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Dactyloscopy over the centuries

Summary

Dactyloscopy as a method of human identification has, at the end of the second decade of the 21st century, an established, strong position, demonstrating itself in the whole range of tools available to law enforcement authorities to support investigations. Thanks to the development and popularization of modern biometric technologies, dactyloscopy is increasingly entering the sphere of non-police applications, used by millions of people every day, e.g. logging into electronic banking or unlocking access to smartphones with a finger. In many cultures, the interest in finger and hand skin ridges goes back thousands of years. Initially, it concerned an intentional creative process in the form of rock drawings, but with time, features were noticed in fingerprints that allow to distinguish and identify people. This process began in China more than two thousand years ago, while Europeans did not pay attention to fingerprints until the 17th century. However, it was not until the turn of the 19th and 20th centuries that a real revolution has begun, which changed the ability to verify human identity.

Key words: dactyloscopy, identification, history, fingerprints

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On the inside of the hands and feet of each person there are visible features of the skin that are unique and different from any other in the world. These features include skin ridges, which leave their print on the surface upon contact. The unique character of the fingerprint morphology is attained during the process of fetal development as a result of a random combination of basic structural elements (Moszczyński, 1997). Human dactyloscopic identification has nowadays become common and serves as an invaluable tool for human identification throughout the world. This concerns both applications related to law enforcement, including large-scale automatic dactyloscopic identification systems, as well as civil ones, such as device (e.g. smartphones) or service (e.g. electronic banking) access control. However, it is not widely known that finger and hand skin ridges have been used as a means of identification in many cultures even for thousands of years.

The unique fingerprint pattern in the form of an imprint on a clay seal together with the author's name was used to confirm the authenticity of documents written on bamboo rolls in China during the Qin and Han dynasties in the period from 221 BC to 220 AD. The earliest example of the use of hand traces as evidence in the detective process is the investigation of the place of the burglary described in a document from the Qin Dynasty – years 221–206 B.C. The first example of the use of handprints as investigative evidence was the investigation of a burglary scene described in the document from the Qin Dynasty – 221–206 B.C. (Barnes, 2014). The 14th century Portuguese traveller João de Barros reported on Chinese merchants using ink prints of hands and feet on paper to distinguish between children (Shoniregun, Crosier, 2008).

Initially, the interest in fingerprints reflected an international creative process in the form of rock drawings. Probably the oldest example of this is the petroglyph discovered in Nova Scotia, which depicts a hand with a system of folds and fingerprint patterns. In Brittany, petroglyphs with visible drawings of fingerprints were discovered on the walls of caves and tombs from the Neolithic period. However, some researchers are opposed to this interpretation, suggesting that these paintings may in fact depict patterns created by the wind on a sandy beach (Moszczyński, 1997). Similar drawings can be found in the Newgrange tomb in Ireland (Barnes, 2014).

In the ancient cities of Jericho and Paphos, brick houses built between 7000–6000 BC contained fingerprints of bricklayer workers. However, there is no evidence that at that time the uniqueness of fingerprints was already known (O'Gorman, 2006). Ceramics discovered in north-west China, which is estimated to be 6000 years old, also contains clear fingerprints. Also in this case, it is unclear whether they were deposited accidentally during the production

process or intentionally as a form of decoration (Barnes, 2014).

