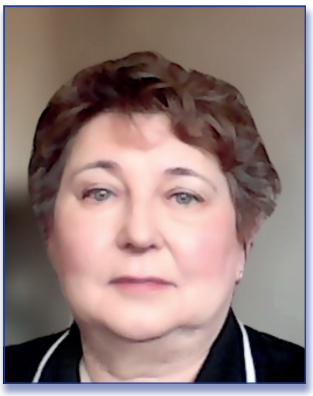

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# Technological breakthrough in criminalistics and forensic examination : new horizons

This scientific article focuses on exploring the directions for the application of the latest technologies in criminalistics and forensic examination in Ukraine and other countries. Thanks to global digitalization, open access to scientific publications and research data has become available to scientists from most countries worldwide. Open science has emerged as a new reality in the research activities of the world's leading scientific communities, including Ukraine. This creates opportunities for a significant technological breakthrough in the development of criminalistics and forensic examination.

Based on the study and analysis of scientific and other sources from Ukraine and other countries, the following open-access digital forensic platforms available to law enforcement agencies were identified and analyzed: the Automated Fingerprint Identification System (AFIS); facial recognition systems Clearview AI (USA) and SmartFace (Slovakia); the BigDataPeople system (Ukraine) for collecting information about individuals using open-source data; the BalScan ballistic identification system (Czech Republic); the databases of cold steel and firearms maintained by the Netherlands Forensic Institute; the IBIS system for automated firearm and toolmark identification based on 3D trace imaging; the free ChemSpider database of medicines and bioproducts (United Kingdom); the ABIS biometric identification management system (Slovakia), which utilizes palm prints, iris scans, and facial features, among others.

The latest forensic methods for evidence examination, described in open sources and considered promising for use in Ukraine, have been identified. These include: studying narcotic materials, explosives, chemical, and biological substances at the atomic and molecular levels (nanotechnology); identifying individuals and determining their age based on the complete set of proteins produced by the human body; determining the time of death based on various markers (blood pH, cholesterol, sodium, potassium, etc.); determining human characteristics (age, skin color, eye and hair color) through DNA analysis, and more.

The integration of Ukrainian forensic knowledge into European and global open science systems requires not only adherence to their standards and principles but also the unification and standardization of metadata exchange protocols, including their content and format.

**Keywords:** technologization, digitalization, research data, criminalistics, forensic examination, open science

**Research Problem Formulation:** Global digitalization creates new opportunities for open access to the results of scientific research by scientists from different countries and new challenges for law enforcement agencies. Social networks, online stores and other e-commerce platforms, and hidden darknet networks are actively used by criminals to illegally trade in wild animals, prohibited substances, human organs, cultural property, and counterfeit products. Some actors use virtual currencies and alternative banking platforms to legalize illicit proceeds, and members of organized crime and terrorist groups use new (encrypted) communication technologies and platforms to communicate and interact covertly[1]. At the same time,

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**CONTRIBUTORS**

The authors contributed solely to the intellectual discussion underlying this paper, case-law exploration, writing and editing, and accept responsibility for the content and interpretation.

**DECLARATION OF COMPETING INTEREST**

The author declare that they have no conflict of interest.

[1] Transformative Technologies: How digital is changing the landscape of organized crime. Global Initiative Against Transnational Organized Crime. Posted on 29 Jun 2020. p.p. 2-3. URL: https://

new tools have emerged to detect the facts of illegal activity and thoroughly investigate its traces to establish the truth and conduct quality investigations.

Thanks to the development of digital and network technologies and the integration of knowledge in forensic science and forensic examination, not only new sources of evidence (computers, mobile phones, photo and video cameras, GPS navigators, social networks and various Internet sites, etc.) and methods of their research have appeared, but also the latest methods of analysis of "classical" forensic objects and traces (blood and other secretions of the human body: traces of hands, feet, lips, human voice; traces of tools and instruments; weapons and their traces; various materials, etc.).

Law enforcement officers today actively use not only special equipment in their work, but also such household electronic technical means as mobile phones, voice recorders, photo and video cameras, GPS trackers. Due to their small size, multifunctionality, and the ability to quickly capture information, they are rightfully used in law enforcement[2]. Analysts at Deloitte International Corporation predict that in the near future, 20 to 30% of law enforcement activities may be automated[3].

The importance of using digital technologies and gaining skills in their use by a forensic expert in order to maintain confidence in forensic examination is emphasized in the Action Plan for the Development of the European Forensic Area until 2030 (EFSA 2.0)[4]. This Plan provides for the development of mechanisms for verifying the reliability of the results of forensic research obtained using digital technologies and artificial intelligence, as well as their entry into legal force. Paragraph 7 of the Plan emphasizes the importance of digitalization of forensic science in all EU member states.

Since on June 23, 2022, Ukraine received the status of a candidate for EU membership and negotiations on Ukraine's accession to the European Union have already begun, our country should digitize forensic and forensic activities as much as possible, using innovations in these areas in the EU and the United States.

The processes of innovative development of forensic science and forensic examination are facilitated by the introduction of open access mechanisms to scientific publications and research data in most developed countries of the world. The UNESCO Recommendations on Open Science define[5] it as a combination of various principles, rules and means aimed at ensuring that scientific knowledge presented in different languages is publicly available and suitable for reuse, reproduction and verification in order to increase cooperation and exchange of information for the benefit of science and society[6].

Open science provides equal conditions for the competition of scientists, facilitates the verification of the reliability of the declared scientific results, promotes rapid progress in various fields, helps society to spend more rationally on research and avoid duplication of research and development topics.

Scientists actively study and use in their work the results of scientific research contained in the following international aggregators of information resources: OpenAIRE[7], OpenDOAR[8], BASE[9], CORE,[10] etc. The obtained new

globalinitiative.net/wp-content/uploads/2020/06/Transformative-Technologies-WEB.pdf

2 Тіхонов С.В., Кобець М.В. Методичні рекомендації щодо застосування GPS-трекерів у розкритті кримінальних правопорушень. Київ : Нац. акад. внутр. справ, 2021. С. 17. URL: https://elar.navs.edu.ua/server/api/core/bitstreams/2c421b7f-e0ad-4e98-8f8f-8d8709007c3b/content

3 Deloitte. Policing 4.0. Deciding the future of policing in the UK. (2018). URL: https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/public-sector/deloitte-uk-future-of-policing.pdf

4 Action Plan for the European Forensic Science Area 2.0. Council of the European Union. Brussels, 9 March 2023. URL: https://data.consilium.europa.eu/doc/document/ST-7152-2023-INIT/en/pdf

