 https://doi.org/10.34836/pk.2022.317.2

Forgery of signatures by means of a mechanical-digital device. Assumptions of the *Rękopis (Manuscript)* Project

warrant officer class II Łukasz Kocielnik[1]
ORCID 0000-0002-9738-7074

[1] Central Forensic Laboratory of the Police, lukasz.kocielnik@policja.gov.pl

Abstract

The issue of forgery using mechanical-digital devices is increasingly appearing in forensic studies. Research conducted by experts on the subject has so far not allowed categorical conclusions on the genesis of a given writing sample. In Poland and around the world, no method has been developed to identify signatures made using various types of mechanical-digital devices. To address concerns and questions, the Central Forensic Laboratory of the Police together with the consortium partners, i.e. The Polish Society of Forensic Science and JAS technologies Ltd. started a research project in 2021 entitled *Intelligent System for Identification of Forgery of Biometric Handwriting Features,* operating under the code name *Manuscript*. The project is in the implementation phase, so this article contains the main ideas of the project. However, the publication began with an introduction to the issue of signature forgery, focusing on a description of its various types. At the same time, the possibilities for the use of mechanical-digital devices reproducing signatures in the United States are introduced, and previous attempts to study mechanically produced manuscripts are described.

Keywords: signature forgery, machine-made signature, CNC mechanical-digital device, *Rękopis (Manuscript)* research project

Introduction

Handwriting is an individual trace of each person. Throughout life, through repeated repetition, a person develops a habit that distinguishes the character of writing and individualizes it. Signatures are a special type of handwriting, and they are the main focus of this article. This distinction is due, on the one hand, to the universality of their use in legal and economic transactions and the functions they performed at the time[2]. On the other hand, because of the frequency of signatures, and thus a certain degree of automation and simplification in their implementation. As signatures are creations that are relatively short, but very valuable in terms of, for example, legal actions, they are quite often subject to forgery attempts.

Forgery of signatures by traditional methods

The literature accepts the following types of signature forgery (Goc, 2016), (Gruza, Goc, Moszczyński, 2011):

- technical copying, direct through a clear medium,
- technical copying, indirect copying – carbon paper,
- close imitation,
- imitation from memory,
- learned imitation,
- intellectual imitation,
- self-falsification.

Direct imitation, through a clear medium, in traditional signatures involves tracing the outlines of the authentic signature, visible on the substrate of the new document. In the case of indirect copying, tracing paper is used, with the help of which the contours of the authentic signature are transferred to the new document and then traced with another writing tool.

Close imitation involves drawing the signature of the imitated while observing the authentic pattern. The realisation of the forged signature takes place at a slow pace, which is reflected in the course of the graphic line of the forged signature. In this case, there

[2] The signature as a component of the ordinary written form of legal actions has the following functions: construction, finalisation, volition, acceptance, warning, guarantee, protection, identification and creation (Kaspryszyn, 2007).

are general analogies between authentic signatures and imitated signatures, but also important differences. In this case, it is possible to exclude the authenticity of the signature, while it is impossible to identify its maker.

Imitation from memory involves drawing a signature after a pattern remembered in the past. Reflecting to a better or worse degree the authentic signature depends on the writing skills of the forger.

Intellectual imitation is the forger's creation of another person's signature without knowledge of the authentic model. Such a signature is the result of the forger's ideas about the possible appearance of an authentic signature. The goal of the forger in this case is to create a composition that is as believable as possible, creating the appearance of authenticity. In the case of intellectual imitation, there is a chance to categorically identify its performer.

Learned imitation is the realisation of a forged signature preceded by the training of continuous observation and repetition of the authentic signature. The goal of the forger is first and foremost to credibly forge an authentic signature while maintaining the appearance of authenticity. The manner in which an authentic signature is learned, just as in the case of imitation from memory, depends primarily on the writing skills of the forger.

A specific type of signature forgery is self-falsification, which involves deliberately altering one's own signature while retaining signs of its naturalness. The purpose of self-falsification is to create the illusory belief that the performer of the signature is another person (Koziczak, Owoc, 2007).

