

A polemic with the papers by K. Kozdrój-Miler and K. Klemczak concerning the „Fingerprint Mapping” project

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Abstract

The papers by K. Kozdrój-Miler and K. Klemczak concern the ‘Fingerprint Mapping’ project, the aim of which was to develop a tool providing statistical support for dactyloscopic identification by determining the frequency of occurrence of specific minutiae types and their patterns. This text is primarily a critique of the second part of the project, in which the authors presented the results of fingerprint mapping and related them to Czesław Grzeszyk’s 1972 study. It was pointed out that the study did not constitute an exact replication of Grzeszyk’s research, as a different methodology was employed. Particular concerns are raised regarding the way in which Grzeszyk’s methodology is portrayed as methodologically limited and potentially subject to measurement errors. In conclusion, it was stated that the CLKP project may constitute a valuable descriptive stage, but should not be regarded as a definitive revision of Grzeszyk’s findings, nor as a ready-made model for the probabilistic assessment of dactyloscopic evidence

Keywords: dactyloscopy, minutiae, fingerprints, CLKdb, Grzeszyk, statistics, methodology.

Introduction

One of the objectives of the ‘Fingerprint Mapping’ project, described by Kozdrój-Miler and Klemczak in two publications, was to develop software that could enhance the two currently co-existing standards of dactyloscopic identification – the numerical and holistic – by enabling the estimation of the identification value of individual minutiae (Kozdrój-Miler & Klemczak, 2019, 2025).

In the first part, the authors accurately identified the fundamental problem with the dactyloscopic identification process, describing the shortcomings of both standards. The numerical standard clear and well-structured, but it treats all minutiae essentially on an equal footing. The holistic approach provides for an assessment of the material as a whole, but – if not supported by rules and empirical data – it can lead to excessive subjectivity.

From this point of view, the need to build a bridge between these approaches is entirely justified. (Kozdrój-Miler & Klemczak, 2019).

In the second part the authors referred to Czesław Grzeszyk’s study on the frequency of minutiae and presented the results of their own study, as announced in the first part (Grzeszyk, 1972; Kozdrój-Miler & Klemczak, 2025).

Project assumptions in the first part

In the first part of their paper, Kozdrój-Miler and Klemczak (2019) stated that:

“As part of the ‘Fingerprint Mapping’ project, financed by the CLKP’s Own Research Fund, software was developed which, on the basis of mathematical calculations (‘scientific basis’), but taking into account the identification value of individual feature types, will make it possible to statistical-

ly estimate the number of features required for a specific pattern of minutiae, selected by an expert, to be unique." As intended, the programme enables:

- entering and storing fingerprint images,
- encoding of fingerprint images – marking (manual) of the locations of specific features on fingerprint images and identification of their types by an expert,
- collecting and recording data on locations and types of specific features,
- carrying out, on the basis of the data collected, calculations to determine: the frequency of occurrence of a particular type of feature, the frequency of occurrence of a particular type of feature in a specific location (a specific area of the print), the frequency of occurrence of a particular pattern of features, and the frequency of occurrence of a particular pattern of features in a specific area of the print." (Kozdrój-Miler & Klemczak, 2019, p. 8).

Therefore, as declared, the authors announced a tool that could prove to be of great significance to Polish dactyloscopy. Indeed, the purpose was not to simply count minutiae electronically, but to create a system that would enable assessing the frequency of feature types, their locations and their patterns. Of particular importance was the declaration concerning the statistical estimation of the number of features required for a particular minutiae pattern to be considered unique.

At the end of the first part of the paper, it was announced that the programme would be presented in the second part, once the database had reached the required minimum number of records (Kozdrój-Miler & Klemczak, 2019).

The second part of the paper and a critique of Prof. Grzeszyk's research

In 2025, the second part of the article was published, intended to describe the implementation of the objectives set out in the first part. The authors attempted to structure the current state of knowledge regarding the frequency of specific types of minutiae in the Polish population. To this end, they referred to the study by Prof. Czesława Grzeszyk, which for many years were the primary source of knowledge in this field in our country (Grzeszyk, 1972; Kozdrój-Miler & Klemczak, 2025).

The authors put forward a supposition that Grzeszyk's data:

"may have been marred by a large measurement error, as the data was collected »manually«, with the use of just a magnifying glass, due to the lack of suitable research equipment." (Kozdrój-Miler & Klemczak, 2025, p. 8).