5 UNESCO Recommendation on Open Science. UNESCO. 2021. 34 p. DOI: https://doi.org/10.54677/MNMH8546

6 Загородній А. Г. та ін. Впровадження європейських принципів відкритої науки в Національній академії наук України. *Вісник НАН України*, 2025, № 1. С. 12. DOI: https://doi.org/10.15407/visn2025.01.011

7 OpenAIRE. URL: https://www.openaire.eu/

8 OpenDOAR. URL: https://v2.sherpa.ac.uk/opendoar/

9 BASE. URL: URL: https://www.base-search.net/

10 CORE. URL: https://core.ac.uk/

**Galina AVDEEVA**

**TECHNOLOGICAL BREAKTHROUGH IN CRIMINALISTICS AND FORENSIC EXAMINATION : NEW HORIZONS**

This scientific article focuses on exploring the directions for the application of the latest technologies in criminalistics and forensic examination in Ukraine and other countries. Thanks to global digitalization, open access to scientific publications and research data has become available to scientists from most countries worldwide. Open science has emerged as a new reality in the research activities of the world's leading scientific communities, including Ukraine. This creates opportunities for a significant technological breakthrough in the development of criminalistics and forensic examination.

Based on the study and analysis of scientific and other sources from Ukraine and other countries, the following open-access digital forensic platforms available to law enforcement agencies were identified and analyzed: the Automated Fingerprint Identification System (AFIS); facial recognition systems Clearview AI (USA) and SmartFace (Slovakia); the BigDataPeople system (Ukraine) for collecting information about individuals using open-source data; the BalScan ballistic identification system (Czech Republic); the databases of cold steel and firearms maintained by the Netherlands Forensic Institute; the IBIS system for automated firearm and toolmark identification based on 3D trace imaging; the free ChemSpider database of medicines and bioproducts (United Kingdom); the ABIS biometric identification management system (Slovakia), which utilizes palm prints, iris scans, and facial features, among others.

The latest forensic methods for evidence examination, described in open sources and considered promising for use in Ukraine, have been identified. These include: studying narcotic materials, explosives, chemical, and biological substances at the atomic and molecular levels (nanotechnology); identifying individuals and determining their age based on the complete set of proteins produced by the human body; determining the time of death based on various markers (blood pH, cholesterol, sodium, potassium, etc.); determining human characteristics

(age, skin color, eye and hair color) through DNA analysis, and more.

The integration of Ukrainian forensic knowledge into European and global open science systems requires not only adherence to their standards and principles but also the unification and standardization of metadata exchange protocols, including their content and format.

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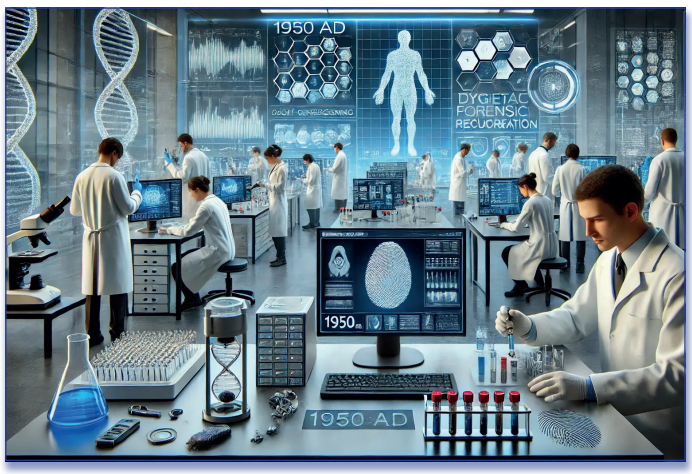
results and research data serve as a basis for further research in certain areas and accelerate their development. Therefore, the search and analysis of the latest technologies for the study of evidence is relevant for the development of forensic science and forensic examination.

This article purpose is to facilitate the dissemination and popularization of scientific results of Ukrainian researchers at the international level, exchange of scientific and technical information with foreign scientific institutions and researchers to intensify scientific cooperation and conduct joint research; to expand the infrastructure and resource base for the use of various biometric technologies, and to intensify the development of new methods of DNA analysis and digital evidence research. Promising is the joint work of forensic scientists and IT specialists to create modern digital systems for investigating evidence and introducing artificial intelligence systems to search for the necessary scientific information in open collections of scientific publications integrated into a single system, to identify individuals by biometric data, regardless of the country in which they live.

**Analysis of recent research and publications.** The following scholars have paid attention to the problems of technologization of criminalistics and forensics: V. D. Bernaz, V. H. Honcharenko, V. A. Zhuravel, A. V. Kovalenko, V. A. Kolesnyk, Ye. D. Lukianchykov, O. H. Predmestnikov, V. H. Khakhanovskyi, D. M. Tsekhan, S. S. Cherniavskyi, Yu. M. Chornous, V. M. Shevchuk, V. Yu. Shepitko, V. V. Yusupov, R. M. Shekhavtsov et al. Due to the constant development of digital technologies around the world and the relevance of the problems of technologization in criminal proceedings, in recent years, considerable attention has been paid to these issues in the world scientific community. In the United States alone, more than 22,000 scientific publications on new advances in forensic science and forensics have been published since 2020. Some of the authors reveal the essence of completely new technologies, while others propose to adapt modern research methods already existing in a particular field to analyze new objects and solve new expert tasks[11]. Therefore, constant monitoring of the current level of technologicalization of criminalistics and forensic science in different countries of the world, analysis of modern achievements in this area and proposals for the introduction of technologicalization in criminal proceedings is relevant.

This article purpose is to highlight the latest world scientific and practical methods of working with evidence, to determine the possibility of their use in Ukraine, to provide proposals on the prospects for using the most effective new technologies in forensic and forensic activities.

**Main Content Presentation:** Ukrainian law enforcement officers receive digital information on organizers and members of international organized criminal groups from the Millennium information and search system, which was created by the International Criminal Police Organization (INTERPOL). The databases of this system contain personal and biometric data, photographs, individual characteristics, links to organized criminal organizations, etc.[12] Interpol enables law enforcement agencies in 196 member countries to exchange intelligence through a secure network called I-24/7 and use 19 police databases with digital information on crimes and criminals (from names and fingerprints to stolen passports), to which countries have access in real time[13].




Interpol databases accumulate a lot of information in digital form, which is analyzed and structured using a system

[11] Kimmy Gustafson. Modern Forensic Science Technologies (2024). Forensics Colleges. Forensic Education Blog. 09.02.2024. URL: https://www.forensicscolleges.com/blog/resources/10-modern-forensic-science-technologies

[12] Project Millennium. Interpol : website. URL: https://www.interpol.int/Crimes/Organized-crime/Project-Millennium#:~:text=Facilitating%20the%20exchange%20of%20investigative,criminal%20networks%20and%20their%20activities

[13] What is INTERPOL? Interpol : website. URL: https://www.interpol.int/Who-we-are/What-is-INTERPOL

with elements of artificial intelligence Criminal Analysis Files. Based on this analysis, intelligence reports are formed for member countries (including Ukraine), socio-demographic information about criminals (age, gender, type of activity, criminal ties), as well as the time and place of criminal activity is accumulated[14].

