Open Access Research Journal of
Science and Technology
Journals home page: https://oarjst.com/
ISSN: 2782-9960 (Online)

OARJ OPEN ACCESS RESEARCH JOURNALS

(RESEARCH ARTICLE)

Short study of using ACE-V and GYRO for fingerprint examination and individualization

Matej Trapečar [1,*], Patricija Jankovič [2] and Sašo Murtič [3]

[1] *Fingerprint Department, National Forensic Laboratory, Ljubljana, Slovenia.*
[2] *Academy for Logistics and Management, Arema, Rogaška Slatina, Slovenia.*
[3] *Department of General Courses and Economic Bussiness Studies, Faculty for Industrial Engineering, Novo mesto, Slovenia.*

Open Access Research Journal of Science and Technology, 2022, 05(02), 053–059

Publication history: Received on 10 July 2022; revised on 14 August 2022; accepted on 16 August 2022

Article DOI: https://doi.org/10.53022/oarjst.2022.5.2.0060

Abstract

The paper presents a short study of fingerprint identification based on ACE-V method and use of GYRO system. In the field of criminalistics and forensics, fingerprint identification was in the past mainly carried out on a numerical standard. With the numerical standard an identification was possible given the finger mark and fingerprint had at least eight consistent morphological characteristics. Due to the need for a scientific approach to identification, the ACE-V method may be used.

Donors intentionally placed fingerprints on glass surfaces and finger marks were recovered with fingerprint powder. Marks were examined in the AFIS system, followed by individualisation procedure using the ACE-V method and GYRO system.

The study established and confirmed that fingerprint identification, using ACE-V method, has elements of more modern and scientific approach. The numerical standard for identification or individualization procedure for Slovenian fingerprint examiners shall be complemented by ACE-V procedure in GYRO system. Their expert opinions will be more detailed, extensive and with some scientific elements, which will be welcome to the courts.

Keywords: Forensic; Fingerprint; Identification; ACE-V method

1. Introduction

When comparing finger marks and fingerprints, the fingerprint expert shall carry out a positive identification once they have been fully compliant and has not found any significant or inexplicable differences between them. The identification process consists of several identification elements with three-level identification procedure [1]. The first level is the determination of the basic fingerprint pattern, for example whorl, left and right loop, arch, accidental. At the next level the morphological characteristics of the ridge flow are determined. These characteristics are bifurcation, dot, ridge ending, island etc. [2]. The third level of the identification procedure is the determination of the number and edge ridge flow and pores. The science that deals with pore examinations is poroscopy, the examination of sweat pores on papillary lines of prints and marks [3, 4]. Locard was a pioneer in this area. He has found a pore size between 88 and 220 μm. In 1912, he showed the value of poroscopy in an experiment called Boudet and Simonin, when he marked 901 finger sweats and more than 2,000 sweat pores on the palmprint. He proposed an identification method based on the size, shape, relative location and frequency of sweat pores. He considered that between 20 and 40 compliant pores were sufficient for a positive identification [5]. The second examination into sweat pores is carried out by comparing the shape of papillary line edges of prints and marks. The examination is edgeoscopy, which was mentioned in 1962 when

* Corresponding author: Matej Trapečar,
Fingerprint Department, National Forensic Laboratory, Ljubljana, Slovenia.

Salil Chatterjee made his findings on the applicability of papillary line edges or its shapes. He named the shapes as straight, convex, pointed, table, and pocket, concave and angular. Both poroscopy and edgescopy methods are today rarely used in the identification process. Normally, the identification procedure is final after the second level. There are also complementary details of papillary lines. They include scars, which are usually of a permanent nature, and folds. In palm print exploration, the predominant fold is seen as the point where the skin is wrinkled, e.g. when the palm is pressed into the fist. William Herschel, comparing the prints of his left hand over a 30-year interval and found an invariability of the folds, demonstrated this [5].

In the past, experts were looking trying to determine how many details on the fingerprint were sufficient to confirm the identification. In 1914, Edmond Locard set a historic landmark. He has set a minimum number of morphological characteristics sufficient for a fingerprint identification. His three-pronged rule states that, if there are more than 12 consistent morphological characteristics on the print and mark, identification is certain. In the case that the consistency of the characteristic is between 8 and 12, identification certainty is achieved by validation of at least two fingerprint experts. The third part of the rule refers to a limited number of morphological characteristics, i.e. less than 8, where there is only a presumption of a proportional number of useful characteristics [1, 6]. But it must be taken into account that the certainty of identification is undisputable to all, the Locard's understanding of decision to individualize is an opinion, not a fact.