After the Chinese invented paper in 105 A.D., the use of fingerprints for signing documents became widespread. It was standard practice to deposit finger-, hand- or phalange-prints on documents such as contracts. The knowledge of the dactyloscopic identification method by the Chinese may be confirmed by the record of the Chinese historian Kia Kung-Jen of 650 AD concerning the description of the old method of contract authorisation. For this purpose, two wooden plates were used on which, next to the contract provisions, incisions were made in identical places, so that these plates could later be matched to prove that they were authentic. Most interestingly, the author, while writing about the possibility of using incisions and their mutual matching, compared this method to fingerprints used at that time (Barnes, 2014). It should be emphasized that these facts contradict the prevailing belief that the Chinese did not know the method of dactyloscopic identification. It is worth mentioning here the thesis formulated in 1955 by a Polish criminologist, W. Gutekunst, stating that: "Numerous discoveries and improvements invented by the Chinese have made their way to Europe over the centuries. It seems that, as perfect identification method as it was, deactyloscopy could have reached us along the same routes as silk, paper or porcelain. Dactyloscopic identification could not reach us from China because China did not know it [...]". However, the very low legibility of the print left at that time may speak in favour of this thesis (Moszczyński, 1997, p. 11).

The use of fingerprints for the purpose of signing contracts, wills and during army recruitments continued in China during the Tang Dynasty, 617–907 AD. It is believed that the use of unique fingerprint patterns for identification purposes has penetrated into other Asian countries through trade contacts with China. In Japan, for example, national law of 702 A.D. required individuals who were illiterate to deposit a fingerprint. This indicates at least the possibility that Japanese people understood the distinguishing value of fingerprints to some extent. In India, in the 17th century, palm print were used by the top social strata to demonstrate the authenticity and authorship of important documents. Today, thanks to the preserved certificates, the use of fingerprints as signatures in China, Japan, India and other countries seems unquestionable (Barnes, 2014).

The preserved documents do not indicate that until the 17th century the Europeans may have known the differentiating characteristics of fingerprints (Cole, 2001). It was not until the end of the 17th century that scientists began to publish their results of research on the human skin. Nehemiah Grew first described the skin ridges forming fingerprints in 1684, giving rise to the interest of modern culture researchers in this issue. In 1685, in his work on the anatomy of the body, Dutch researcher Govard Bidloo contained a detailed description of the skin and ridges of the thumb's fingerprints, but completely ignored the issue of their individuality and durability. In 1687, Italian physiologist Marcello Malpighi first noted that ridging of the skin due to the presence of fingerprints increases friction between the object and the skin surface, which improves adhesion when grabbing or walking. Despite many years of research in Europe, it was not until 1788 that the uniqueness of fingerprints was recognised. Johann Mayer, a German physician and anatomist, wrote a book in which he stated that the same pattern of skin ridges does not occur in two individuals. It is assumed that he was the first to describe the uniqueness of the fingerprints (Barnes, 2014).

At the turn of the eighteenth and nineteenth centuries, English ornithologist Thomas Bewick published books with illustrations of birds and other animals, made using the technique of graver woodcut. Noteworthy is the fact that Bewick prepared three stamps carved in wood, containing an image of all the details of fingerprints. It is not certain, however, whether he was aware of the possibility of using these fingerprints to identify people (Barnes, 2014; Moszczyński, 1997).

In his 1823 work, Czech researcher Jan Evangelista Purkyně from the University of Wrocław, in addition to an exceptionally accurate description of fingerprints, classified the observable patterns, dividing them into nine categories and specifying their names. Although he did not know the basic properties of fingerprints, his classification became the basis of the subsequent Henry Classification System (Barnes, 2014; Moszczyński, 1997).

The first studies on the durability of fingerprints were carried out by the German anthropologist Hermann Welcker. In 1856 and 1897, he took right hand fingerprint. However, it is William Herschel who is most commonly considered to be the first person to examine the durability of fingerprints. Born in England in the 1830s, he settled in 1853 in India, where he worked as an administrator of the British East India Company. In 1858, he came up with the idea of using Rajyadhar Konai's hand as a signature, who put his right hand on the back of a contract for the supply of road construction materials. This could be considered the first official use of fingerprints by Europeans (Barnes, 2014). Later, in 1877, Herschel, as an administrator in Hooghly near Calcutta, was able to promote the use of fingerprints in various cases involving criminal courts, prisons, registration of acts or payment of pensions to Indian soldiers. On August 15, 1877, he wrote a letter to the authorities of Bengal, the so-called Hooghly Letter, in which he presented his ideas and suggestions concerning the need to extend the fingerprint-based identification system to other areas. Herschel continued to work on the invariability of fingerprints and published prints of his own hands in 1859, 1877 and 1916 (Barnes, 2014; Moszczyński, 1997).