Interpol for law enforcement agencies of participating countries also provides access to the AFIS Automated Fingerprint Identification System and to the face recognition system using portable biometric data collection devices[15].

Since 2022, law enforcement agencies of Ukraine have been using the facial recognition system based on the appearance of the American company Clearview AI[16], and the BigDataPeople system of the Ukrainian company Artellence has been used to collect information about persons using information from open sources[17]. Since the full-scale invasion of Ukraine by the Russian Federation, criminal analysis units have been identifying war criminals, collaborators, traitors, saboteurs, etc. During 2022, criminal analysis units identified almost 5.5 thousand people involved in armed aggression[18].

In current conditions, digital images of objects serve as the basis for creating various automated expert information and reference collections and forensic records[19]. Employees of forensic institutions in different countries form and actively use specialized information resources, in particular, on cold arms[20] and firearms[21], during forensic research, Netherlands Forensic Institute (NFI). Examples of automated identification fingerprint, trace and ballistic systems include the following: Dakto-200, TrasoScan, BalScan, etc.[22] For facilitating interaction between forensic experts, lawyers, investigators and judges, France has created the Opalexe[23] digital platform containing sample documents and materials on the appointment and conduct of forensic examinations.

The BalScan identification ballistic system manufactured by Laboratory Imaging s.r.o. (Czech Republic) has been used in Ukraine since 2019. It is designed for digital capture and comparative analysis of images. The system database contains images of bullets and cartridges fired from registered firearms, and also allows you to scan and compare traces of firearms even on deformed bullets and their fragments in order to identify a specific instance of firearms.

14 Criminal Intelligence analysis. Interpol. URL: https://www.interpol.int/en/How-we-work/Criminal-intelligence-analysis2

15 Мовчан А. В. Міжнародний досвід застосування сучасних технологій у протидії організованій злочинності // Актуальні питання психологічного забезпечення службової діяльності структурних підрозділів МВС України в умовах воєнного стану : матеріали V міжвідомчого науково-практичного круглого столу (Київ, 20 квітня 2023 року). С. 115. URL: https://elar.naiau.kiev.ua/collections/1233252c-327f-41ef-a52a-a3cc38eeb9fe

16 War in Ukraine. Clearview AI : website. URL: https://www.clearview.ai/

17 Open Data matters now. Artellence : website. URL: https://artellence.com/

18 Овсянюк Д.І., Худенко Д.М. Використання підрозділами кримінального аналізу технологій розпізнавання облич та фенотипування днк в умовах воєнного стану // Актуальні питання психологічного забезпечення службової діяльності структурних підрозділів МВС України в умовах воєнного стану: матеріали V міжвідомчого науково-практичного круглого столу (Київ, 20 квітня 2023 року). С. 232.

19 Інструкція з організації функціонування криміналістичних обліків Головного експертно-криміналістичного центру Державної прикордонної служби України. Затверджена Наказом Міністерства внутрішніх справ України 10.07.2017 № 580. URL: https://zakon.rada.gov.ua/laws/show/z0957-17#Text

20 Databank voor messen moet politie helpen in onderzoek naar steekpartijen. NOS Nieuws. Dinsdag 14 maart 2023. URL: https://nos.nl/artikel/2467375-databank-voor-messen-moet-politie-helpen-in-onderzoek-naar-steekpartijen

21 Politie en NFI gaan meer wapenonderzoek doen. NOS Nieuws, Donderdag 30 september 2021. URL: https://nos.nl/artikel/2399759-politie-en-nfi-gaan-meer-wapenonderzoek-doen

22 Кожевніков В. Штучний інтелект як інструмент криміналістики та судової експертизи. // Актуальні питання судової експертизи і криміналістики : зб. мат-лів міжнар. наук.-практ. конф. з нагоди 100-річчя Національного наукового центру «Інститут судових експертиз ім. Засл. проф. М. С. Бокаріуса» (Харків, 10.11.2023). Харків : НІЦ «ІСЕ ім. Засл. проф. М. С. Бокаріуса», 2023. С. 190.

23 La dématérialisation des expertises civiles avec OPALEXE. *Parole au cncej, Experts* № 133, août 2017. P. 40. URL : https://www.martinique-expertsdejustice.com/wp-content/uploads/2018/03/article-RE_15

**Galina AVDEEVA,**

## PERCÉE TECHNOLOGIQUE EN CRIMINALISTIQUE ET EN CRIMINALISTIQUE : NOUVEAUX HORIZONS

L'article scientifique est consacré à la mise en évidence des domaines d'utilisation des dernières technologies en criminalistique et en criminalistique en Ukraine et dans d'autres pays. Les dernières méthodes criminalistiques de recherche de preuves ont été identifiées, dont la description est contenue dans des sources ouvertes et qui sont prometteuses pour une utilisation en Ukraine, à savoir : la recherche de matières narcotiques, d'explosifs, de substances chimiques et biologiques au niveau des atomes et des molécules (nanotechnologie) ; identification des individus et détermination de leur âge à partir de l'ensemble des protéines produites par le corps humain ; déterminer l'heure du décès de la victime à l'aide d'un certain nombre de marqueurs (pH sanguin, cholestérol, sodium, potassium, etc.) ; détermination des caractéristiques d'une personne (âge, couleur de la peau, des yeux et des cheveux, âge) à l'aide de l'ADN, etc. Le but de l'article est de promouvoir la diffusion et la vulgarisation des résultats scientifiques des chercheurs ukrainiens au niveau international, l'échange d'informations scientifiques et techniques avec des institutions scientifiques et des chercheurs étrangers afin d'intensifier la coopération scientifique et de mener des recherches conjointes ; élargir l'infrastructure et la base de ressources pour l'utilisation de diverses technologies biométriques, accroître le développement de nouvelles méthodes d'analyse de l'ADN et la recherche de preuves numériques. Le travail conjoint des scientifiques criminalistiques et des spécialistes en informatique pour créer des systèmes numériques modernes d'examen des preuves et introduire des systèmes d'intelligence artificielle pour rechercher les informations scientifiques nécessaires dans des collections ouvertes de publications scientifiques intégrées dans un système unique, afin d'identifier les individus à l'aide de données biométriques quel que soit le pays dans lequel ils résident, est également prometteur.