In 1973, the International Association for Identification decided that there was no justification in identification based on a minimum number of morphological characteristics of a fingerprint. Similarly, representatives of 11 states in Israel in 1995 stated that there is no scientific basis for number of Locard's standard, especially in the establishment of a minimum number of consistent morphological characteristics. Nevertheless, the majority of European fingerprint experts were in favour of a purely numerical approach. Countries had defined the numerical standard differently. The minimum number of morphological characteristics required for confirmatory identification [1] were in Italy between 16 and 17, in Germany, Sweden, the Netherlands and Switzerland between 8 and 12, in United Kingdom 16, in South Africa 7 and in Belgium, Finland, France, Israel, Ireland, Greece, Poland, Portugal, Romania, Slovenia, Spain, Turkey, Japan and South American countries 12 morphological characteristics. The fact is that Locard justified the basic concepts of the quantification of fingerprint probative values, but without satisfactory scientific arguments for any numbering of morphological characteristics and identification. Above all, it is about taking into account the experience, professionalism and honesty of the fingerprint examiner.

At the beginning of the 1990s, American and other international forensic laboratories and medical departments established cooperation in the so-called scientific working groups. The purpose of cooperation was to improve working practices and to reach consensus on the establishment of international standards. One of the working groups was Scientific Working Group on Friction Ridge Analysis, Study and Technology (SWGFAST). Standards were developed in the field of Analysis, Comparison, Evaluation and Verification (ACE-V) [7] for fingerprints and finger marks [8, 9, 10].

1.1. ACE-V Method

It is a documentation of analysis, comparison, evaluation and verification, which can be used in the identification process with fingerprints [11, 12, 13, 3, 14]. ACE-V method is an examination of finger and palm marks and prints with the aim to determine or exclude a common source [15]. The purpose of the ACE-V method is also to document the data needed by another qualified expert to review what has been done in the preliminary examination. Documentation is created during the examination procedure. It consists of photographs, worksheets, copies, drawings, AFIS records and other records. The purpose of the ACE-V is therefore to provide a description of the fingerprint examination and to provide the basis for documentation completion. The basic principles for investigating fingerprint and finger marks are the uniqueness and durability of fingerprint morphology, the possibility of transferring details of ridge to the contact surface, and the individualisation or exclusion of origin. Below is a short explanation of phases of the ACE-V method.

The analysis is an assessment or determination of suitability for comparison of the finger mark. The factors are as follows: quality (clarity) and quantity of details (details of grade I, II and III), source anatomy (finger, palm, foot). Quality factors include residue of marks (matrix), disposal, surface, environment, recovery method, transfer method, skin condition etc. During this phase, the mark is examined prior to examination of any fingerprint.

The comparison is direct or comparative observation of details of papillary lines to determine whether the details of two prints are consistent based on similarity, sequence and spatial relationship and absence of unexplainable dissimilitude on the common observable areas.

The evaluation is a conclusion based on analysis and comparison of papillary lines. Conclusions may be:

- Individualisation is the opinion of a common source for a mark and a print, containing sufficient quality (clarity) and sufficient details of papillary lines. Individualisation occurs when the fingerprint examiner or expert determines that two fingerprints or marks have the same origin and excludes the other.
- Exclusion is the result of a comparison of mark or print of sufficient quality (clarity) and of details of papillary lines, which are not consistent. Exclusion occurs when the fingerprint examiner determines that fingerprint or finger mark have different origins. A few inconsistencies are sufficient to exclude, also.
- Inconclusive: the examiner cannot individualise or exclude the origin of the mark.

The verification is an independent examination by another examiner who comes to the same conclusions; all individualisations, exclusions or inconclusive results must be verified.

1.2. GYRO system

The GYRO system (Green, Yellow, Red and Orange System) is essentially dedicated to more transparent fingerprint documentation [16]. The system is suitable for use in the analysis and comparison phase of fingerprints, e.g. in the ACE-V method. It is not only a matter of selecting the morphological characteristics of the finger mark or fingerprint, but above all of documenting the examiner's procedure. This determines the findings of certainty as to the existence of morphological characteristics, weight of the individual morphological characteristics and expectation that the morphological characteristic will also be present in the sample. It also provided that the sample be made with the same area of the fingerprint and the tolerance accepted by the examiner, which is still possible for accepting any differences. Gyro System is a colour tagging. Green colour is used to indicate highly convinced existing morphological characteristics on the finger mark, which must also be present on the fingerprint in the subsequent identification procedure. The yellow colour is to designate a morphological characteristic, which is characterised by a medium degree of belief in the existence of these characteristics. With red colour examiners mark characteristics that are doubtful as morphological characteristics. All three colours or grades should be marked in the comparison phase, i.e. from green over yellow to red. Colours expresses the strength of belief of the examiner regarding the observed characteristics on the finger mark. Orange, however, shall indicate those morphological characteristics that were not observed during the analysis phase of the ACE-V identification procedure, but only at the stage of the comparison procedure.