The first reference to the possibility of using fingerprints in the fight against crime in modern times dates back to 1877, when Thomas Taylor from the U.S. Department of Agriculture drew attention to the possibility of identifying the perpetrator on the basis of fingerprints stamped with blood revealed at the crime scene. He described his observations in a paper published in the June issue of The American Journal of Microscopy and Popular Science (Barnes, 2014).

In 1880, Henry Faulds, an English physician on a medical mission in Tsukiji, Japan, where he opened a hospital, became interested in fingerprints fixed on clay products found on Japanese beaches. In a letter to the famous Charles Darwin dated February 16, 1880, he made observations about the uniqueness, durability and classification of fingerprints. In the same year, Nature journal published, for the first time, an article describing the possibility of using traces of fingerprints to identify crime perpetrators, containing two practical examples. The first one concerned the identification of a person drinking alcohol on the basis of a latent mark left on a glass, while the second one referred to the soot contaminated finger mark on a white wall. Henry Faulds conducted his research on the uniqueness, durability and classification of fingerprint patterns using human and monkey test material (Barnes, 2014; Faulds, 1880).

Describing the history of dactyloscopy, it is impossible to omit Alphonse Bertillon. In 1879, in the Prefecture of the Paris Police, he began research involving measurements of various individuals; in practice, the results were first put into use three years later. Bertillon's anthropometric method included 11 body measurements. As a scientific biometric method of human identification, it was widely used around the world until 1914, when fingerprints began to be added to the registration card, the usefulness of which had already been proven experimentally. Since then, the standard registration card contained information including 11 body measurements, two facial photographs and 10 fingerprints, and the use of fingerprints for identification purposes has become more and more common (Barnes, 2014).

In 1883, the American writer Samuel Langhorne Clemens, known as Mark Twain in his autobiographical book entitled *Life on the Mississippi*, included an excerpt on the durability and uniqueness of fingerprints: "When I was a youth, I knew an old Frenchman who had been a prison-keeper for thirty years, and he told me that there was one thing about a person which never changed, from the cradle to the grave – the lines in the ball of the thumb; and he said that these lines were never exactly alike in the thumbs of any two human beings. In these days, we photograph the new criminal, and hang his picture in the Rogues' Gallery for future reference; but that Frenchman, in his day, used to take a print of the ball of a new prisoner's thumb and put that away for future reference. He always said that pictures were no good – future disguises could make them useless; "The thumb's the only sure thing," said he; "you can't disguise that". And he used to prove his theory, too, on my friends and acquaintances; it always succeeded" (Twain, 1984, pp. 191–192). A year later, Twain wrote the novel *Pudd'nhead Wilson*, in which he depicted a lawyer collecting fingerprints of local residents in order to solve a murder mystery. The book also contains information on the value of the uniqueness of fingerprints in court, the difference in their patterns even in twins, and a case involving a positive identification of traces, allowing to identify the murderer (Barnes, 2014).

A German scientist, Arthur Kollman, expanded public knowledge of dactyloscopy in 1892 by presenting the theory of formation of fingerprints in fetal life. He stated that the ridges visible already in the fourth month of pregnancy develop fully in the sixth month of development. Research initiated by Kollman was continued by Hermann Klaatsch, who claimed that evolution was responsible for the development of human fingerprints (Barnes, 2014).

