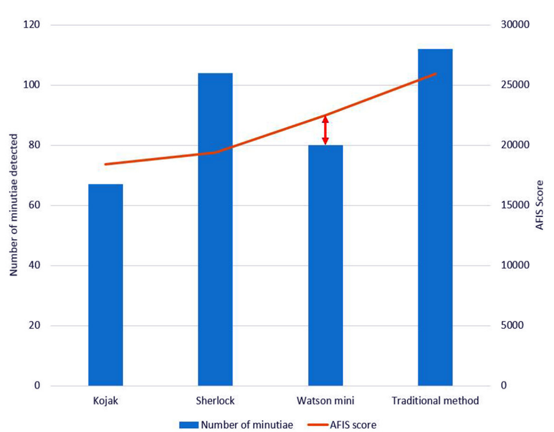

Figure 17

Number of minutiae detected and score for the left middle finger of PM2 tested in the AFIS.

ing conclusions without prejudicing the ability to use traditional methods: the sensor was more than nine times faster than the traditional technique in the complex case of PM2 (less than 2 minutes, compared to 18 minutes) (Table 2).

Traditional methods certainly offer better results from a fingerprint expert's point of view. Nevertheless, they are time-consuming, whereas the sensor gives the best quality-to-time ratio, enables quick victim identification, and, consequently, a more rapid return of the bodies to their relatives.

There might be situations where the sensor will not be enough, in the cases of burned bodies, cases needing the use of injections (PM2), or cases needing dissection.

Conclusions

The Fingerprint DVI Toolkit meets the needs of fingerprint experts involved in disaster victim identification. It responds to operational considerations and offers a customized working area. Processing times are significantly reduced by the implementation of a biometric system for the bodies that are not too degraded. In the other cases (burned, mummified bodies), the Fingerprint DVI Toolkit provides all of the necessary equipment to perform traditional techniques, adding to its versatility.

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