Mots-clés : technologisation, numérisation, données de recherche, criminalistique, analyse scientifique, science ouverte

**Galina AVDEEVA,**

**TECHNOLOGISCHER DURCHBRUCH IN DER KRIMINALISTIK UND FORENSISCHEN EXPERTISE: NEUE HORIZONTE DIESER WISSENSCHAFTLICHE**

Artikel beleuchtet die Anwendungsrichtungen neuester Technologien in der Kriminalistik und forensischen Expertise in der Ukraine und weiteren Ländern. Neue kriminalistische Methoden zur Untersuchung von Beweismitteln, die in offenen Quellen beschrieben werden und für die Ukraine vielversprechend sind, werden vorgestellt: die Analyse narkotischer, explosiver, chemischer und biologischer Substanzen auf Atom- und Molekülebene (Nanotechnologien); Personenidentifikation und Altersbestimmung anhand des kompletten Proteinprofils des menschlichen Organismus; Todeszeitanalyse über Marker wie Blut-pH, Cholesterin, Natrium und Kalium; Bestimmung individueller Merkmale (Alter, Haut-, Augen- und Haarfarbe) mittels DNA-Analysen. Ziel des Artikels ist die Förderung und Popularisierung der wissenschaftlichen Ergebnisse ukrainischer forschender auf internationaler Ebene, der Austausch technischer Informationen mit ausländischen Forschungseinrichtungen zur Intensivierung der Kooperation und gemeinsamen Studien sowie der Ausbau der Infrastruktur und Ressourcenbasis für biometrische Technologien, die Weiterentwicklung neuer DNA-Analyseverfahren und digitaler Beweismitteluntersuchungen. Perspektivisch wird die Zusammenarbeit von Kriminalist:innen mit IT-Fachkräften zur Entwicklung moderner digitaler Systeme für Beweismitteluntersuchungen und Einführung von KI-Systemen zur Recherche in integrierten offenen Sammlungen wissenschaftlicher Publikationen und zur biometrischen Identifikation von Personen weltweit hervorgehoben.

Schlüsselwörter: Technologisierung. Digitalisierung. Forschungsdaten. Kriminalistik. Forensische Expertise. Open Science.

The armed aggression of the Russian Federation against Ukraine accelerated the creation of an electronic database of digital copies of traces of firearms on cartridges using the BalScan system including more than 600 thousand images of cartridges with traces of more than 200 thousand weapons. These cartridges are removed from crime scenes and cartridges fired from lost weapons or those registered to certain persons[24].

In more than 80 countries around the world, law enforcement and military personnel use the IBIS system to automatically identify firearms and tools in their tracks[25]. Trace analysis in this system is carried out using 3D microscopy and special comparison algorithms with a significant number of 3D images of traces of shell casings and bullets contained in an integrated network of separate databases of different countries.

For fixing (creating a 3D model) of terrain areas, individual objects and traces, investigative and forensic practice uses three-dimensional scanning technology developed by Artec 3D allowing for high accuracy and resolution to quickly obtain color three-dimensional electronic copies of objects and traces of foreign objects[26], which subsequently serve as objects of trace, ballistics, explosives, automotive, transport and trace and other types of forensic examinations.

Scientists at the Massachusetts Institute of Technology (USA) have developed high-speed video cameras capable of recording events with microsecond accuracy. These fairly easy-to-use devices are successfully used during an expert experiment in forensic ballistic research to determine the mechanism of damage formation on various objects (including the human body) from various kinds of shells, determine their flight speed and solve other expert problems by investigating the traces of interaction of objects with ballistic objects[27].

Law enforcement officers actively use digital databases from open sources that are developed in other areas of knowledge. Most often, such databases are designed to store and search information in medicine, biology, physics, engineering and other fields[28]. They contain data on pharmaceuticals, biological materials, narcotic drugs, chemical compounds, cold steel and firearms, types and properties of metals and alloys, and other background information.

Forensic experts use digital resources created by well-known global scientific communities to publish research results in various fields of science as references. Examples of such sources are: 1) a system of free databases of medicines and biological products, marine natural products, chemicals and their properties ChemSpider, natural products, catalysts, methods in organic synthesis", etc. (developed by the Royal Society of Chemistry of the United Kingdom)[29]; 2) PubChem, an open chemical database of the National Institute of Health (NIH, USA), which allows searching for chemicals by name, molecular formula, structure and other characteristics30; 3) Cambridge Structure Database (CSD), Inorganic Crystal Structure Database (ICSD) and digital services of CCDC and FIZ Karlsruhe contain experimental research-based information in the field of structural chemistry,

[24] Лебідь С.О., Шевчук О.Ю. Проблеми використання балістичних обліків у розкритті злочинів в умовах воєнного стану // Актуальні питання психологічного забезпечення службової діяльності структурних підрозділів МВС України в умовах воєнного стану : матеріали V міжвідомчого науково-практичного круглого столу (Київ, 20 квітня 2023 року). С. 92. URL: https://elar.naiau.kiev.ua/collections/1233252c-327f-41ef-a52a-a3cc38eeb9fe

[25] Firearm and Tool Mark Identification – IBIS. Forencic technology. https://www.ultra-forensictechnology.com/en/products-and-services/firearm-and-tool-mark-identification-ibis/

[26] Фролов А., Варлахов В., Федорченко В. Застосування сучасного програмного забезпечення під час дослідження зіткнень транспортних засобів // Актуальні питання судової експертизи і криміналістики : зб. мат-лів міжнар. наук.-практ. конф. з нагоди 100-річчя Національного наукового центру «Інститут судових експертиз ім. Засл. проф. М. С. Бокаріуса» (Харків, 10.11.2023). Харків : ННЦ «ІСЕ ім. Засл. проф. М. С. Бокаріуса», 2023. С. 387.

[27] Ballistic Photography. URL: http://facweb.cs.depaul.edu/sgrais/ballistic_photography.htm

[28] Бондар В. С. Цифрові бази даних в судово-експертній діяльності як засіб оптимізації її інформаційного забезпечення. Вісник ЛДУВС ім. Е. О. Дідоренка. 2021. Вип. 3 (95). С. 242. DOI: 10.33766/2524-0323.95.241-256

[29] Royal Society of Chemistry. Updating Databases and Literature. URL: https://www.rsc.org/journals-books-databases/databases-literature-updates/#databases

[30] PubChem. National Library of Medicine. URL : https://pubchem.ncbi.nlm.nih.gov/

software and information on properties and methods of research of various materials and substances[31], etc.

Chemists of the State University of Campinas (Brazil) improved the well-known method of qualitative and quantitative analysis of synthetic cannabinoids in forensic toxicology using liquid chromatography and tandem mass spectrometry (LC-MS/MS) and proposed to automate the research processes, which allows to facilitate the processes of preparing objects for research and improve the accuracy of the results[32].