Forging signatures with mechanical devices

The literature is increasingly addressing the topic of signatures forged using various types of mechanical devices. However, these are not photocopies or printouts, which are verifiable by an experienced handwriting examination expert, but signatures made by a device equipped with a writing instrument. We are mainly talking about CNC plotters and modern machine tools[3]. Such a signature is made directly on the substrate, with any writing tool, and correlates structurally with the authentic model. In graphology research, the fundamental fact is that no two signatures are identical, and no one is able to sign even twice in exactly the same way. Thus, if two identical signatures are found, one of them is forged or a copy of the other (Hołyst, 2000). It can also not be ruled out that both signatures are copies of another, which we do not have at our disposal during our research. At present, there are no suitable tools to conclusively determine whether a signature is a handwritten creation or was produced by a mechanical device equipped with a writing tip. It should be noted that the continuous development of mechanical-digital devices and graphic processing programs can lead to the use of such graphic creations for various criminal acts. Gramatyka and Widła (2006) point to the use of such machines to forge valuable autographs.

Hecker (2002) described the commercial operation of such devices in the United States. Among the most popular machines are Autopen and Autosign, which work on the principle of master signature templates. In the aforementioned equipment, the control system is built from a mechanical system of lever conveyors and resistance springs. The created templates rotate thanks to electric motors, while the speed of rotation can be varied. The ball joint allows you to attach any writing tool and change the angle of writing. Hecker's research showed that the expected coverage of reproduced signatures did not occur, in the case of intentionally or unintentionally changing the angle of the writing tool, which at the same time prevented the recognition of *an automatic* signature. Such changes in signatures were further caused by the loosening of the screws holding the writing tool, its strong tension or other external factors. An important risk for a handwriting expert is that various types of disorders in reproduced signatures can be considered the result of natural exogenous or endogenous factors.

In the past, there have been attempts to study this type of signatures in Poland. Popławski (2006) conducted research using a CNC machine tool, which was high-tech equipment at the time. The line of reproduced signatures was defined along its entire length by thousands of points defined by *x*, *y*, *z* coordinates. The scanned image of the authentic signature was transferred to a digital version using 3D programs based on CAD/CAM systems. The digital version of the signature was then transferred to the machine's computer, which executed the commissioned signatures on the paper substrate. Pens with black and blue ballpoint pen paste, a gel pen and a fine tip pen were used for the study. The study showed no clear differences between the compared groups of records that would contribute to the identification of signatures created by the CNC machine tool. At the same time, the author of the study pointed out that further analysis of this type of records should be directed at assessing the quality of the relief and how the amplitude of the imprint varies.

Another example of research using a CNC machine tool was that conducted by Szczepańczyk (2014).

[3] *Computerized Numerical Control tj. komputerowe sterowanie urządzeń numerycznych*, https://www.automatyka.pl/artykuly/maszyny-cnc-co-to-jest-jak-dzialaja-obrabiarki-cnc-sprawdz--164963-6 (date of access: 21.11.2022).

A CNC milling and engraving machine with a proprietary two-axis writing tool holder that allows the angle to be adjusted during the writing cycle was then used for the study. The device's control system was based on CAD/CAM software. The device allowed smooth control of the shape of the marks in the plane (*x*, *y* coordinates), but also the depth of the imprint in the substrate (*z* coordinates). The original manuscripts were converted to vector form and then reproduced on a CNC machine. As a result of the study, it was determined that the manuscripts made by the device were characterized, in the case of a ballpoint pen, by blunt finalisation of graphic lines, lack of adjacency (the device imitated hairlines by supplying the writing tool), rapid change in saturation of the ballpoint paste, and in the case of a gel fine tip pen, by faults in the graphic line realized by the machine, increased pressure and lack of adjacency (as in the case of a ballpoint pen, supplying lines). These elements, however, cannot be considered unambiguous distinguishing features of a handwriting made by a machine, as they can occur in manuscripts made by a human. The author of the research points out the significant dangers of using this type of equipment, for their accuracy and operation at high resolutions, gives the possibility of making a forgery with very high precision. In addition, the transfer of the signature from paper to digital is possible through the use of home devices such as a scanner/apparatus.