2. Material and methods

The Best Practice Manual for Fingerprint Examination [15] is the one of basic material of fingerprint comparison in the European Forensic laboratory. This manual is part of a series of 10 manuals issued by the European Network of Forensic Science Institutes in November 2015. The aim of the manual is to help the expert at the examination of marks and fingerprints with variery of results, from exclusion or determination of a common source. Manual describes three approach to evaluate the strength of finger mark evidence. The first approach is numerical with fixed number of features, second is holistic approach where the quantity and the quality of the features have to be evaluated by the practitioner, and the third is probabilistic approach where the evidential value is evaluated by subjective probability assignment and calculated using software based on probabilistic model. Slovenian experts use the holistic approach.

Six fingerprint experts with many years of experience participated in the investigation (four experts with thirty-three years' experience in table 1, 2 and 3 referred as experts 1, 2, 3 and 4 and two experts with twenty-five years' experience in table 1, 2 and 3 referred as experts 5 and 6). The investigation included the deposition of fingerprints on specific objects, finger mark recovery by a physical method, and fingerprint foil for transfer and fingerprint examination in the AFIS system (Automated Fingerprint Identification System). The finger marks were recovered on glass surfaces with fingerprint powder one hour after deposition. Transfer marks on black fingerprint foil were examined in the AFIS system, followed by an identification procedure using the ACE-V method and the Gyro system.

Four different finger marks from the same donor were deposited on glass surfaces and each expert carried out six complete identification procedures. In total, 24 identification procedures were investigated which included the examination and comparison of fingerprints and finger marks.

2.1. Silver Special powder / Brush

Physical methods are good for recovery finger marks and therefore are the method most often used in Slovenia. The use of fingerprint powders is recommended when a shorter period of the finger mark deposition and recovery is. The application of various powders (e.g. aluminium, magnetic, Swedish) results in visible finger marks on the material or surfaces under investigation. Depending on the shape of the primary particles, fingerprint powders are divided into scaly and granular. Granular powders are applied to the finger marks with brushes, most often from squirrel hair [1]. In

our study, Silver Special powder B-32000 (100/250 mL) produced by the Dutch company BVDA was used. Finger marks recovery took place in a laboratory under controlled conditions, where the ambient temperature was around 22 °C and relative humidity about 50 %.

2.2. Transfer Method

Black gelatin lifter produced by the Dutch company BVDA were used. The lifter consists of three components: transparent protective polyester film, gelatin layer and rubber canvas.

AFIS System is a computer system to help a professional perform fingerprint examinations and comparisons. The first step of the investigation is to enter marks and prints with case data into AFIS. A fingerprint or mark is entered using a digital camera, an optical scanner or electronic medium (e.g. USB stick). In our case, the finger marks caption was done using a digital camera.

2.3. ACE-V method

Analysis documentation should be done before comparison procedure [9]. In our experiment experts made analysis documentation of finger marks suitable for comparison. In these records, they documented following information: anatomical orientation, anatomical source, presence of level 1 and 2 detail, substrate, development medium and preservation method. Experts did not make documentation about matrix, latent movement, lateral movement and other friction skin detail, as they did not need this information for the purposes of our investigation.

Following the analysis of finger marks, comparison documentation for each comparison was made. In this documentation, the experts documented information about anatomical sources represented in the exemplars, exemplar data and fingerprinting medium. Experts documented the conclusions of the comparison for each finger mark. The evaluation procedure followed. The documentation included examined fingerprints, anatomical source, examiner data and conclusion date and the reason for inconclusive such as bad exemplar fingerprints or insufficient friction ridge details. Last step was verification. The verification documentation covered data on examined finger mark, anatomical source, verifying expert conclusion and date of verification.

In the analysis and comparison phase, where morphological and other characteristics are indicate based on a colour system the Gyro System has been used.

