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TECHNICAL MEANS FOR ESTABLISHING OBJECTIVE QUALITATIVE CHARACTERISTICS OF COPIES OF HANDWRITTEN DETAILS. METHODOLOGICAL RECOMMENDATIONS

Abstract. *the article considers the possibility of preliminary research of digital images of handwritten details in order to obtain objective information about the suitability of such an object for the production of handwriting examination. The lower threshold values of the suitability of objects of handwriting examination submitted for the study in the form of digital images are obtained on the basis of the results of an experimental study presented together with the analysis of the expert practice of Russian expert institutions of the Ministry of Justice, Ministry of Internal Affairs of the Russian Federation, non-state expert laboratories and also the author's expert practice. Besides, the algorithm for working with signature strokes in order to obtain the necessary information is provided; the relevance of the production of such studies in the practice of handwriting experts is justified.*

Keywords: *forensic handwriting examination, handwriting, signatures, preliminary research, suitability.*

Introduction. Handwriting examination as a traditional field of forensic science has been undergoing significant changes in its theoretical basis and methodological foundations in the conditions of digitalization of social life. This concerns the signature to the greatest extent and manifests in a change in its internal structure as an object of forensic examination. Due to the development of the use of digital technologies the signature has become the object of influence of the technical modes of various devices used in particular for copying in the broadest sense so far. The number of copy objects is growing steadily: over a 4-year period statistics at the author's place of work (non-state forensic institution) has shown a 20% increase making up the majority of objects of handwriting examination in 2019 in the ratio of 60% of copy objects and 40% of original handwritten objects (Fig. 1.). This proves that a copy of the signature has acquired considerable importance for forensic handwriting practice.

The significance of a copy of the signature lies not only in the increased demand for handwriting research in relation to the copy but also in the demand for expansion of knowledge basis necessary for an expert to effectively solve the tasks as the process of making a copy of the signature includes an additional intermediate technical process which is not present in handwritten production of a signature - the process

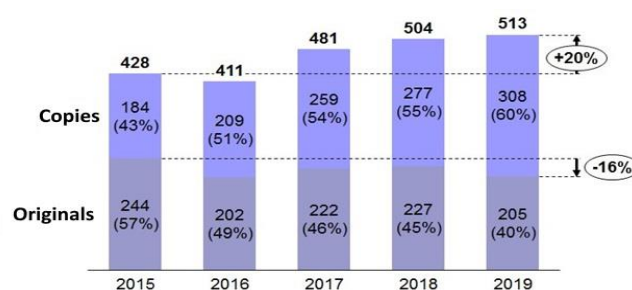


Fig. 1. Growth trends in the number of copy objects for the period from 2015 to 2019 based on the practice of the Autonomous non-profit organization «Forensic examiner».

of technical production of a signature copy. The process may have an additional subprocess in the form of montage an existing detail and / or manufacturing a new unique object which is created on the basis of an existing signature(s) and is one of the montage types.

Another important criterion for the research of digital copies of handwritten requisites is to increase objectivity in the process of evaluating the suitability of a copy object for the production of separate and comparative research in order to obtain an effective conclusion. This circumstance acquires special significance in view of the fact that both Russian [1] and European [2] methodological sources leave the question of determining the suitability of the object at the subjective discretion of the expert who carries out the research.

Such an approach suffers from obvious uncertainty and can lead to expert error,

complication of the process of evaluating the expert report and also carries a corruption risk.

The above circumstances indicate that at the moment there is a significant demand for improving the methodological support for the research of digital copies of handwritten details.

The purpose of the study is the supplement to the existing methodological framework for digital images of handwritten details which will increase the objectivity of the preliminary research of such an object of handwriting examination. The author does not propose abandoning the subjective criteria for assessing the suitability of an object for research since such characteristics of an expert's personality as his practical experience, knowledge of the theoretical basis of handwriting examination and reliance on his own empirical knowledge in the field of digital image research are of great importance for an objective and thorough research.

However, the process of scientific cognition of an object should be based not only on the personality characteristics of the examiner but also confirmed by objective data that can be verified by another researcher under similar conditions.

Materials and methods: this study was undertaken on the basis of 73 reports of state experts (the Ministry of Justice and the Ministry of Internal Affairs of the Russian Federation) and non-state forensic institutions of the Russian Federation, 81 expert reports made by the author regarding digital images of handwritten details. The experimental part of the study was carried out using 44 ballpoint pens, 31 gel pens, 19 roller pens, 19 graphite pencils (having the values "TM", "T", "M", "2T" according to the Russian hardness scale which corresponds to the values "HB", "H", "B", "2H" on the European scale) and 9 capillary pens. Scanning of the obtained strokes was carried out using an HP Color LaserJet Pro MFP M477fdw MFP - 2 pcs., an HP Color LaserJet Pro MFP M477fdn MFPs - 2 pcs., in resolution from 75 to 600 dpi, image processing was carried out using the graphic editors "Photoshop CC" (v. 20.0.9), "Paint.net" (v. 4.1.4) and the MicroCapture software (v. 3.0).