***Rękopis (Manuscript)* Project**

With the arrival of 2021, the Central Forensic Laboratory of the Police, together with consortium partners, i.e. The Polish Forensic Association and the innovative company JAS Technologie Sp. z o. o. have begun work on a research project funded by the National Center for Research and Development titled *Intelligent System for Identifying Falsification of Biometric Handwriting Features,* operating under the code name *Manuscript*. The idea for the project came after considering the real threats posed by the growing crime in the area of various types of documents. It was also necessary to expand the research capabilities of experts dealing with this issue and to create appropriate methods and means to combat crimes against document reliability. It was also not insignificant to fill the existing gap in the area of the forensic specialty in question. The project was not an idea completely detached from the findings of previous researchers, but was intended to deepen previous analyses and work out what had not been achieved. Indeed, today there is no solution that includes the technologies and functionality of the prototype system being built as part of the project.

The main objective of the project is to develop a test methodology to identify the forgery of biometric features of a handwriting imaged using a mechanical-digital device. The implementation of the project's tasks will affect the efficiency, as well as the standardisation and objectivity of handwriting identification research, by

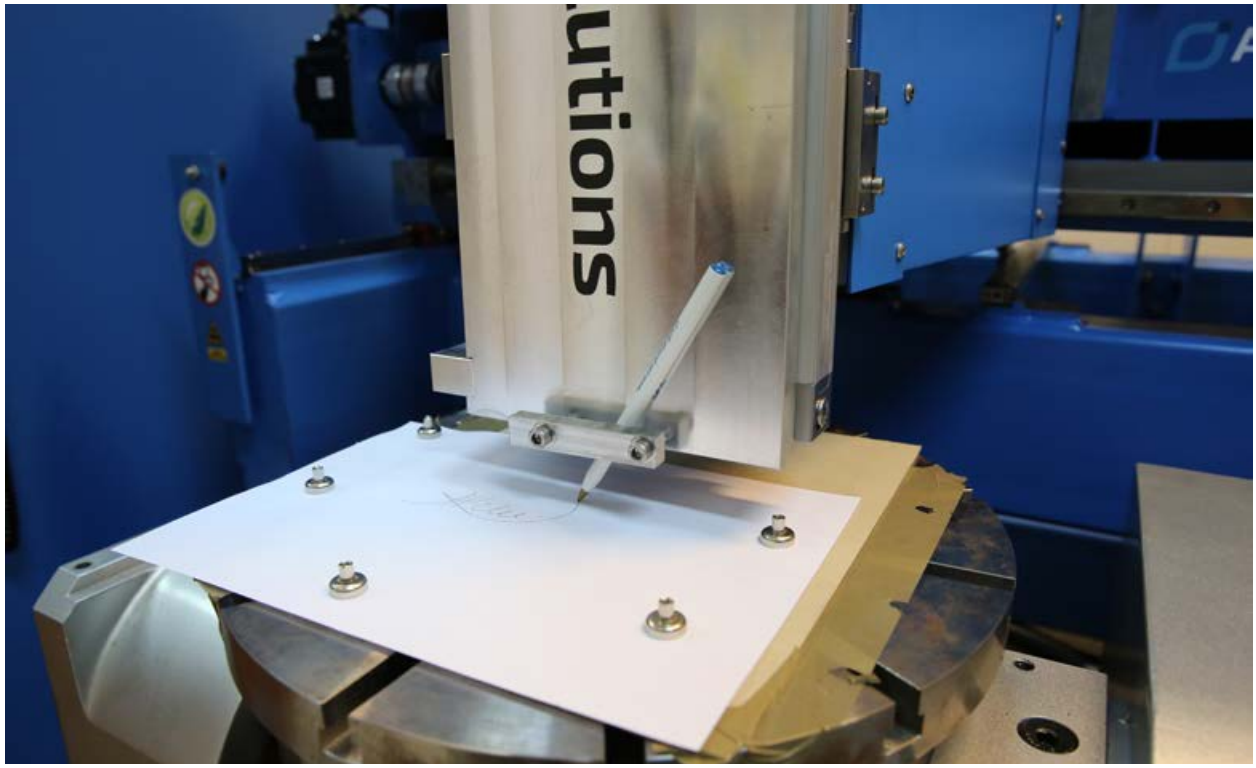


Fig. 1. CNC mechanical-digital device

Fig. 2. CNC mechanical-digital device

expanding the analytical scope of handwriting. The end result of the project will be a prototype of an intelligent system for identifying the falsification of biometric features of handwriting, recognizing in an automated way whether a given handwriting sample is from a human or a machine. The specific objectives of the project are discussed below.

1. Construction of a station for reproducing handwriting samples using a CNC-type mechanical-digital device.