3. Results and discussion

Determination of basic finger mark and print patterns (Table 1): all experts marked A mark as right loop (\) or whorl (W) pattern, as the partial mark did not allow them to decide on a specific pattern, and A print they marked as a whorl pattern. The mark B could not be determined by the basic pattern (unknown) from experts 1, 2 and 5; the other experts determined the mark as right loop. The experts marked B print as right loop. All experts' marked C mark and print as right loop, and D mark and print as the left loop (/).

Table 1 Determination of basic fingerprint and mark patterns

Expert	Mark A	Print A	Mark B	Print B	Mark C	Print C	Mark D	Print D
1	\ or W	W	unknown	\	\	\	/	/
2	W or \	W	unknown	\	\	\	/	/
3	\ or W	W	\	\	\	\	/	/
4	\ or W	W	\	\	\	\	/	/
5	W or \	W	unknown	\	\	\	/	/
6	W or \	W	\	\	\	\	/	/

Marking of the morphological characteristics of finger marks and prints: table 2 shows the morphological characteristics (minutiae) of the material studied and compared during the analysis phase (G, Y, R) and comparison phase (O). The greater difference between the sum results of all morphological characteristics for A mark is for expert 3, since he

marked 13 characteristics. There are no major differences in the B mark, but C mark analyse showing greater differences, as the number of characteristics varies between 15 and 30. There are also minor differences in the D mark.

Based on the analysis of basic fingerprints and marks patterns, morphological characteristics and other details, the experts expressed the opinion that the material under investigation is suitable for further comparisons.

Table 2 Marked characteristics in the analysis phase (G, Y, and R) and comparison phase (O)

Expert	A mark					B mark					C mark					D mark				
	G	Y	R	O	Σ	G	Y	R	O	Σ	G	Y	R	O	Σ	G	Y	R	O	Σ
1	0	4	3	2	9	4	2	4	0	10	9	6	2	0	17	9	3	3	0	15
2	0	6	1	1	8	3	3	2	0	8	6	4	3	2	15	9	6	2	2	19
3	6	3	0	4	13	6	1	3	0	10	12	10	4	4	30	9	2	3	1	15
4	0	6	0	3	9	4	1	0	3	8	14	4	0	2	20	13	4	1	3	21
5	2	7	0	2	11	4	2	3	0	9	10	5	3	1	19	10	2	3	1	16
6	1	5	2	2	10	3	3	1	1	8	11	8	6	0	25	11	3	4	0	18

The conclusions based on analysis and comparison, i.e. evaluation (Table 3): the experts gave their conclusions based on a three-step scale. All experts determined that the C mark and print contained sufficient quality (clearness) and details of ridgelines and that C mark and C print had the same origin. However, for A mark and print, and B mark and print, they could not individualise or exclude the origin. They also concluded for no exclusion and all marks were useful for comparisons.

Table 3 Evaluation — conclusions based on analysis and comparison

Evaluation conclusions	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6
Individualization	C mark/print D mark/print	C mark/print D mark/print	C mark/print D mark/print	C mark/print D mark/print	C mark/print D mark/print	C mark/print D mark/print
Exclusion	/	/	/	/	/	/
Inconclusive	A mark/print B mark/print	A mark/print B mark/print	A mark/print B mark/print	A mark/print B mark/print	A mark/print B mark/print	A mark/print B mark/print
Mark of no use	/	/	/	/	/	/

In the identification procedures, experts described the method of examination ridge flow and formed a conclusion. They write conclusions based on the examination of morphology, durability and uniqueness and sufficiency of ridge flow. In the analysis, the usefulness of the fingerprint was determined and details of ridge flow were examined directly or comparatively during the investigation phase. They drew conclusions from the analysis and comparison of ridge flow. The Gyro system was used to document the procedure more transparently. In addition to selection of morphological characteristics of the fingerprint, they also determined their degree of certainty about existence, weight, expectations that the morphological characteristic is also in the finger mark and print, and the tolerance that may be possible to accommodate any differences. Verifications followed in the end.

4. Conclusion

The identification value of fingerprint is based on internationally recognised facts that there are no two persons with the same ridge flow on the fingers, palms or feet, and that the ridge flow does not change from human birth to the disintegration of his body.

The numerical standard for fingerprint identification is still permissible and consistent with the profession. In addition to the determination of the basic fingerprint sample only and the enumeration of morphological characteristics, which should not be less than 8 for validation, a more in-depth and scientifically supported method is missing in the process.