This is where the first significant inaccuracy arises. In his paper, Grzeszyk clearly specified the type of optical equipment he used:

"In the areas marked out on the dermatograms of the fingers and palms of adults and children, I counted the minutiae under a stereoscopic microscope using a magnification of 5.3×1 or 6.3×1.6 " (Grzeszyk, 1972, p. 182).

I am not raising this point because I consider a magnifying glass to be an inappropriate tool for dactyloscopic examinations. On the contrary, it is widely used by both experts and staff at the fingerprint registry. However, given that the authors had built their argument regarding a possible measurement error around the alleged use of a magnifying glass alone, one would have expected greater precision in reconstructing Grzeszyk's research methodology.

Elsewhere in the paper, the authors write:

"A second plausible reason for the differences observed may be that the study by Prof. Grzeszyk was marred by a greater measurement error due to the limited technical capabilities at the time – collecting and recording data »manually« increases the likelihood of inaccuracies in both counting and qualifying individual types of minutiae" (Kozdrój-Miler & Klemczak, 2025, p. 11).

The authors therefore suggest that there are not only observational limitations, but also a risk of errors in data collection and analysis. Meanwhile, Grzeszyk wrote:

"The arithmetic and percentage means, as well as the frequency of individual types of minutiae, contained in the tabular summaries, were calculated at the Department of Numerical Methods of the Chair of Mathematical Statistics at UMCS using the Odra 1013 electronic digital machine." (Grzeszyk, 1972, p. 182).

The available literature on the Odra 1013 digital machines indicates that their library of application software included, amongst other things, programmes for statistical calculations (Thierry, 1967, p. 22). This means that at least the stage of tabular calculations in Grzeszyk's work was computer-assisted. This makes the contrast between his 'manual work' and the CLKP authors' modern computer software seem all the more inaccurate.

Without a doubt, the findings of Grzeszyk's study may be subject to review. This could be done, for instance, by re-analysing the raw research data, if available, or by faithfully replicating his method. However, the authors do not indicate that they carried out such a procedure. Consequently, their comments regarding a possible error on Grzeszyk's part remain a hypothesis, rather than a proven fact.

The issue of children prints

Elsewhere, the authors take a critical view of another issue relating to Grzeszyk's study:

"In addition, he included in his study children aged 2 years and over (more than half of all subjects), in whom the correct identification of minutiae types could have been very difficult due to the small size of the examination field and high density of papillary ridges. Therefore, in order to eliminate the influence of the aforementioned factors on the results, the material selected from Prof. Grzeszyk's work for the purpose of comparison with the results obtained currently included solely fingertip data collected from adults" (Kozdrój-Miler & Klemczak, 2025, p. 11).

This statement could be interpreted as suggesting that the analysis of minutiae details in children prints is, by its very nature, particularly problematic.

As mentioned above, Grzeszyk provided in his paper two magnification ranges for the microscope used. In the first case, i.e. 5.3×1 , the magnification was approximately 5 times, which can be regarded as standard in dactyloscopic examinations. In the second variant, i.e. 6.3×1.6 , it was about 10 times, and therefore twice as large. This magnification may have made it possible to analyse fingerprints from children's hands effectively, despite the greater density of the ridges.

A close reading of Grzeszyk's paper also provides some interesting information on the differences between the material taken from adults and children:

"in adults, there are more dots and short ridges than in children, while the number of lakes, bifurcations and single junctions is reduced. The above differences should be regarded as temporary (generally caused by work or skin conditions)" (Grzeszyk, 1972, p. 208).

In other words, the legibility of children's fingerprints, where the skin has generally not yet been exposed to long-term effects of work or pathological changes, is higher than that of adults' fingerprints. For this reason, contrary to what the authors write (Kozdrój-Miler & Klemczak, 2025), correct identification of minutiae types on such dactylograms is also less problematic.

Does the CLKP study actually replicate Grzeszyk's study?

The authors decided to repeat the study on the prevalence of specific types of papillary minutiae. It should be noted, however, that they made a number of methodological changes compared with Grzeszyk's work.

Grzeszyk analysed left and right-hand minutiae focusing on the fingertips and the areas of each palm of the individuals whose dactyloscopic were taken. The Kozdrój-Miler/Klemczak team, however, limited their study to the fingertips (Grzeszyk, 1972; Kozdrój-Miler & Klemczak, 2025). In this sense, Grzeszyk's classic study was broader in scope and more in line with the realities of forensic practice, as a dactyloscopic print can originate from either a finger or the palm.