The discussed handwriting forgery technique using a CNC-type device, due to its very high degree of technological sophistication and accuracy, in practice can be used for crimes of high gravity, i.e. in complex, multi-threaded cases of an economic nature, in which the subject will be property of great value. It was therefore important for the project to purchase a device of the highest quality, enabling the execution of manuscripts in five axes, i.e. allowing for a smooth change of writing angle (during one creation) and drafting speed, as well as controlling the depth of the imprint left by the writing tool (pressure control). **Figures 1–2** show a CNC-type mechanical-digital device purchased for the project acting as a forger of signatures and handwritten records.

2. Preparation of samples made by probands and then their reproduction by the CNC machine, with a gradual increase in the quality of the reproduced records.

The project prepared sets of samples made by different people, a wide range of writing instruments, consisting of pens, gel pens, fine tip pens, ballpoint pens, fountain pens, with a breakdown of inks, inks, nibs, nib sizes. For the study, a multiple set of writing substrates was purchased in the form of sheets of paper of various weights (from 80 to 200 g/m2), sheets of self-copy and decorative paper, among others, chalkboard. Only such a variety of materials used will allow the intended research to be carried out comprehensively, which will not be without consequences for the reliability and accuracy of the developed research method. These factors will be taken into account in the development of characteristics of the features of the studied records indicating their non-manuscript genesis, such as, for example, the way of initiating and finalizing graphic lines, the shape of line edges, the distribution of shading and saturation of the writing center, pressure, the structure of reliefs and imprints, the construction of characters and the bonds between them.

Then, the handwritten samples were 3D scanned on an optical profilograph, combining the work of devices such as a conturograph, the aforementioned 3D scanner, a measuring microscope, a laser and

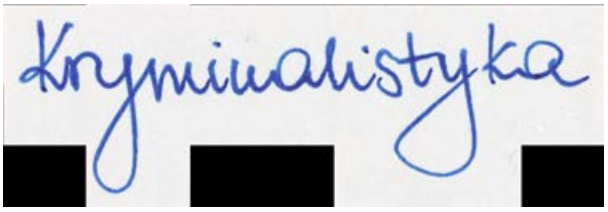
a stereoscope. The device made it possible to scan handwritten manuscripts, taking into account the depth of the imprint left by the writing tool. The variation in imprint depth will be used when the machine attempts to more accurately reflect the records. **In Figures 3 and 4**, a scanned signature is presented, with the depth of the relief colour-coded. Currently, graphic files of handwritten records are processed into Bezier curves and implemented into the CNC device in this form. **Figure 5** presents examples of manuscripts- a. man-made, b. machine-made (based on pattern a.)

