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3D APPLICATION FOR FINGERPRINT IDENTIFICATION

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Abstract: *The demonstrations of fingerprint identification presented so far are based on the examination and processing of digital images in a two-dimensional system, providing biometric limitations for evaluation when having to deal with the identification of a person from whom we only have a print which does not contain sufficient identification elements or when the print was deposited on a soft base (dough, paint, silicone, wax, gel, etc..), difficult to reveal by traditional methods, the only method available being direct photographs that do not alter the details of the print.*

Key words: *dactyloscopy, print, identification, fingerprint examination, comparative examination.*

1. Introduction

Forensic identification of the person according to dermal impressions is scientifically based on the dermal ridge design properties: uniqueness (individuality) and fixity (stability) and inalterability.

The uniqueness of the dermal ridge pattern was found by researchers in the field of fingerprint based on the studies carried out and the practical experience in this area, who reached the indubitable conclusion that it is impossible to meet two people with identical fingerprint designs, each finger having a unique morphology .

By developing the human body, a number of changes intervene due to age and certain diseases, but the form of the dermal ridge pattern remains the same, which demonstrates the fixity and inalterability of the papillary design.

Experiments conducted have shown that taking the fingerprints from a person at long intervals and comparing them with each other, it appears that their structure remains the same, changing only in size.

There are cases when the burns and deep cuts affect the dermis and because of them, after healing, the dermal ridge pattern is no longer visible, leaving scars that are very important features in fingerprint identification, given their form and the place they occupy in the morphology of the pattern.

In Romania, coroner Nicolae Minovici made in 1896 the first research in dactyloscopy, and the fingerprint recording and classification system replaced anthropometry in 1914.

Since 1923 Dr. Andrei Ionescu established the fingerprint classification system based on combining the methods of VUCETICH, OLORITZ and DAEE.

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In 1929, the Palace of Justice had an Identification Central Service and in the area there was a service for the dactylographic identification of the non-custodial criminals, and in 1952 the Unique Evidence of Criminal Record at central and local level came into being.

Under current practice, in order to decide whether a dermal print was created by a certain person, a minimum number of coincident characteristic details must be established. Practice and theory establish three methods used in fingerprint identification:

- the quantitative method - imposes a minimum number of coincidence points, mentioning Balthazar's calculations in 1911, which led to the enunciation of the 12 coincident point rule, commonly used in Romania;
- the qualitative method - appreciates the value of coincidence points given by their frequency irrespective of their number;
- the mixed method - takes into account both the quantity and the quality of characteristic details discovered.

Identification through the elaborated dactyloscopy methods requires the prior conduct of numerous comparative tests between the fingerprints in question and the comparison model, which means those in fingerprint records, those from the circle of suspects, from the people whose identity is to be established, of the corpses whose identity is unknown or fingerprints collected from the various objects belonging to the missing person.

With the introduction of the automatic comparison system AFIS, the optimisation of the activity of identifying people by fingerprints is to be noticed, many cases of this kind being solved by means of this method.

After nearly a century from the establishment of dactyloscopy as a certain method of identifying a person, of identifying repeat offenders and proving the guilt of perpetrators based on the fingerprints collected from the crime scene, the technique in this area was very little advanced.

Updating with new dactyloscopic cards, fingerprints and exploiting them manually by conventional fingerprint card indexes using magnifying glasses or some less advanced optics diminished in time the efficiency required in these activities.

Increasing the number of specialists in dactyloscopy, developing the methods and means of revealing the fingerprints, the efforts to improve the entire activity, as well as the diversification of classification formulas meant only small steps in this area.

With all the preparation, the human factor was outweighed by the amount of data - marks and fingerprints - which had to be compared, imposing an automatic system in this area, which was ultimately developed through years of studies and applied research of computer technology in the field of dactyloscopy.

Diversifying the methods of searching and revealing fingerprints allowed the wider exploitation of all types of media together with the professionalization of forensic specialists, leading to an increase in the number of fingerprints taken from the crime scene. Paradoxically, this was not professionally reflected in the final identification.