The first handbook on fingerprints was written by Francis Galton (Margot, Lennard, 1994). Born in England, the cousin of the famous Charles Darwin worked on the inheritance of physical traits and their individuality. It is interesting to note that visitors to his anthropometric laboratory were characterized by 17 body measurements, whose results were placed on a special card and given as a gift to the guests. Based on these measurements, Galton came to the conclusion that the forearm length is correlated with human height. The researcher supplemented the measurements, initially with the prints of the thumb, and then of all ten fingers. As the author of the first dactyloscopy handbook published in 1892, he pointed out that fingerprints are permanent and unique. He created the first probability model for a repetition of the same set of traits and ruled out the connection between fingerprints and character traits of a person. He was also the first to define the names of specific patterns, namely minutiae (Barnes, 2014) and to distinguish four types thereof: bifurcation, ending, beginning and island/lake (Moszczyński, 1997).

In 1891, a French scientist René Forgeot published a paper proposing the use of powders and chemical reagents to detection latent marks at a crime scene, in order to identify the person who touched the object (Barnes, 2014).

At the end of the 19th century, the practical use of fingerprint identification became more and more common. In 1886, in San Francisco, a photographer Isaiah West Taber proposed the use of thumb prints to establish and verify the identity of Chinese immigrants. In 1889, the Director General of the Indian Post Office collected fingerprints from workers to prevent re-hiring individuals who have previously been dismissed (Barnes, 2014).

Another recognized fingerprint researcher of that time was Juan Vucetich, initially employed as a statistician at the Central Police Department of La Plata, Argentina, and, subsequently, the head of the anthropometric identification office. After getting acquainted with Galton's research, he initiated his own studies related to the potential of fingerprints. He started collecting fingerprints from criminals and developed his own classification system, the so-called *vucetichissimo*. Nowadays, it is assumed that the system of classification and individualization of Vucetich's inmates was the first example of using the scientific foundations of dactyloscopy by law enforcement officials. Soon, other countries adopted this system to identify prisoners (Barnes, 2014; Moszczyński, 1997). However, in 1886, Vucetich was ordered to abandon his fingerprint-based system and return to Bertillon's measurement system. Realizing that this meant a step backwards, he unsuccessfully tried to explain to his superiors the progress made by the introduction of fingerprint testing as compared to the body measurement system. Fortunately, in 1896, Argentina ceased to use the Bertillon system and implemented *vucetichissimo*. Currently, the Vucetich system is not used outside the countries of South America (Barnes, 2014).

In 1892, for the first time, law enforcement authorities officially used dactyloscopic identification to single out the perpetrator of the murder. The case concerned the murder of two children of a woman named Rojas, who herself suffered a neck injury during the incident. Ms. Rojas accused a certain Velasquez, testifying that he wanted to marry her, while she, being in love with another man, refused him. In addition, as she claimed, he was sickly jealous of her. Despite brutal interrogations, Velasquez did not admit to having committed the murder. Then, Inspector Eduardo Alvarez came to Buenos Aires from La Plata to carry out a thorough investigation. He began his work by investigating the crime scene, where he found a bloody latent marks on the door. Since he had been previsously trained by Vucetich in comparative fingerprint analysis, he compared the bloody latent marks with Roja's fingerprints. During the confrontation, when it was shown that the fingerprint on the registration card and that on the door originated from the same finger, the woman admitted to the murder of her sons (Barnes, 2014).

In 1883, a Committee was set up in England to assess the feasibility of using different methods of perpetrator identification. It was chaired by Charles Edward Troup, hence its name: The Troup Committee. The Committee's work included extensive research on the identification methods in place at the time, such as photography and memory of police officers, and new methods, including anthropometry and dactylscopy. The lack of an appropriate system of classification of fingerprint patterns was then considered a weak point. As a result of the Committee's work, a compromise was reached, including the recommendation to use five main anthropometric measurements and, additionally, dactyloscopic identification as the basic system. These guidelines were respected in England and Bengal. They were implemented by means of anthropometric measurements and fingerprinting of all registered criminals from 1894 onwards (Barnes, 2014).