Grzeszyk carried out a multi-layered analysis: he took into account, amongst other things, whether the material came from the palm or the fingertip, gender, age, skin condition, as well as the number of individuals and families from whom the material originated. In the paper by Kozdrój-Miler and Klemczak, however, only the number of fingerprints mapped – 1,104 – is given, without specifying the actual number of donors. (Kozdrój-Miler & Klemczak, 2025).

This is a serious statistical problem. In theory, the number of people whose dactyloscopic prints were taken could have ranged from around 110 – assuming ten prints were taken from each person – to 1,104, if only one print was taken from each person. The paper does not explain this point. There is also no information on how many prints were rejected due to poor quality.

Consequently, it is difficult to assess the actual size and representativeness of the research sample.

Digital imaging and the problems it brings

Another issue concerns the research methodology applied to specific prints. Contemporary experts worked with digital print images in JPEG format, while Grzeszyk analysed the minutiae directly through the lens of a stereoscopic microscope (Grzeszyk, 1972; Kozdrój-Miler & Klemczak, 2025).

The mere fact that the JPEG format was used does not in itself constitute a research error. However, this is a lossy format, which means that, depending on the level of compression, some of the image details may be distorted. When examining fine structures like dots, bridges, lakes or interruptions, such distortions may be significant. Furthermore, this format can affect the way in which the tonal extremes – that is, very bright and very dark areas – are rendered. Where optical equipment can still reveal a range of nuances, a digital image saved in a lossy format may lose some of them.

Furthermore, the authors point out that, where necessary, image editing tools were used on JPEG files, including adjustments to contrast, brightness, levels, curves and exposure (Kozdrój-Miler & Klemczak, 2025). These actions may improve image clarity, but they should be validated in terms of their impact on the classification of fine minutiae.

In my view, fingerprint images should have been saved in a lossless format, such as TIFF, at least during the scanning of the prints and their subsequent examination. It would also be advisable to carry out the analysis on monitors capable of providing a stable and consistent assessment of images saved in that format. At that, it is important that these devices offer adequate resolution, contrast and uniform backlighting, while also providing for calibration.

Doubts are also raised by the stated scanning resolution: 600 pixels per centimetre (ppc). In scanner specifications, the unit 'ppi' (pixels per inch) is used more commonly. A 600 ppc resolution corresponds to approximately 1,524 ppi, which is a very high and rather unusual value. It cannot be ruled out that this resolution was indeed used, but it is equally likely that the value was 600 ppi. This requires further clarification to rule out the possibility that the programme, which is at the prototype stage, was set to a different resolution from the source material and was interpolating the images.

The geometry of the examination field

Another issue concerns how the examination field was delineated. Grzeszyk used 'anatomical' units – he measured a distance corresponding to the width of 15 papillary ridges, including the furrows, and took this as the radius of a circle within which he counted the minutiae. The Kozdrój-Miler/Klemczak team, on the other hand, used a square with a side length of 2.5 cm (Grzeszyk, 1972; Kozdrój-Miler & Klemczak, 2025).

In my view, Grzeszyk's method has a significant advantage in this respect. This is because it takes into account the individual density of papillary ridges. In children, females and males, the number of ridges within

the same area may vary. Consequently, a 2.5×2.5 cm square may contain more ridges and potentially more minutiae in one person than in another.

Grzeszyk's method was more technically demanding, but better suited to the morphology of a specific print. The modern method is more convenient, but it may introduce a systematic error into statistical calculations if it does not take account of papillary ridge density.

The scope of the statistics and follow-up to the announcement made in the first part

In the first part, the authors stated that, as part of the project, a tool had been developed that not only counts types of minutiae but also analyses their location, feature patterns and the frequency of these patterns in specific areas of the print (Kozdrój-Miler & Klemczak, 2019). Meanwhile, the second part primarily presents a general table showing the numbers and percentage shares of the respective minutiae types (Kozdrój-Miler & Klemczak, 2025).

In this sense, the project description must be regarded as incomplete..

Absence of actual presentation of the CLKdb programme

A significant shortcoming of Kozdrój-Miler and Klemczak's publication is the lack of an actual presentation of the CLKdb programme. In the first part, the authors announced that, once the database had been populated, the second part of the paper would be published, containing detailed information about the software developed and the results obtained (Kozdrój-Miler & Klemczak, 2019). Meanwhile, the second part focuses primarily on the results of the minutiae count, while the IT tool itself is described only in very general terms (Kozdrój-Miler & Klemczak, 2025).