Another particularly significant element was revealing for the fingerprints card indexes of fragments of palmar or digital prints whose application through exploiting the traditional card indexes did not relate to the ideal situations in which the center or the delta of the dermal ridge pattern were found.

These considerations have led both globally and nationally to the establishment of the identity of people and identification of the people who have left prints at the crime scene after 2-3 years.

Certainly it can be said that the combined studies of dactyloscopy specialists and those in computing have resulted in the creation of systems for automated fingerprint identification ever since 1980.

Automated systems for the identification of individuals by fingerprints known generically as the AFIS - Automated Fingerprint Identification System, are now in continuous improvement and expansion worldwide.

The practice of using such systems and the tests performed led to considerable advantages over the classic working methods as follows:

- almost complete automation of the most difficult and time-consuming operations in the recovery of fingerprints, from selecting data to comparing impressions or prints;
- accuracy and reliability, factors that enable the analysis of millions of impressions and prints in a unit of time previously unimaginable, respectively minutes, allowing professionals to carry out activities of validation and analysis of results;
- compatibility with pre-existing IT systems;
- modular and flexible architecture that allows adaptation to user's requirements;
- relatively simple operation, the working methods being acquired by fingerprint specialists in a relatively short period of time;
- automated coding of any fingerprint, including fragments of fingerprints, impossible through traditional methods;
- the possibility to process images - the operator being able to fill its gaps - by partially zooming areas with clear details, adjusting the contrast or reversing the ridges (white-black, left - right);
- reading directly the print on the person's thumb without the need for traditional fingerprinting using electronic scanning.

The forensic research study that I bring into attention pertains to the domain of dactyloscopy, this great and inexhaustible method of identifying on which none is entitled to assign paternity rights.

Like most great inventions, it is the work of time, thousands of small and anonymous contributions that have provided separate notions, which have been made available to men of genius, for whom they became elements that were to be coordinated.

Those who are considered the fathers of this science did nothing but, according to E. Locard's phrase "summarize certain floating ideas".

The study addresses the difficult situations that we encounter in the dactylographic identification process, when the fingerprints collected when investigating the crime scene do not contain identification elements or were printed on a soft material (plasticine, paint, silicone, wax, gel etc., supports improper to highlight on or subject to classical methods) and the relief of ridges and the channels of the print can be examined using 3D technology, after being photographed under special conditions.

In such cases, the dactyloscophic expert is put in difficult situations, either to declare the fingerprints unfit or to issue conclusions of probability, which does not help in finding the truth and in the administration of justice.

For the cases presented, the forensic expert can use poroscopic examination and the crestoscopic one (combs shapes) in the dactylographic identification process, only as an aid and only if the print has been taken and processed in special conditions fit to be examined using poroscopy.

In what follows I will briefly introduce these two sub-branches of dactyloscopy which basically provide the scrientific prerequisites for the study and processing of fingerprints and marks in the 3D technological system.

Crestoscopy is the more recent science which includes methods of identifying individuals based on individual characteristics of dermal ridges in isolation and not in the context of the dermal ridge pattern, and poroscopy is another branch of dactyloscophy which studies the form of pores, the orifices of sweat glands situated in the palm of the hands and soles [5], its practical efficiency involving comparing the pores by shape, position and number which give groups a configuration that does not change [2].

The print of an imprinted dermal ridge, examined microscopically in special conditions contains a number of design features, such as: direction, shape, width, contour edges, number, shape and position of pores [1].

The marginal contour of dermal ridges has a varied and constant design, so that the elements of this outline can be used in the forensic identification activity.

The technical details observed on the edges of dermal lines seen under the microscope appear as hollows or coves that have various shapes (straight, concave, convex, angular), being taken into account in the preparation of expertize or technical-scientific dactylographic crestoscopic reports.

The pores positioned on the dermal ridges are many in number, arranged at different distances of various sizes and certain shapes in a relatively long period of existence of the individual.

This high variability in shape, size and density per square millimeter gives the possibility to distinguish between two people, if analyzing the same dermal region.