In 1894, Edward Henry, the general police inspector of the province of Bengal, who also worked with Galton, developed a method for classifying fingerprints. Hindu police officers: Khan Bahadur Azizul Haque and Rai Bahaden Hem Chandra Bose teamed up with him to develop a fingerprint classification system called the Henry Classification System. As the system proved to be effective, Henry asked the Indian Government for an opinion comparing the two methods of identification, namely anthropometric and dactyloscopic. Charles Strahan, India's chief surveyor and chemist Alexandre Pedler were sent to Bengal to meet Henry and to give an opinion on the matter. At the end of 1897, they produced a report in which they concluded that the dactyloscopic identification method developed and used in Bengal outperforms the anthropometric method in several respects: it is simpler, cheaper, faster, all work requiring qualified staff can be transferred to central offices and the results are more reliable. The Indian government has thus sanctioned the use of dactyloscopic identification as the only method of identifying prisoners (Barnes, 2014). Henry was also the author of the second statistical probability model for a repetition of the same minutiae pattern, published in 1910. (Langenburg, 2014).

In December 1900, The Belper Committee, chaired by Lord Belper in England, recommended that all criminal dactyloscopic registrations should be classified. At this point, the Henry Classification System became standard practice in England and was adopted in most English-speaking countries (Barnes, 2014).

The first criminal trial in England that which was based on evidence derived from dactyloscopic identification was the result of the work of inspector Charles Stockley Collins of Scotland Yard. Collins used dactyloscopy to identify the perpetrator of the burglary. Hence, 1902 was written in history as the beginning of the recognition of dactyloscopy as a reliable method of human identification by the courts of England. In the same year, in October, Bertillon carried out a fingerprint identification study on the murder in Paris. Bertillon was called upon to help resolve the case of the murder of a man named Joseph Reibel. In this case, broken glass fragments from a damaged cabinet were collected. On one of the pieces there were fingerprints stamped with blood. This evidence was meticulously photographed and secured. The tests carried out revealed that the fingermarks did not originate from the victim. Bertillon started searching for anthropometric cards, to which fingerprints were already routinely added. Finally, he found the cards, which contained areas matching the

fingermarks found at the crime scene. The murderer, Henri Leon Scheffer, was arrested and brought to court, thus becoming the infamous hero of the first murder case resolved in continental Europe through fingerprint identification (Barnes, 2014).

The systematic use of dactyloscopy in the USA began in 1902, when Henry de Forest of the New York Civil Service Commission started the practice of training experts, with the aim of preventing unskilled staff from using fingerprint identification. In 1903, Captain James Parke developed an American classification system, which, in combination with the collection of fingerprints from all criminals in the State of New York, was the first methodical use of fingerprints for detection purposes in the United States. Although this classification system did not become widespread in the United States, fingerprint identification was becoming more and more common. It is also worth quoting the history in which the anthropometric measurement system showed its imperfection. In Leavenworth, Kansas, a man who introduced himself as Will West was brought to prison. The prison staff photographed the prisoner and collected his anthropometric data, in accordance with the Bertillon system. The man claimed that he had never been previously arrested, so he should not be on the records. In fact, the prison register contained data on a man, whose name – William West – as well as the appearance and anthropometric data were very similar to that of a new prisoner. The guards suspected that Will West was an escapee and that the cell in which William West should have been remains empty. However, William, who had previously been incarcerated, was found asleep in his cell and the prison staff were unable to determine which of the men was Will and which was William on the basis of the records. It was only by collecting and comparing fingerprints that made it possible to distinguish between both men. Interestingly, the story described was somewhat verified in later years, namely it turned out hat that William and Will were related; it was even claimed that they were twin brothers. However, this does not change the fact that many people, in particular twins, may have similar or even identical anthropometric features. Nevertheless, even identical twins have different fingerprints (Barnes, 2014).