Fig. 3. Signature with a colour indication of the depth of the relief

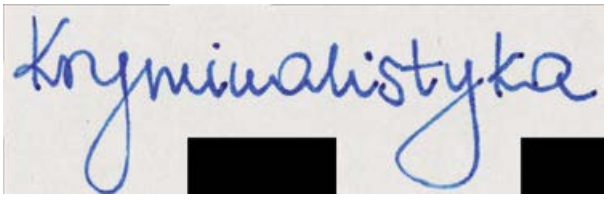
Fig. 4. Signature with a colour indication of the depth of the relief

a

b



a



b

Fig. 5. Manuscripts a. man-made, b. reproduced by a machine

3. Evaluation of the effectiveness of solutions currently used in forensic document examination (in progress).

Samples of handwriting made by man and by machine, collected as part of the project, will be analysed by experienced handwriting research experts to determine whether the existing methods and tools used in graphology analysis will allow the genesis of a given sample to be determined. Experts will provide answers to the following questions:

- Which of the samples submitted for testing is manuscript in nature i.e. from a human being?
- Which of the samples submitted for testing is non-manuscript in nature, i.e., from a machine?
- On the basis of what characteristics were the above findings made?
- Are there characteristics that are the hallmark of a machine-produced writing?

The above research will be carried out using the standard equipment of the document research laboratory, i.e. stereoscopic microscopes, 3D digital microscopes, VSC 8000 videospectrocomparators, ESDA indented writing analysis device (substrate relief analysis) and profilometers. As the quality of forged writing samples continues to increase, expert research will be conducted at every stage of the project. **Figures 6–7** shows the relief analysis process.

4. Building a system concept based on IT and optical-mechanical solutions.

Based on the analyses conducted and the differences found between manuscripts drawn by a human and a machine, data will be extracted, which will consequently form the basis for the functioning of artificial intelligence. It should be signalled that a certain group of handwriting features, can not be assigned specific values indicating that the sample came from a man or a machine. Such groups of variables have so far been subject to the subjective evaluation of the expert. The designed solution assumes the use of artificial intelligence, which will be able to verify the genesis of a given writing sample based on an extensive amount of training data.

The IT techniques used in the project will work on digitally processed writing samples and data analysis algorithms. Since there are many off-the-shelf software solutions on the market, the designed system does not assume the development of new software, but the use of off-the-shelf solutions. The system will be a locally run application, on a computer equipped with a specific operating system.