Quantitative, qualitative, experimental, model and graphic methods were used to obtain process and evaluate the results of this study.

The unit of measurement was the number of square pixels (sq.px) per measured space.

Results of the study: The number of square pixels is estimated on a separate section of the signature according to the following data: the best section for calculating the number of square pixels is a straight (or close to straight) stroke 1 cm long. In the case that there is no such stroke use an arc (or close) stroke 1 cm long. The calculation of the arc is carried out according to the formula $L = \pi r \alpha / 180^\circ$, where L is the required length of the arc; π is the Pi number (3.14); r is the radius of the circle; α is the angle (Fig. 2), or by using software to calculate the length of non-linear objects (for example, MicroCapture software, etc.). Considering the fact that the forms of movements in signatures and handwriting often have geometric deviations from strictly rectilinear or arc elements the calculated values must be estimated taking into account the error the value of which depends on the degree of deviation of the examined stroke fragment from a rectilinear or arc form.

The measurement of the number of square pixels is carried out by using the built-in function of selecting an arbitrary area or automated selection of the stroke area (the functions are available in

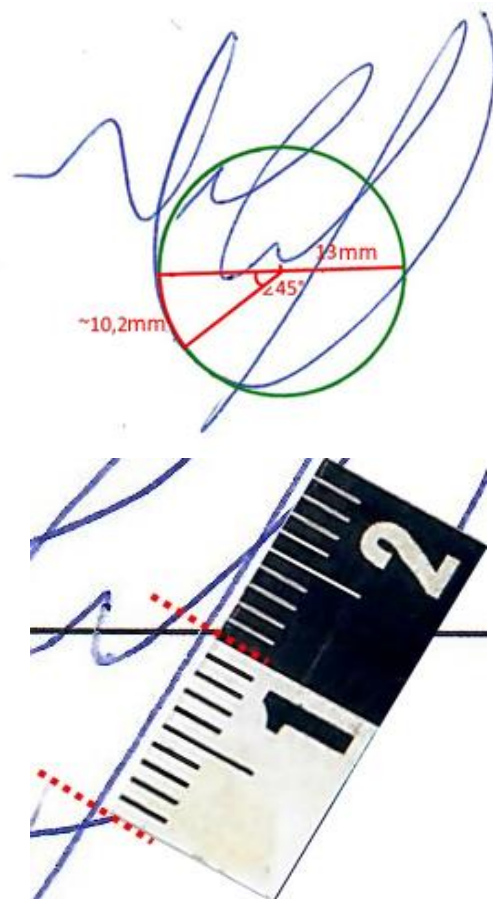


Fig. 2. Calculation of the length of the arc (left) and the rectilinear element (right).

almost all graphic editors) according to the results of which the expert receives a numerical value of the number of square pixels for a straight line stroke 1 cm long.

Sharing the point of view of the authors of the Russian methodology for the research of electrophotographic copies of handwritten details according to which the higher the quality of the copy is, the higher the possibilities of handwriting research are [1, p. 160] we proceed from the need

to determine the lower threshold value of the suitability of copies of handwritten requisites for the research production as the upper threshold is not limited: the higher the quality is the more objective the research is carried out.

The numerical values (Table) were identified through an experimental research of strokes performed by various writing devices under various conditions and taking into account handwriting dynamic characteristics.

Table

Numerical indicators of the number of square pixels in strokes made by various writing devices in various conditions with different distribution of dynamic characteristics

| Resolution | Full-color images | | | | | |
|------------------------|-------------------|---------|------------|-----------------|---------------|---------------|
| | Ballpoint pen | Gel pen | Roller pen | Graphite pencil | Capillary pen | Average value |
| 75 dpi | ~ 52 | ~ 63 | ~ 52 | ~ 52 | ~ 36 | ~ 51 |
| 150 dpi | ~112 | ~ 206 | ~ 140 | ~ 168 | ~ 188 | ~ 163 |
| 300 dpi | ~392 | ~ 756 | ~ 605 | ~ 746 | ~ 736 | ~ 647 |
| 600 dpi | ~1702 | ~ 3376 | ~ 2362 | ~ 3068 | ~ 2821 | ~ 2666 |
| Black-and-white images | | | | | | |
| 75 dpi | ~ 40 | ~ 62 | ~ 43 | ~ 50 | ~ 46 | ~ 48 |
| 150 dpi | ~ 114 | ~ 209 | ~ 145 | ~ 157 | ~ 230 | ~ 171 |
| 300 dpi | ~ 398 | ~ 776 | ~ 596 | ~ 733 | ~ 726 | ~ 646 |
| 600 dpi | ~ 1646 | ~ 3228 | ~ 2421 | ~ 3070 | ~ 3269 | ~ 2727 |