The World Exhibition (Expo) held in Saint Louis in 1904 also contributed to the spread of fingerprint identification in the United States. There were three thematic stands dedicated to human identification. One was dedicated to Bertillon's anthropometric measurements, while the others represented fingerprint identification and were maintained by the aforementioned Parke and Inspector John Ferrier of New Scotland Yard. The latter presented one millimetre different anthropometric measurements of two men, whose fingerprints were completely different. After the fair, Ferrier remained in the United States, where he conducted educational activities involving fingerprint identification, including methods of developing latent prints with the use of development powder. His trainees worked in police and military services throughout the country. In October 1904, the collection of fingerprints from all inmates in Leavenworth Federal Prison began, marking the beginning of the U.S. government's fingerprint collection (Barnes, 2014).

Currently, dactyloscopic examinations are performed exclusively by experts – appropriately trained individuals with confirmed competences and so-called special knowledge. Initially, Galton believed that legible traces can even be handled by untrained people. Expert knowledge was considered to be necessary only to examine unclear, difficult traces. A similar opinion was expressed by a court in India, which in the case of Abdul Hamid in 1905 acquitted the accused, rejecting the expert's opinion indicating positive identification. It was believed that any participant in the trial could carry out comparative identification tests. The case went to the Court of Appeal, where Judge Henderson personally compared the print with the fingerprint, also using magnifying glass. He concluded that both were similar, however, not beyond doubt, nor sufficiently legible for him. Therefore, he decided that he should not challenge the decision of the court of first instance to reject the evidence. However, the other courts did not share such an opinion, believing that expert knowledge was necessary for fingerprint identification tests, while at the same time requiring that the expert's conclusions be based on evidence that could be assessed by any intelligent person with good eyesight (Cole, 2001).

In England, in 1905, the first criminal trial in a murder case using a fingerprint as evidence was conducted, the so-called Depford Murder Trial. The case concerned the murder of a man and his wife. The aforementioned Inspector Collins identified a thumb's fingerprint left on the money box by one of the Stratton brothers. This was the strongest piece of evidence in support of the accusation in the trial. As a result, brothers Alfred and Albert Stratton were sentenced to death (Barnes, 2014).

The first public trial in the United States, in which the court admitted evidence from a dactyloscopic opinion, concerned Thomas Jennings. On September 18, 1910, at night, shortly after midnight, Clarence Halsted of Chicago was awakened by a man entering his bedroom through a window. The man stood on a window sill and lit a match. Halsted immediately got out of bed and grabbed him, tearing his coat pocket apart, but the intruder managed to lean out of the window and run away. On the same night, around 2 a.m., an unknown individual invaded another house nearby. This time he jumped into Mrs. McNabb's bed and tried to harass her. As the victim pushed away his hand and started screaming, the attacker, whom she later described as a tall, bulky, black man, escaped down the stairs into the house. A few minutes later, McNabb's neighbours discovered him in their home. Fifteen-year-old Clarice

Hiller was woken up by a man with a lit match standing in the entrance to the room. Then he invaded the room of her thirteen-year-old sister.

When leaving the room, the intruder stumbled upon Clarence Hiller – the father of both girls – in the hallway, a struggle took place, and they both rolled down the stairs. During a fall from the stairs, the intruder fired at Clarence Hiller twice, hitting him deadly in the neck and chest. He was detained thirteen minutes after the incident, less than a mile from the Hiller's home by police officers after duty, whose attention was drawn to his bloodstained shirt. In addition, a revolver with traces of recent use was found there, whose cartridges fit the shells found at the scene. The man's coat had a torn pocket, which coincided with Halsted's testimony, and he himself had fresh hand wounds that might have arisen when defending himself during the struggle with Hiller. The accused Jennings claimed that he had never fired from a revolver, that his coat had been damaged at work, and his hand had been injured as a result of a fall when he got off the tram. None of the witnesses saw the attacker's face in the darkness; they only pointed out that he was a black man. Nevertheless, they testified that Jennings resembled a man who invaded their homes at night.