For our investigation, we supplemented the number the existing number identification procedure with the ACE-V method. The documentation is the basis of the ACE-V methodology and is created during the implementation of the identification process. The Gyro system is also a possible element in supplementing fingerprint examination documentation. In addition to the more transparent identification documentation in this colour system, experts not only select the morphological characteristics of the finger mark or fingerprint, but also determine the degree of belief about the existence and value of the characteristics and the expectation that it will also be in the sample and establish an acceptable tolerance for any differences. The results of the analyses and comparisons carried out between the finger marks and prints of all six experts, was established that the evaluation or conclusion of all the experts covered by the investigation was consistent. They made conclusions about usability of mark, individualisation, exclusion or inconclusive. Extensive documentation material has been produced, which can be used for later examination and verification. The investigation confirmed the contribution of the ACE-V method and Gyro system.

Compliance with ethical standards

Acknowledgments

The authors are very grateful to all experts who participated in this study.

Disclosure of conflict of interest

There is no conflict of interests to declare.

References

[1] Champod C, Lennard C, Margot P, Stoilovic M. Fingerprints and other ridge skin impressions. 1st ed. Boca Raton: CRC Press. 2004.

[2] Holder EH, Robinson LO, Laub JH. The fingerprint sourcebook. Washington: U.S. Department of Justice, Office of Justice Programs, National Institute of Justice. 2011.

[3] Wertheim Pat A. Scientific comparison and identification of fingerprint evidence. Fingerprint Whorld. Jul 2000; 26: 95–106.

[4] Kaur J, Dhall M. Reproducibility of fingerprint microfeatures. Egyptian journal of forensic science. Jan 2022; 12(7): 2-9.

[5] Ashbaugh DR. Quantitative-qualitative friction ridge analysis, An introduction to basic and advanced ridgeology. 1st ed. Boca Raton: CRC Press. 1999.

[6] Wójcikiewicz J. Forensics and justice: Judicature on scientific evidence 1993–2008. Toruń: Dom organizatora. 2009.

[7] Vanderkolk JR. ACE+V: A model. Journal of forensic identification. 2004; 54(1): 45–52.

[8] SWGFAST. Standard for the documentation of analysis, comparison, evaluation, and verification (ACE-V) (Latent), Ver 2.0 [internet]. Scientific Working Group on Friction Ridge Analysis, Study and Technology; 2009 [web posting date 2012 Nov 24; cited 2022 Aug 1] Available from: https://www.nist.gov/system/files/documents/2016/10/26/swgfast_standard-documentation-ace-v_2.0_121124.pdf

[9] SWGFAST. Standard for the documentation of analysis, comparison, evaluation, and verification (ACE-V) in tenprint operations (Tenprint), Ver 2.0 [internet]. Scientific Working Group on Friction Ridge Analysis, Study and Technology: 2012 [2012 Mar 12; cited 2022 Aug 1] Available from: https://www.nist.gov/system/files/documents/2016/10/26/swgfast_standard-documentation-ace-v-tenprint_2.0_121124.pdf

[10] SWGFAST. Standard for examining friction ridge impressions and resulting conclusions (latent/tenprint), Ver 2.0 [internet]. Scientific Working Group on Friction Ridge Analysis, Study and Technology: 2011 [web posting date 2013 Apr 27; cited 2022 Aug 1] Available

from:https://www.nist.gov/system/files/documents/2016/10/26/swgfast_examinations-conclusions_2.0_130427.pdf

[11] Beeton M. Scientific methodology and the friction ridge identification process. Georgia forensic news. 2021; 32(3): 1–8.

[12] Langenburg GM. Pilot study: A statistical analysis of the ACE-V methodology – analysis stage. Journal of forensic identification. Jan 2004; 54(1): 64–79.

[13] The fingerprint sourcebook [internet]. Washington, DC: National Institute of Justice, U.S. Department of Justice, Office of justice programs; 2011 [cited 2022 Aug 1]. Available from: http://purl.fdlp.gov/GPO/gpo18039.

[14] Tuthill H. Individualization: principles and procedures in criminalistics. Salem: OR Lighting powder company. 1994.

[15] ENFSI. Best practice manual for fingerprint examination, Ver 01 [internet]. Europe: European Network of Forensic Science Institutes. 2015 [2015 Nov; cited 2022 Aug 1]. Available from: https://enfsi.eu/wp-content/uploads/2016/09/6._fingerprint_examination_0.pdf

[16] Langenburg G, Champod C. The GYRO System – A recommended approach to more transparent documentation. Journal of forensic identification. Jul 2010; 61(4): 373–384.