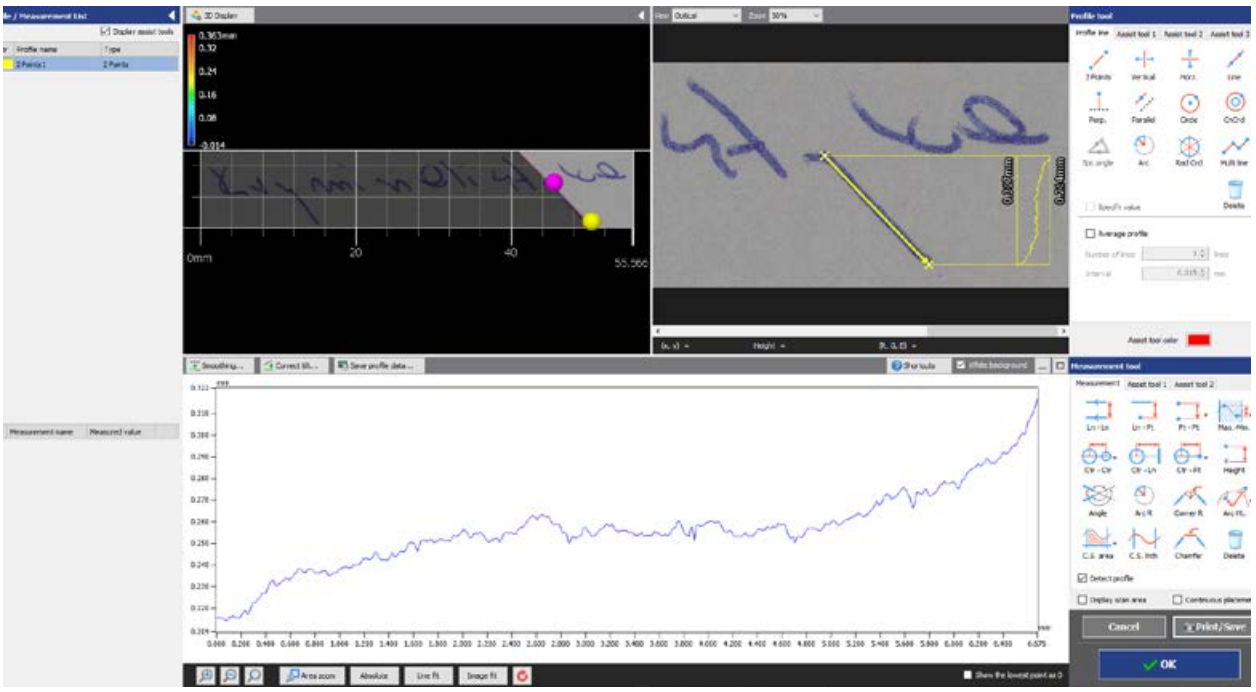


Fig. 6. Relief analysis

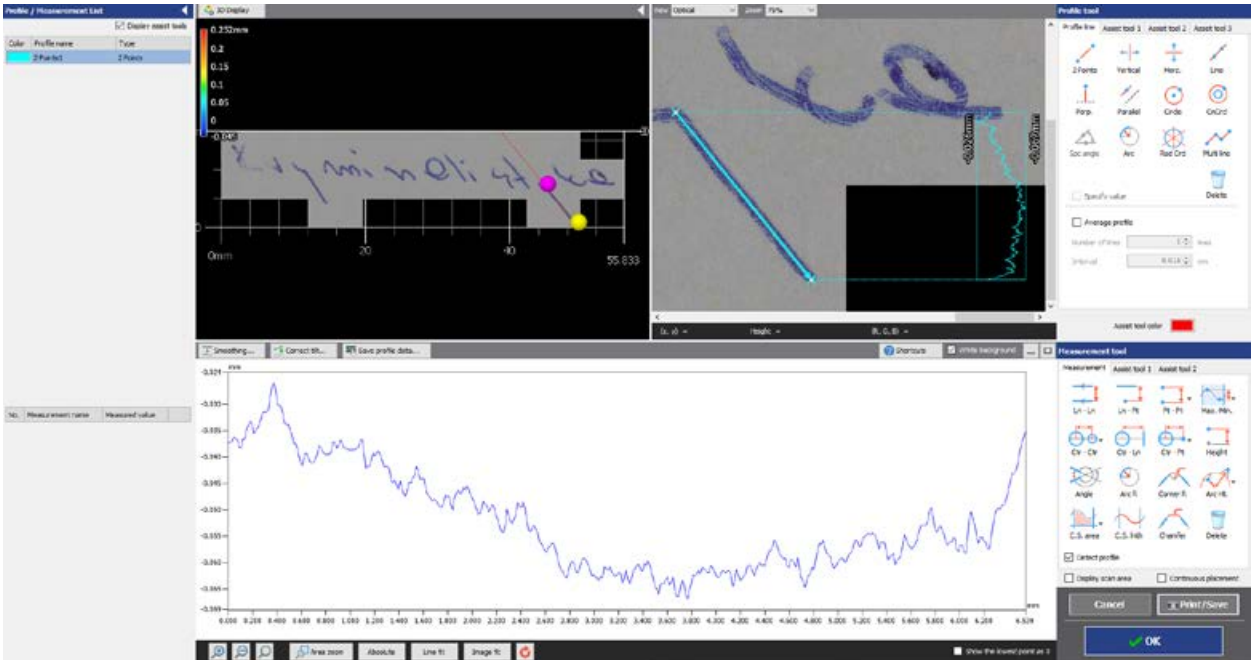


Fig. 7. Relief analysis

5. Development of technical documentation and a manual for the use of the system, including a description of the detailed methodology and testing technique to identify the forgery of the handwriting produced by the mechanical-digital device.