The police in Chicago, due to difficulties in identifying the perpetrator on the basis of testimonies from witnesses who were unable to recognize the face of the attacker, made use of the possibilities offered by dactyloscopy. William Evans, working for his father Michael of the Chicago Police Department Bureau of Identification, found a fingermark on freshly dried paint on porch railings in Hiller's home. This fingermark was consistent with the fingerprints taken from Jennings, both in the context of this case and in connection with his previous arrest (Cole, 2001). Jennings, accused of murder, was convicted when five experts identified a fingermark left at the scene. During the trial, the defence appealed, claiming that dactyloscopic evidence should not be admissible and that it was not necessary to appoint dactyloscopy experts. However, the Court admitted the evidence, considering that there were scientific grounds for this method of identification. In addition, the court found that dactyloscopy is a scientific method, the application of which requires appropriate preparation, and it is not possible for a person with ordinary education and experience available to the majority of people to carry out such examinations. This was therefore the first time in the United States that the Court of Appeal admitted the testimony of a fingerprint identification expert (Barnes, 2014).

In 1911, French forensic professor Victor Balthazard, third after Galton and Henry, proposed a model describing the unique character of fingerprint patterns. He assumed that each minutia could occur in four possible forms: right bifurcation, left bifurcation, right end of the line and left end of the line. Assuming equal probability for all these forms, Balthazard assumed the probability value as 1/4 and the value of *N* as the number of minutiae. He came to the conclusion that in order to observe *N* randomly matched minutiae, it would be necessary to examine 4 to the power of *N* patterns. He accepted the criterion that a given population should include one or less of the same minutiae configurations. Assuming that the world population at that time was 1.5 billion, 17 identical minutiae would be needed. The Balthazard model assumed the frequency of 17 minutiae occurring in the same fingerprint patterns as 1 to about 17 billion. Taking into account smaller populations, often geographically separated, the researcher concluded that a sufficient number of minutiae could be 11 or 12 (Stoney, 2001).

In the following years, other authors created new, more extensive statistical models, covering, among other things, a larger number of variables, including: Rai Sahib Hem Chandra Bose in 1917, Harris Wilder and Bert Wentworth in 1918, Karl Pearson in 1933, T.J.Y. Roxburgh 1933 and others in later years (Langenburg, 2014). In 1914. Edmund Locard proposed a pragmatic approach to dactyloscopic identification, the famous Tripartite Rule, which was not a statistical model (Langenburg, 2014). He suggested setting a numerical threshold for minutiae, corresponding to the level of conformity between the trace and the comparative print. Locard's tripartite rule assumes three possible situations:

1. More than 12 obvious traits have been demonstrated; the imprint is clear; the identity is beyond doubt.
2. 8–12 traits have been demonstrated. Certainty depends on: (a) the clarity of the print; (b) the rarity of its pattern; (c) the presence of the center of the figure the delta in the exploitable part of the print; (d) the presence of pores; (e) the perfect and obvious identity regarding the width of the papillary ridges and valleys, the direction of the lines, and the angular value of the bifurcations. In this case, certainty can only be achieved after obtaining the opinion of one or more experienced specialists.
3. A limited number of traits have been demonstrated. In this type of case, the fingerprints cannot provide certainty, but only a presumption depending on the number of traits available and their clarity (Locard, 1937, p. 108).

At the beginning of the 20th century, identification based on the unique character of fingerprint and palmprint patterns was therefore formally recognized as a method of establishing identity known as dactyloscopy, and became a standard for routine forensic research. Organisational units using dactyloscopy as a method of identification or verification of identity have been established all over the world.

Methods of detection of latent prints, classification of patterns, or for conducting comparative research have been developed. The progress in the implementation of dactyloscopy into practice was significant, as e.g. in the U.S. the FBI's dactyloscopic identification department

with a database containing dactyloscopic cards was established already in 1924. (Maltoni et al., 2009).