In recent years, research on objects at the level of atoms and molecules (nanotechnology) has intensified in various fields of science, which have been "picked up" by scientists in the field of forensic science and forensic examination. This made it possible to develop nanomaterials based on polymers and significantly expanded the ability to detect micro-quantities of narcotic materials, explosives, chemical and biological substances at the molecular level[33].

In order to detect invisible (latent) or subtle traces of hands, scientists from the Northern University of China proposed to use fluorescent coal powder, which, after spot application to the surface with handprints and fixation of fingerprints on the sweat substance, allows to detect and photograph traces in ultraviolet light due to their fluorescence in red, yellow or orange[34]. This greatly expands the possibilities of forensic identification of persons by handprints.

Chemists at the University of Albany (USA) proposed to process them with special biosensors that allow not only to identify a person, but also to establish his age, gender, etc. for the analysis of the flow and fatty matter of small traces of hands and other secretions of the human body[35].

Slovak developers offer a number of the latest forensic technologies, such as ABIS (biometric identification management system based on handprints, iris, and facial features), SmartFace (face recognition system), OEM Solutions (algorithms for analyzing handprints and faces), DOT (Digital Onboarding Toolkit - document verification, facial analysis for identification, identification by handprints), etc.[36] The AFIS system developed by them for magnetic extraction of handprints and automatic identification of persons37 allows investigators, forensic experts and specialists to "read" the prints directly at the scene after applying magnetic dust to them without contact with the trace, to qualitatively record it and compare it with a large array of handprints contained in the fingerprint registration system. This technology makes it possible to extract a very clear handprint (without any foreign contamination) and significantly save time and procedural resources.

Indian scientists for forensic scientists, anthropologists and forensic scientists have developed a fast and effective computerized method of 3D forensic reconstruction of a person's face behind his skull, which reduces the number of errors that occurred earlier during the manufacture of two-dimensional drawings and three-dimensional clay models[38].

For simulating (reconstructing) the movement of vehicles during the accident and their subsequent movement to the place of their stop, the Cybid V-SIM software package is used in automotive and transport traceology

**Galina AVDEEVA,**

**PRZEŁOM TECHNOLOGICZNY W KRYMINALISTYCE I BADANIU SĄDOWYM: NOWE HORYZONTY**

Artykuł naukowy poświęcony jest objęciu kierunków wykorzystania najnowszych technologii w dziedzinie nauk karnych i wiedzy sądowej na Ukrainie i innych krajach. Najnowsze metody kryminalistyczne badań dowodów, które są zawarte w otwartych źródłach i które są obiecujące do zastosowania na Ukrainie, a mianowicie: badanie materiałów narkotycznych, wybuchowych, chemikaliów i substancji biologicznych na poziomie atomów i cząsteczek (nanotechnologia); identyfikacja osób i ustanowienie swojego wieku przez pełny zestaw białek wytwarzanych przez ludzkie ciało; określanie czasu śmierci ofiary przez szereg markerów (pH krwi, cholesterol, sód, potas itp.); Określenie cech twarzy (wiek, kolor skóry, oczy i włosy, wiek) przez DNA itp. Celem artykułu jest promowanie rozprzestrzeniania się i popularyzacji wyników naukowych ukraińskich badaczy na poziomie międzynarodowym, wymianie informacji naukowych i technicznych z zagranicznymi instytucjami naukowymi i badaczami w celu zintensyfikowania współpracy naukowej i przeprowadzenia wspólnych badań; Rozszerzając bazę infrastruktury i zasobów do stosowania różnych technologii biometrycznych, aktywację w opracowywaniu nowych metod analizy DNA i badań cyfrowych dowodów. Obiecująca jest również wspólna praca kryminalistów z specjalistami ds. IT na temat tworzenia nowoczesnych systemów cyfrowych do badania dowodów i wprowadzenia systemów sztucznej inteligencji w celu znalezienia niezbędnych informacji naukowych w zintegrowaniu z jednym systemem otwartych zbiorów publikacji naukowych, w celu identyfikacji osób zgodnie z danymi biometrycznymi, niezależnie od kraju, w którym żyją.

Słowa kluczowe: technologia, cyfryzacja, dane badawcze, kryminalistyka, badanie kryminalistyczne, otwarta nauka

[31] CCDC's and FIZ Karlsruhe's. Access structures. URL : https://www.ccdc.cam.ac.uk/structures/

[32] Noroska Gabriela Salazar Mogollón, Cristian Daniel Quiroz-Moreno, et al. (2018). New Advances in Toxicological Forensic Analysis Using Mass Spectrometry Techniques. DOI: https://doi.org/10.1155/2018/4142527

[33] Díez-Pascual, A.M.; Cruz, D.L.; Redondo, A.L. Advanced Carbon-Based Polymeric Nanocomposites for Forensic Analysis. Polymers 2022, 14, 3598. DOI: https://doi.org/10.3390/polym14173598

[34] Ruonan Wang, Zihong Huang, Lifeng Ding, Feiyan Yang, and Di Peng. ACS Applied Nano Materials 2022 5 (2), 2214-2221. DOI: https://doi.org/10.1021/acsanm.1c03901

[35] McGoldrick, L.K.; Halámek, J. Recent Advances in Noninvasive Biosensors for Forensics, Biometrics, and Cybersecurity. Sensors 2020, 20, 5974. DOI: https://doi.org/10.3390/s20215974

[36] Innovatrics. Products. URL: https://www.innovatrics.com/digital-onboarding-toolkit/

[37] AFIS (Automated Fingerprint Identification System). Innovatrics. URL: https://www.innovatrics.com/glossary/afis-automated-fingerprint-identification-system/

[38] Gupta S, Gupta V, Vij H, Vij R, Tyagi N. Forensic Facial Reconstruction: The Final Frontier. Journal of Clinical and Diagnostic Research. 2015 Sep, Vol-9(9): ZE26-ZE28. DOI: 10.7860/jcdr/2015/14621.6568 URL: https://jcdr.net/articles/PDF/6568/14621_CE(Ra1)_F(GH)_PF1(EKAK)_PFA(P)_PF2(PAG).pdf

expertise, which allows you to get a visual model of the event using satellite imagery of the area that is closest to the actual accident[39].

Thanks to global digitalization, investigators receive information from CCTV cameras and digital registers during an accident investigation about the latest destinations of the vehicle, its typical routes, personal data of the vehicle owner and places of the most frequent parking[40].

In recent years, a number of new algorithmic techniques have been developed within the framework of video and audio recording examination to establish the authenticity of digital signatures, which allow detecting traces of editing in digital photographs, phonograms and video recordings. On their basis, the experimental expert-analytical automated systems Academy and Fractal[41] were created, which are capable of establishing the authenticity of digital signograms, as well as identifying the electronic device on which they were recorded.