There are no screenshots, flowcharts, database structure, information on how coordinates are recorded, programme version details, operating environment, hardware requirements, validation rules or error-checking procedures.

It is also unclear whether the programme is intended to be a standalone tool or whether there are plans to integrate it with existing dactyloscopic databases. This is significant not only from a technical point of view, but also from a legal and organisational perspective.

The authors point out that the database was populated with data of deceased persons in order to avoid issues relating to the protection of personal data (Kozdrój-Miler & Klemczak, 2025). However, the question arises as to whether the programme is to be updated in future solely on the basis of such data, or whether provision is made for the use of dactylograms from living persons. Should the programme be used for specific opinions while also serving to permanently collect data for a statistical database, it would be necessary to set out in detail the legal basis, the purpose of the processing and the access controls.

A research programme vs. a programme for experts

From the available descriptions of the programme, it can be inferred that it is intended both to store data and, potentially, to support experts in their research. From a methodological and legal point of view, such a combination of functions may be problematic.

In my view, the software should be split into two tools:

1. a research programme, operating in a controlled environment, designed to generate and update population statistics;
2. a programme designed to assist with the preparation of expert opinions, used by an expert in a specific case, which does not need to permanently store fingerprint images but utilises an updated statistical module.

A programme for experts should have built-in statistical tables, support algorithms and a report-generation mechanism. However, it does not need to create or update a biometric database. Such an approach would be consistent with the principle of data minimisation and would mitigate legal risks.

Summary

The authors of both parts of the paper attempted to propose a new statistical approach to supporting dactyloscopic examinations, while at the same time challenging some of Grzeszyk's classic findings. In my view, however, neither the critique of the earlier study the presentation of the new tool was carried out in a manner that was entirely methodologically convincing.

The main reservations relate to:

1. the inaccurate description of Grzeszyk's methodology, in particular the omission of the fact that he used a stereoscopic microscope and an Odra 1013 digital machine;
2. the absence of evidence for Grzeszyk's measurement errors, despite the hypothesis that such errors exist;
3. the insufficiently substantiated assessment of the degree of difficulty involved in correct identification of minutiae types in children prints;
4. the reduced topographical scope of examination – Grzeszyk examined the fingers and palms, whereas the modern examination was limited to the fingertips;
5. the unclear number of print donors, which makes it difficult to assess the representativeness of the sample;
6. the selection of prints on the basis of quality, without any information on the number of rejected prints;
7. the use of a fixed geometric field in minutiae analysis, which may have affected the statistical results;
8. the use of digital processing of the analysed papillary images without demonstrating its impact on the classification of fine minutiae;
9. the failure to present CLKdb programme as announced;

10. the lack of a model for determining the frequency of minutiae patterns and the lack of a real probabilistic model, despite the announcement made in the first part;
11. the failure to separate the programme's research and expert functions, which may give rise to methodological and legal problems in the future.

In my view, the study by Kozdrój-Miler and Klemczak can be regarded as a pilot or descriptive phase. However, it should not be presented as a definitive revision of Prof. Grzeszyk's classic study, nor as a ready-made foundation for a probabilistic standard of dactyloscopic identification in Poland.

Paradoxically, despite the passage of more than half a century, Grzeszyk's work continues to impress with its scope, complexity and practical focus (Grzeszyk, 1972). Modern studies should build upon, verify and supplement this body of work, but should do so with due methodological rigour and with full respect for the actual research methodology of the predecessor.

Bibliografia

1. Grzeszyk, Cz. (1972). Badania nad minucjami linii papilarnych. *Problemy Kryminalistyki*, nr 96(XVIII), s. 175–212.
2. Kozdrój-Miler, K. & Klemczak, K. (2019). Projekt „Mapowanie odbitek linii papilarnych” (część I) – geneza. *Problemy Kryminalistyki*, nr 306(4), s. 5–8.
3. Kozdrój-Miler, K. & Klemczak, K. (2025). Projekt „Mapowani e-odbitek linii papilarnych” (część II) – wyniki. *Problemy Kryminalistyki*, nr 323(3), s. 7–13.
4. Thierry, J. (1967). Maszyny matematyczne ODRA. Przegląd produkcji Zakładów ELWRO w zakresie maszyn cyfrowych. *Maszyny Matematyczne*, nr 1, s. 21–23.