The origins of the use of dactyloscopy in Poland are closely related to the implementation of this method by the occupying countries (during the period of partitions). In Tsarist Russia, they date back to 1903, when the first cases involving fingerprinting of criminals were recorded. Dactyloscopy was officially introduced into the set of detection methods in 1906, which was associated with the establishment of the Central Dactyloscopic Office at the Main Prison Administration, where fingerprint cards were collected for those sentenced to hard labor [katorga] and exile. Seeing the advantages of this method of identification, it was quickly introduced throughout Russia, including Polish soil.

In 1909, a registration office was established in Warsaw, whose tasks included establishing identity on the basis of fingerprints or photographs and identification of criminals on the basis of fingermarks left by them. In 1909, 6277 people were registered in the Warsaw office, and 268 perpetrators were identified based on fingerprints (Buras, 2009). The dactyloscopic registration on Polish territories under Russian occupation was consistent with the Lebedev system published in St. Petersburg in 1912. The registration was described by Michał Żabczyński in 1909 and published in 1910 the form of a circular of the Commander-in--Chief of the Police [oberpolicmajster] Major General Mejer in office in Warsaw (Szwarc, 2005).

After regaining independence, the State Police, established in 1919, started to use dactyloscopy in their detective work. In December of the same year, the Commander-in-Chief introduced the first Polish dactyloscopic guidelines. At that time in Poland, great emphasis was placed on detective work, including identification of perpetrators of crimes based on fingermarks collected left at the crime scene. In the years 1920–1936, a total of 126 people were trained in fingermarks collected (Buras, 2009).

The State Police have collected fingerprints cards of persons suspected of committing crimes since the 1920s. Initially, however, there were no clear rules for the maintenance of dactyloscopic registry. The collection was first enlarged by records collected by the police of the occupying countries. It was only the instruction from 1928 that precisely defined the rules of fingerprinting people. The obtained fingerprints cards were sent to the central registry operated by the Central Investigation Service in Warsaw. Until 1938, the Central Dactyloscopic Registry (CRD) collected a database containing 442,966 fingerprints cards (Buras, 2009). For comparison, as early as 1924, the FBI's Fingerprint Identification Department collected a database containing 810,000 fingerprints cards (Maltoni et al., 2009). The incoming cards were classified in accordance with the Henry system and then, in order to identify persons previously listed under other names, they were compared with the cards present in the database. For example, in 1936, 1291 people were found to have provided false data during arrest (Buras, 2009).

It is worth pointing out that as early as the 1930s, there was cooperation between police authorities in Europe. As a result, on the basis of dactyloscopic checks, the so-called interviews, in 1936 alone, 203 people were identified who came to Poland under false names, and 52 were searched for by international arrest warrants. The Central Dactyloscopic Registry was commissioned by police offices in Antwerp, Amsterdam, Berlin, Lisbon, London, Helsinki and Paris (Buras, 2009).

In 1926, in order to increase the detection of crimes through establishing the identity of the perpetrators on the basis of fingermarks collected at the crime scene, a special one-finger registry, the so-called monodactyloscopy, was created. Due to the costs, it was decided that it would be centrally operated by the Central Investigation Service and it would admit the incoming fingerprints in order to search the database. Initially, the expected results, i.e. positive hits, were not achieved, but with the acquisition of experience, as early as in 1938, 176 hits were obtained (Buras, 2009).

Dactyloscopy has proved its usefulness over the years. Initially treated as a supplement to Bertillon's superior (as it was thought of at that time) anthropometric measurement method, it has completely displaced the latter over time. It also found its place in the age of digitalization, as confirmed by the large scale automatic dactyloscopic identification systems – AFIS – functioning all over the world. In addition, fingerprint verification as a form of access control has become common in devices such as smartphones and computers. Despite the continuous rapid development and dissemination of modern methods of human identification, including DNA profile analysis, dactyloscopy with its databases is still an important element of this process, which nowadays increasingly goes beyond typical police applications.

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