Research on mobile phones, tablets and other electronic devices, which serve as a repository of a variety of general and personal information, is carried out using modern portable hardware and software complexes Cellebrite UFED Touch 2 Ultimate and Cellebrite UFED 4 PC Physical Analyzer. They are capable of detecting, decoding and analyzing digital data and allow: to extract data without entering a graphic key, password or PIN code from Android, Apple and other devices; to restore previously deleted information; to decrypt the encrypted WhatsApp history database; to extract application data, passwords, instant messages (in particular, from Viber, WhatsApp and Telegram messengers), contacts, SMS messages, emails, audio and video files, call logs, information about the location of the phone and the route of its owner by analyzing the history of using Wi-Fi access points, etc.[42]

Since the 1980s, DNA analysis has become one of the most powerful tools in criminal proceedings, allowing the identification of criminals even after a long time after the crime. In accordance with the Law of Ukraine: On State Registration of Human Genomic Information[43], automated system for recording human genetic characteristics has been created in forensic expert service of the Ministry of Internal Affairs of Ukraine, with the help of which DNA identification of individuals is carried out. At the same time, scientists from the American Chemical Society propose to identify individuals by proteomes (a complete set of proteins produced by the human body)[44]. Proteomes are found in blood, bones and other biological materials, and their analysis allows detecting microtraces of poison and other substances that cannot be detected by any other method. Thanks to age-related changes in proteomes, it is possible to establish the age of the victim during their research.

Joint studies of DNA chromosomes by scientists from Germany, the United Kingdom and the Netherlands have identified 23 chromosomes on which the appearance of a person

[39] Бодоряк Ю., Шминдюк Ю., Пипко Ю. Використання програми Cybid V-SIM 4.0 під час проведення автотехнічної експертизи // Актуальні питання судової експертизи і криміналістики : зб. мат-лів міжнар. наук.-практ. конф. з нагоди 100-річчя Національного наукового центру «Інститут судових експертиз ім. Засл. проф. М. С. Бокаріуса» (Харків, 10.11.2023). Харків : ННЦ «ІСЕ ім. Засл. проф. М. С. Бокаріуса», 2023. С. 95.

[40] Nhien-An Le-Khac, Daniel Jacobs, John Nijhoff, Karsten Bertens, Kim-Kwang Raymond Choo. Smart vehicle forensics: Challenges and case study. *Future Generation Computer Systems*. Volume 109, August 2020, Pages 500-510. DOI: https://doi.org/10.1016/j.future.2018.05.081

[41] Методика ідентифікаційних і діагностичних досліджень матеріалів та апаратури цифрового й аналогового звукозапису зі застосуванням програмного забезпечення «Фрактал» при проведенні експертиз матеріалів та засобів відео та звукозапису : наук.-мет. посіб. / Рибальський О. В., Соловйов В. І., Журавель В. В., Татарнікова Т. О. Київ : ДУІКТ, 2013. 75 с.

[42] Кобець М. В. Апаратно-програмний комплекс «Cellebrite Ufed» як засіб отримання інформації з мобільних терміналів // Актуальні питання та перспективи використання оперативно-розшукових засобів у розкритті злочинів в умовах воєнного стану : матеріали міжвідом. наук.-практ. конф. (Київ, 30 берез. 2023 р.). Київ : Нац. акад. внутр. справ, 2023. С. 71.

[43] Про державну реєстрацію геномної інформації людини : Закон України № 2391-IX від 09.07.2022. URL: https://zakon.rada.gov.ua/laws/show/2391-20#Text

[44] Carolyn Wilke. Proteomics Offers New Clues for Forensic Investigations. ACS Central Science 2021 7 (10), 1595-1598. DOI: 10.1021/acscentsci.1c01232 URL: https://pubs.acs.org/doi/10.1021/acscentsci.1c01232

depends. This allowed a person's DNA samples to establish the color of their hair, eyes, and skin. In the future, scientists plan to develop a method for establishing the age of a person following the traces of DNA[45]. Japanese scientists have proved that genomic studies can also be used to estimate the time of bodily injury (wound) by studying the microarray DNA analysis of a skeletal muscle sample near the injured area[46].

Scientists from the UK have carried out a detailed analysis of 34 variants of the Bloodstain Pattern Analysis (BPA) software, which, based on traces of blood on surrounding objects, can provide researchers with retrospective information about the spatial location and trajectory of movement of an injured person[47]. The scientists have found that certain technologies allow them to establish the sequence of events at the crime scene and the mechanism of inflicting bodily injuries. However, most software products are not sufficiently used in real criminal proceedings. Scientists consider BPA technologies to be quite promising, but note that they require further development in order to verify the objectivity of the results obtained and compliance with procedural legislation.

Chinese scientists have developed a methodology for the qualitative extraction of micro-quantities of seeds, pollen and spores of plants from human skin, shoes and clothing and their research in order to identify areas of the terrain[48].

Determining the time of death of the victim is an important task of forensic medical examination during the investigation of murders. Scientists of the Department of Forensic Sciences of Amity University (Dubai, UAE) have proved that human blood contains a number of markers (blood pH, triglycerides, cholesterol, sodium, potassium, etc.), which, after a person's death, gradually undergo changes over time and by comparing these changes with available statistical data using a special device and a "built-in" artificial intelligence system, it is possible to accurately determine the time of death49.

Scientists around the world have developed many new methods and means of researching evidence. Their search in open sources and analysis allows to enrich forensic science and forensic examination with new tools for obtaining evidential information.

**Conclusions:** In recent years, scientists around the world have been working in the realities of open science, which means publishing the results of their research in open digital sources and databases to familiarize the widest range of scientists and the public around the world. Not only the European Union, but also the United States, the United Kingdom, Japan, Australia, Ukraine, and other countries are actively developing legal mechanisms for open access to scientific achievements. This opens up new channels of communication for scientists and practitioners and provides a powerful impetus for further research in certain areas, which leads to progress in various fields, including forensic science and forensic science.