During a lifetime, some pores atrophy, even disappear, some change their shapes and sizes. Sometimes it happens that some features are shown deformed in the prints created either because of the surface of the receiving object or because of the means used to highlight and take those prints.

For these reasons, the study of pores under the microscope can be applied in the dactylographic identification process only as an aid [3].

For a microscopic examination, the print will be increased 45-80 times, an activity that involves primarily a special procedure concerning the taking of the print.

Thus, the hand prints to be examined by the poroscophic method must be photographed in the latent form in which they were discovered, using the method of reflection through transparence, if the object on which the print has been discovered permits this, i.e. it is transparent, and if the support is opaque, it requires the print to be treated with iodine vapours or alcoholic solution of Sudan III red.

In order to obtain impressions fit to be examined using poroscophy, a mixture of 4 g of yellow wax, 16 g of Greek resin and 5 g of fat will be used, in which the fingers defatted with ether will be run.

Then, the impressions taken on a paper sheet are fixed by spraying with a composition consisting of: 25 g of arabic gum, 10 g of potassium aluan, 40% formalin (5 g) and 30 ml water.

The features of the pores design will be rendered fairly if working carefully, otherwise there is danger that these details are poorly imprinted due to the large amount of substance used in taking impressions and too much finger pressure when running on the work surface.

In order to illustrate the characteristic elements of the pores in the experts report, the dermal ridge pattern will be increased 20-35 times by macrophotography.

Examination of the characteristic coincident points of the pores will be done in the following way:

- firstly, the characteristic shape of the pores will be taken into account, which can be: circular, oval, crescent, etc. fragmented;
- the placement of the pores in relation to one another will be studied and retained as elements of comparison, as well as the distance and position lopsided from the ridge: central, close to marginal and marginal;
- the size of the pores will be estimated in absolute units or compared with the neighbouring pores;
- the number of existing pores either on a unit length or on a determined fragment or a bifurcation arm, which also has a determined length will be taken into account [4].

Crestoscopy has the same role of completing the dactyloscopic research just like poroscopy, being a more modern version of it.

The dermal lines are formed from the fusion of epidermal elements aligned, of a round or oval structure, each containing a pore for exudation.

Due to this fusion of epidermal elements, dermal ridges acquire their own characteristics.

The pore is generally located in the center of the dermal ridge but may also be on the edge of the ridge, creating a sort of shattering, an indenture characteristic to the dermal ridge.

This marginal position will give the edge the features of the ridge, a feature on which the identification of the person through crestoscopy is based.

The edge characteristics were classified into 9 types: straight shape, convex-shaped tooth-shaped, mass-shaped, pocket-shaped, concave, angle-shaped and indefinite.

To support the theoretical arguments, I will present how these processes are actually carried out using the combined studies of both specialists in dactiloscopy and of those in computing, presenting an application of the automatic identification system according to their fingerprints known generically as the AFIS (Automated Fringerprint Identification System).

2. Demonstration drawings

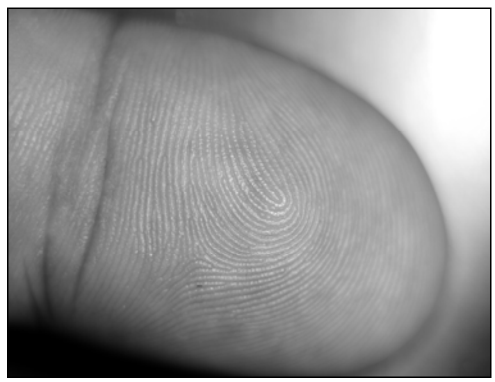
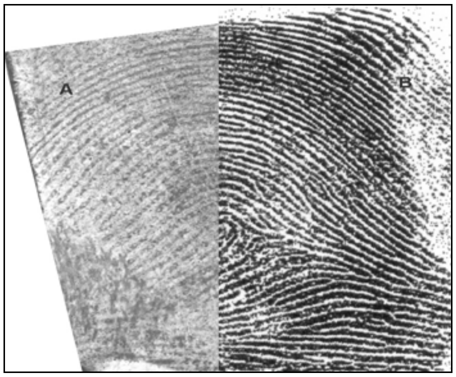


Fig. 1. *The finger*

Fig. 2. *Fingerprint on soft material*

2.1. Classical methods used in the fingerprint identification process



The continuity of the dermal ridge pattern between the print and the impression.