The discussion of determining the suitability degree of copies of handwritten details from the point of view of studying the technical aspect is not considered in Russian methodological sources [1]; methodological sources of the Russian Ministry of Internal Affairs system contain a direct prohibition [3] on the production of this type of handwriting research (although such studies used to be carried out [4]). European methodological sources offer a classification of objects of handwriting examination performed digitally [4, p. 54-65]. However, they do not consider the features of the technical research of the strokes of handwritten requisites submitted for the research in the form of digital images. The methodological sources [2] also indicate the presence of such objects and recognize them as acceptable object for expert examination but do not consider any technical features of their research. In some scientific papers [5] the term “copy” is considered in the context of making a signature by imitation without addressing the technical side of the stroke research of such objects. In some works [6] the authors call for a thorough research of the features displayed in copies without specifying the features of the

preliminary research of the object in order to determine its suitability through the use of technical or software. Some sources in the specialized literature [7] give practical recommendations on the qualitative characteristics of copies of documents without indicating specific numerical values and methodological approach to research while recent works in the field of signature research offer [8, p. 196] to carry out additional research of digital images of handwritten details which, however, are also not related to the technical research of strokes of digital images of signatures.

Similar studies were carried out although they were mainly aimed at researching the features of handwriting in copies of documents [9, p. 36] or at establishing the fact of the possibility of research copies of handwritten details as objects of forensic examination [10] while some scholars consider it necessary [11, p. 45] to completely abandon the production of forensic examination of copies of handwritten details.

Conclusions: The analysis and processing of the obtained data allows us to list the following conclusions:

- no fundamental differences in the number of square pixels in the research of full-color and black-and-white images were detected;

- numerical values in images of resolution from 75 to 150 dpi have insignificant differences depending on the type of a writing device while the average indicators have differences: the number of square pixels in full-color and black-and-white images made with a resolution of 75 and 150 dpi differs slightly (~ 5-6%);

- numerical values in images of resolution from 300 to 600 dpi have insignificant differences depending on the type of writing device while the average values have practically no differences (~ 2% for images of 600 dpi).

The obtained calculation results were correlated with visual analysis of such objects of research. The process of visual research of details includes the analysis of sharpness and contrast of the image, the tones in which the copy was made (full-color or black-and-white image for paper media), the presence or absence of intersections with other details of the document (printed text, stamp imprints, other handwritten strokes), the presence or absence of geometric distortions of the paper surface at the location of the investigated detail, the lighting at which the image of the detail was made, the presence or absence of background (most relevant for copies of signatures and other handwritten details that are located on documents equipped with background protective nets). However, this part of the preliminary research of the image of the handwritten details is not the subject of this article and therefore will be described more thoroughly in other works.

Based on the correlation of the results of technical and visual research of copies of handwritten details approximate numerical values of the number of square pixels which are the lower threshold value in terms of determining the suitability of an object for the production of handwriting research are identified:

- for ballpoint pens ~ 100 square pixels;
- for gel pens ~ 200 square pixels;
- for roller pens ~ 140 square pixels;
- for graphite pencils ~ 160 square pixels;
- for capillary pens ~ 180 square pixels.

The values obtained may be meaningful for practicing handwriting experts who research copies of handwritten details in order to prevent

expert errors at the stage of establishing the suitability of an object for handwriting examination. The relevance of this circumstance is confirmed by the author's assessment of 73 expert and specialist reports (state and non-state forensic expert institutions of Russia) made in relation to copies of handwritten details during which it was found that 29 expert and specialist reports made in relation to the copies that were absolutely unsuitable for carrying out an examination. Therefore this circumstance indicates the lack of objectivity of ~ 21% of research evaluated which substantially questions the implementation of the principle of objectivity of such an expert report.

Consideration of these methodological recommendations in the production of handwriting examination in relation to copies of handwritten details can increase the objectivity of determining the suitability of an object for examination which in turn will reduce the number of expert errors on the one hand and increase its level of scientificness and validity on the other.

Prospects for further research in this direction are seen in the development and practical implementation of albums containing a summary of various writing instruments in expert practice. The practical significance of creating such albums is as follows: firstly, their existence will make it possible to indicate the lower threshold value for specific types of writing devices more clearly, secondly, it will provide orientation information on writing devices that are distributed in some regions and countries and are absent in others (for example, pencils having a hardness of 2½ according to the American classification and "F" according to the European do not have their own classification group in Russia). Establishment of the unified approach to determining the suitability of a copy of handwritten details in terms of its qualitative characteristics seems to be an important direction in the development of this field. Achieving this target seems to be a solvable task since the scanning and photo devices as well as other devices that can objectively capture a digital image use the same or similar algorithms making it possible to apply the same research algorithm to objects created by means of such devices.

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