The study and analysis of information sources in the field of criminalistics and forensics showed that scientists from different countries of the world have made significant progress in creating centers of open scientific communications, which provide researchers, research organizations, funding agencies and all participants in research and innovation

[45] Schneider PM, Prainsack B, Kayser M. The Use of Forensic DNA Phenotyping in Predicting Appearance and Biogeographic Ancestry. Dtsch Arztebl Int. 2019 Dec 23; 51-52(51-52):873-880. DOI: 10.3238/arztebl.2019.0873. URL: https pmc.ncbi.nlm.nih.gov/articles/PMC6976916/

[46] Gaballah MH, Fukuta M, Maeno Y, et al. Simultaneous time course analysis of multiple markers based on DNA microarray in incised wound in skeletal muscle for wound aging. *Forensic Sci Int.* 2016; 266:357–368. DOI: 10.1016/j.forsciint.2016.06.027. URL: https://www.sciencedirect.com/science/article/abs/pii/S0379073816302791?via%3Dihub

[47] Patrick H. Home, Danielle G. Norman, Mark A. Williams. Software for the trajectory analysis of blood-drops: A systematic review. *Forensic Science International*. Volume 328, November 2021, 110992. DOI: https://doi.org/10.1016/j.forsciint.2021.110992 URL: https://www.sciencedirect.com/science/article/pii/S0379073821003121

[48] Chen YX, Shi HF. Research Progress on Forensic Palynology and Its Application in Forensic Science. Fa yi xue za zhi. 2020 Jun; 36(3): 354-359. DOI: 10.12116/j.issn.1004-5619.2020.03.011. PMID: 32705849. URL: https://europepmc.org/article/med/32705849

[49] Artificial intelligence in prediction of postmortem interval (PMI) through blood biomarkers in forensic examination-a concept. Hachem M, Sharma BK. Amity International Conference on Artificial Intelligence (AICAI) 2019:255–258. URL: https://ieeexplore.ieee.org/abstract/document/8701416

with various tools and services of integrated open collections of scientific publications (OpenAIRE, OpenDOAR, BASE, CORE, etc.), databases of offenders, cold and firearms, drugs, chemicals and methods of their research (BigDataPeople, TrasoScan, BalScan, IBIS, ChemSpider, PubChem, ICSD, FIZ Karlsruhe, CSD, etc.). Thanks to technological progress and open access to scientific results, nanotechnology methods, modernized methods of evidence research, and the latest effective methods of researching invisible and barely visible handprints, sweat and fat, and various secretions of the human body have been introduced into criminology and forensics, which allow not only to identify a person, but also to establish his age, gender, eye color, skin, hair, and other features. Digital technologies for managing biometric identification by handprints, irises, and facial features (ABIS, SmartFace, OEM Solutions, Digital Onboarding Toolkit) and systems for magnetic extraction of handprints and automatic facial identification (AFIS) have been developed.

Exchange of advanced forensic technologies with economically developed countries contributes to the technologization of criminal proceedings, improving the quality and efficiency of the work of its participants, reducing the number of procedural errors and, as a result, serves as support for the realization of individuals' rights to fair justice.

In order to intensify the process of introducing world achievements in criminalistics and forensics in Ukraine, the state should promote the dissemination and popularization of scientific results of Ukrainian researchers at the international level, exchange of scientific and technical information with foreign scientific institutions and researchers to intensify scientific cooperation and joint research.

Infrastructure and resource base for the use of various biometric technologies needs to be expanded, and the development of new methods of DNA analysis and digital evidence research needs to be intensified. The joint work of forensic scientists and IT specialists to create modern digital systems for investigating evidence and introducing artificial intelligence systems to search for the necessary scientific information in open collections of scientific publications integrated into a single system, to identify individuals by biometric data, regardless of the country in which they live is promising.

In order to integrate Ukrainian science into global scientific and technical information retrieval systems, much work needs to be done to unify file metadata, streamline the protocol for their transfer, agree on an open license for research results, improve the copyright protection system in the context of open science, etc.

## References


AFIS (Automated Fingerprint Identification System). Innovatrics. URL: https://www.innovatrics.com/glossary/afis-automated-fingerprint-identification-system/ [in English].

Artificial intelligence in prediction of postmortem interval (PMI) through blood biomarkers in forensic examination-a concept. Hachem M, Sharma BK. Amity International Conference on Artificial Intelligence (AICAI) 2019:255–258. URL: https://ieeexplore.ieee.org/abstract/document/8701416 [in English].

Ballistic Photography. URL: http://facweb.cs.depaul.edu/sgrais/ballistic_photography.htm [in English].

BASE. URL: https://www.base-search.net/ [in English].

Bodoriak Yu., Shmyndiuk Yu., Pypko Yu. (2023). Vykorystannia prohramy Cybid V-SIM 4.0 pid chas provedennia avtotekhnichnoi ekspertyzy [Using the Cybid V-SIM 4.0 program during automotive inspection] .. Aktualni pytannia sudovoi ekspertyzy i kryminalistyky : zb. mat-liv mizhnar. nauk.-prakt. konf. z nahody 100-richchia Natsionalnoho naukovoho tsentru «Instytut sudovykh ekspertyz im. Zasl. prof. M. S. Bokariusa» (Kharkiv, 10.11.2023). Kharkiv : NNTs «ISE im. Zasl. prof. M. S. Bokariusa», 2023. [in Ukrainian].

Bondar V. S. (2021). Tsyfrovi bazy danykh Àsudovo-ekspertnii diialnosti yak zasib optymizatsii yii informatsiinoho zabezpechennia [Digital databases forensic activities as a means of optimizing its information support] Visnyk LDUVS im. E. O. Didorenka. 2021. Vyp. 3 (95). C. 241-246. DOI: 10.33766/2524-0323.95.241-256 [in Ukrainian].

Carolyn Wilke. Proteomics Offers New Clues for Forensic Investigations. ACS Central Science 2021 7 (10), 1595-1598. DOI: 10.1021/acscentsci.1c01232 URL: https://pubs.acs.org/doi/10.1021/acscentsci.1c01232 [in English].

CCDC's and FIZ Karlsruhe's. Access structures. URL : https://www.ccdc.cam.ac.uk/structures/ [in English].

Chen YX, Shi HF. Research Progress on Forensic Palynology and Its Application in Forensic Science. Fa yi xue za zhi. 2020 Jun;36(3):354-359. DOI: 10.12116/j.issn.1004-5619.2020.03.011. PMID: 32705849. URL: https://europepmc.org/article/med/32705849 [in English].

CORE. URL: https://core.ac.uk/ [in English].

Council Conclusions on the Action Plan for the European Forensic Science Area 2.0. Council of the European Union. Brussels, 9 March 2023. URL: https://data.consilium.europa.eu/doc/document/ST-7152-2023-INIT/en/pdf [in English].

Criminal Intelligence analysis. Interpol. URL: https://www.interpol.int/en/How-we-work/Criminal-intelligence-analysis2 [in English].