2.2. Chart of coincidence points

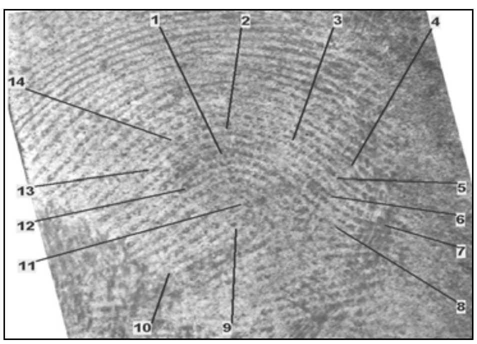


Fig. 3. *Print*

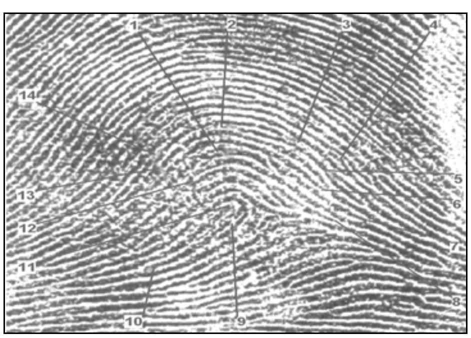


Fig. 4. *Impression*

Individual characteristic elements of coincidence:

1. Buttonhole
2. Forepart of the dermal ridge
3. Ending of dermal ridge
4. Adherent ridge
5. Dermal ridge bifurcation
6. Dermal ridge ending
7. Dermal ridge ending
8. Dermal ridge ending
9. Buttonhole
10. Fusion of dermal ridges
11. Forepart of dermal ridge
12. Dermal ridge bifurcation
13. Dermal ridge bifurcation
14. Dermal ridge ending

3. Poroscopic demonstration

Fig. 5. *Print*

Fig. 6. *Impression*

The study zone of the impression marked by the rectangle will be increased 20 to 30 times.

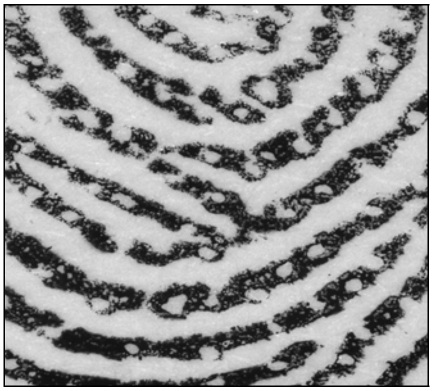


Fig. 7. *20 times larger*

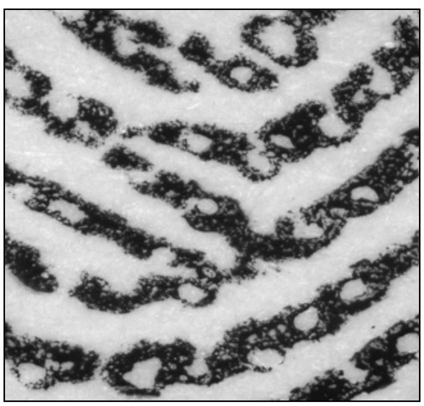


Fig. 8. *25 times larger*

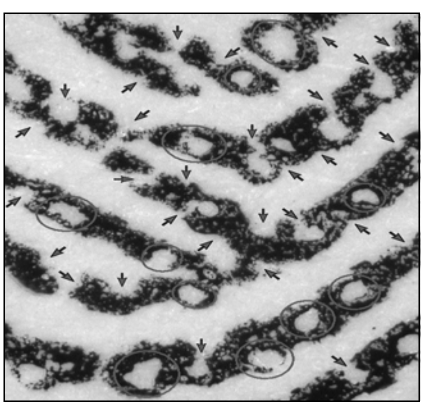


Fig. 9.