The project involves the creation of a research method that allows a complete analysis of the characteristics of handwriting and machine-generated handwriting, representing an important step toward objectivizing research. The development of the methodology will contribute to raising the profile of issued document examination expertise and increasing the efficiency of various services. The proposed research method will find its application in police forensic laboratories, university laboratories, Internal Security Agency, Border Guard, Military Police. Due to the innovation of the target product, it may have a global character, i.e. find application in foreign centers.

Conclusions

The ongoing research project at the Central Police Forensic Laboratory, codenamed *Manuscript*, is a very important and groundbreaking step in forensic document research, both in Poland and around the world. Technological advances, seen by us every day, have caused criminals to change or transform their former behaviour. The role of law enforcement in this aspect is unique. We need to create effective tools to detect and combat crimes committed using ever newer methods. Such a tool will undoubtedly be the effect of the project described in this article. However, it should be borne in mind that the designed application will be a supporting element of the expert's work and will never replace it. The role of computer programs for handwriting analysis has already been emphasised by Goc (2016). The final interpretation of the test results and, consequently, the correctness of the opinion will always depend on the competence, reliability and experience of the expert. This does not contradict the claim that the application will enrich the previously used catalog of handwriting features and increase the value of the issued opinion.

REFERENCES

1. Kaspryszyn, J. (2007). *Podpis własnoręczny jako element zwykłej formy pisemnej czynności prawnych (The handwritten signature as an element of the ordinary written form of legal actions).* Warsaw: Wolters Kluwer Polska.
2. Goc, M. (2016). *Współczesny model ekspertyzy pismoznawczej wykorzystanie nowych metod i technik badawczych (The modern model of graphology expert analyses, the use of new methods and research techniques).* Warsaw/Szczecin: Polish Forensic Society.
3. Gruza, E., Goc, M., Moszczyński, J. (2011). *Kryminalistyka – czyli rzecz o metodach śledczych (Forensic science – or about investigative methods).* Warsaw: Wydawnictwa Akademickie i Profesjonalne.
4. Koziczak, A., Owoc, M. (eds.) (2007). *Słownik Terminów Pismoznawczych (Dictionary of Graphology Terms).* Krakow: Instytut Ekspertyz Sądowych.
5. *Computerized Numerical Control tj. komputerowe sterowanie urządzeń numerycznych*, https://www.automatyka.pl/artykuly/maszyny-cnc-co-to-jest-jak-dzialaja-obrabiarki-cnc-sprawdz--164963-6 (dostęp 21.11.2022).
6. Hołyst, B. (2000). Kryminalistyka (Forensic Science), 9th Edition revised and expanded. Warsaw: Wydawnictwa Prawnicze PWN.
7. Gramatyka, M., Widła, T. (2006). Podrabianie podpisów z wykorzystanie plotera (Forging signatures with the use of a plotter). [In:] Z. Kegel (ed.), The *impact of experimental research on the evidentiary value of document expertise*, Materials of the XII Wrocław Symposium on Graphology. Wrocław: University of Wrocław.
8. Popławski, B. (2006). *Wykorzystanie urządzeń kopiujących w fałszowaniu podpisów (Use of copying devices in signature forgery).* Warsaw: Forensic Laboratory of the Capital City Police Headquarters, Document Examination Laboratory.
9. Hecker, M. (2002). *Podpisy wykonane automatycznie (Machine-made signatures).* [In:] Z. Kegel (ed.), *Problematyka dowodu z ekspertyzy dokumentów (Problems of evidence from the expert analysis of documents.* Wrocław: University of Wrocław.
10. Szczepańczyk, S. (2014). Podrobienie pisma ręcznego (Handwriting forgery). [In:] B. Hołyst (ed.), Technika Kryminalistyczna w pierwszej połowie XXI wieku wybrane problemy (Forensic Technology in the First Half of the 21st Century, Selected Problems). Warsaw: Wydawnictwo Naukowe PWN.