The circles mark the presence of pores within the dermal ridges and marginal pores on the edge of the ridges are marked with arrows.

4. Common coincident features of the pores placed on the dermal ridges of the print and of the impression

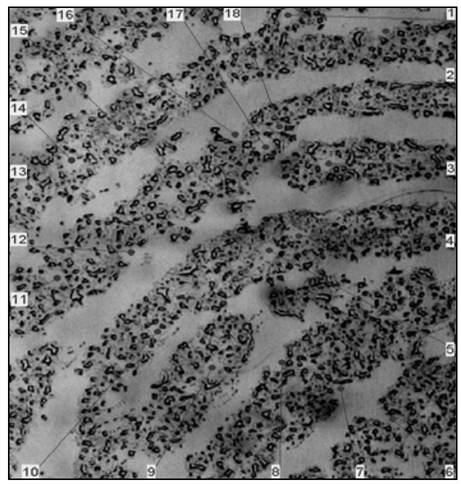


Fig. 10. *Print*

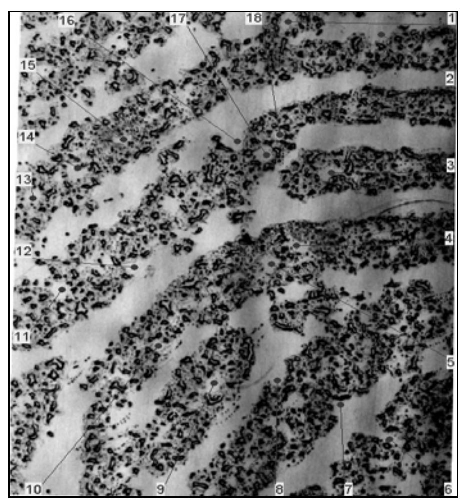


Fig. 11. *Impression*

The fingerprint identification demonstrations presented so far are based on examinations and processing of the images of a digital print in a two-dimensional system, providing biometric limits of evaluation when we must identify a person from whom we have a residue of a print which does not contain sufficient identification elements or when the print was deposited on a soft material (dough, paint, silicone, wax, gel, etc.), hard to reveal by traditional methods, direct photography remaining the only alternative that does not alter the details of the print.

For these situations that apparently seem impossible or almost unachievable, I propose the technical processing of the fingerprint and dermal ridge image in 3D system, which allows the three-color coding of the friction ridges, improves the peculiarities (minutiae) of the print, helps the forensic fingerprint expert to edit more real details in an exceptional optical comfort thus increasing the possibility to identify and relieves the computer system when we have a request for matching in a complicated case.

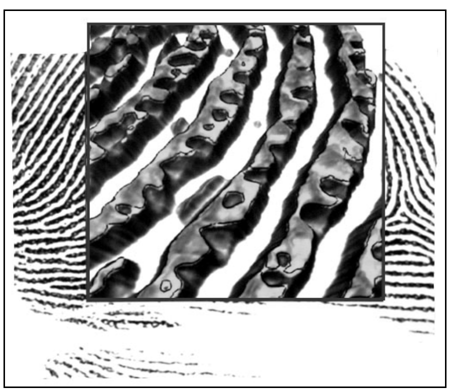


Fig. 12

The practice of using such systems and the tests performed led to considerable advantages over the classic working method as follows:

- almost complete automation of the most difficult and time-consuming operations in the recovery of fingerprints from selecting data to comparing impressions or prints;
- accuracy and reliability, factors enabling the analysis of millions of impressions and traces in a unit of time previously unimaginable, respectively minutes, a fact that allows professionals to carry out activities of validation and analysis of results;
- compatibility with existing computer systems;
- modular and flexible architecture that adapts to user requirements;
- relatively simple operation, the working method being acquired by fingerprint specialists in a relatively short period of time;
- automated coding of any fingerprints, including fragments of fingerprints, unexploitable by traditional methods;
- the possibility of image processing - the operator being able to fill its gaps - by partially increasing the areas with clear details, adjusting the contrast or reversing ridges (white-black, left - right).

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