Databank voor messen moet politie helpen in onderzoek naar steekpartijen. NOS Nieuws. Dinsdag 14 maart 2023. URL: https://nos.nl/artikel/2467375-databank-voor-messen-moet-politie-helpen-in-onderzoek-naar-steekpartijen [in Dutch].
Deloitte. Policing 4.0. Deciding the future of policing in the UK. (2018). URL: https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/public-sector/deloitte-uk-future-of-policing.pdf [in English].
Díez-Pascual, A.M.; Cruz, D.L.; Redondo, A.L. Advanced Carbon-Based Polymeric Nanocomposites for Forensic Analysis. Polymers 2022, 14, 3598. DOI: https://doi.org/10.3390/polym14173598 [in English].
Firearm and Tool Mark Identification – IBIS. Forencic technology. https://www.ultra-forensictechnology.com/en/products-and-services/firearm-and-tool-mark-identification-ibis/ [in English].
Frolov A., Varlakhov V., Fedorchenko V. (2023). Zastosuvannia suchasnoho prohramnoho zabezpechennia pid chas doslidzhennia zitknen transportnykh zasobiv [Application of modern software in the study of vehicle collisions] // Aktualni pytannia sudovoi ekspertyzy i kryminalistyky : zb. mat-liv mizhnar. nauk.-prakt. konf. z nahody 100-richchia Natsionalnoho naukovoho tsentru «Instytut sudovykh ekspertyz im. Zasl. prof. M. S. Bokariusa» (Kharkiv, 10.11.2023). Kharkiv : NNTs «ISE im. Zasl. prof. M. S. Bokariusa». [in Ukrainian].
Gaballah MH, Fukuta M, Maeno Y, et al. Simultaneous time course analysis of multiple markers based on DNA microarray in incised wound in skeletal muscle for wound aging. Forensic Sci Int. 2016; 266:357–368. DOI: 10.1016/j.forsciint.2016.06.027. URL: https://www.sciencedirect.com/science/article/abs/pii/S0379073816302791?via%3Dihub [in English].
Gupta S, Gupta V, Vij H, Vij R, Tyagi N. Forensic Facial Reconstruction: The Final Frontier. Journal of Clinical and Diagnostic Research. 2015 Sep, Vol-9(9): ZE26-ZE28. DOI: 10.7860/jcdr/2015/14621.6568 URL: https://jcdr.net/articles/PDF/6568/14621_CE(Ra1)_F(GH)_PF1(EKAK)_PFA(P)_PF2(PAG).pdf [in English].
Innovatrics. Products. URL: https://www.innovatrics.com/digital-onboarding-toolkit/ [in English].
Instruktsiia z orhanizatsii funktsionuvannia kryminalistychnykh oblikiv Holovnoho ekspertno-kryminalistychnoho tsentru Derzhavnoi prykordonnoi sluzhby Ukrainy [Instruction on the organization of the functioning of forensic records of the Main Forensic Center of the State Border Guard Service of Ukraine]. Zatverdzhena Nakazom Ministerstva vnutrishnikh sprav Ukrainy 10.07.2017 № 580. URL: https://zakon.rada.gov.ua/laws/show/z0957-17#Text [in Ukrainian].
Kimmy Gustafson. Modern Forensic Science Technologies (2024). Forensics Colleges. Forensic Education Blog. 09.02.2024. URL: https://www.forensicscolleges.com/blog/resources/10-modern-forensic-science-technologies [in English].
Kobets M. V. (2023). Aparatno-prohramnyi kompleks «Cellebrite Ufed» yak zasib otrymannia informatsii z mobilnykh terminaliv [Hardware and software complex "Cellebrite Ufed" as a means of obtaining information from mobile terminals] // Aktualni pytannia ta perspektyvy vykorystannia operatyvno-rozshukovykh zasobiv u rozkrytti zlochyniv v umovakh voiennoho stanu : materialy mizhvidom. nauk.-prakt. konf. (Kyiv, 30 berez. 2023 r.). Kyiv : Nats. akad. vnutr. sprav, 2023. [in Ukrainian].
Kozhevnikov V. (2023). Shtuchnyi intelekt yak instrument kryminalistyky ta sudovoi ekspertyzy [Artificial intelligence as a tool for criminalistics and forensics] // Aktualni pytannia sudovoi ekspertyzy i kryminalistyky : zb. mat-liv mizhnar. nauk.-prakt. konf. z nahody 100-richchia Natsionalnoho naukovoho tsentru «Instytut sudovykh ekspertyz im. Zasl. prof. M. S. Bokariusa» (Kharkiv, 10.11.2023). Kharkiv : NNTs «ISE im. Zasl. prof. M. S. Bokariusa». [in Ukrainian].
La dématérialisation des expertises civiles avec OPALEXE // Parole au cncej, Experts № 133, août 2017. P. 40. URL : https://www.martinique-expertsdejustice.com/wp-content/uploads/2018/03/article-RE_15 [in French].
Lebid S.O., Shevchuk O.Yu. (2023). Problemy vykorystannia balistychnykh oblikiv u rozkrytti zlochyniv v umovakh voiennoho stanu [Problems of using ballistics records in solving crimes under martial law] // Aktualni pytannia psykholohichnoho zabezpechennia sluzhbovoi diialnosti strukturnykh pidrozdiliv MVS Ukrainy v umovakh voiennoho stanu : materialy V mizhvidomchoho naukovo-praktychnoho kruhloho stolu (Kyiv, 20 kvitnia 2023 roku). URL: https://elar.naiau.kiev.ua/collections/1233252c-327f-41ef-a52a-a3cc38eeb9fe [in Ukrainian].
McGoldrick, L.K.; Halámek, J. Recent Advances in Noninvasive Biosensors for Forensics, Biometrics, and Cybersecurity. Sensors 2020, 20, 5974. DOI: https://doi.org/10.3390/s20215974 [in English].
Metodyka identyfikatsiinykh i diahnostychnykh doslidzhen materialiv ta aparatury tsyfrovoho y analohovoho zvukozapysu zi zastosuvanniam prohramnoho zabezpechennia «Fraktal» pry provedenni ekspertyz materialiv ta zasobiv video ta zvukozapysu [Methods of identification and diagnostic studies of materials and equipment for digital and analog sound recording using the Fractal software in the examination of materials and means of video and sound recording] : nauk.-met. posib. / Rybalskyi O. V., Soloviov V. I., Zhuravel V. V., Tatarnikova T. O. Kyiv : DUIKT, 2013. [in Ukrainian].
Movchan A. V. (2023). Mizhnarodnyi dosvid zastosuvannia suchasnykh tekhnolohii u protydii orhanizovanii zlochynnosti [International experience of using modern technologies in combating organized crime] // Aktualni pytannia psykholohichnoho zabezpechennia sluzhbovoi diialnosti strukturnykh pidrozdiliv MVS Ukrainy v umovakh voiennoho stanu : materialy V mizhvidomchoho

naukovo-praktychnoho kruhloho stolu (Kyiv, 20 kvitnia 2023 roku). URL: https://elar.naiau.kiev.ua/collections/1233252c-327f-41ef-a52a-a3cc38eeb9fe [in Ukrainian].
Nhien-An Le-Khac, Daniel Jacobs, John Nijhoff, Karsten Bertens, Kim-Kwang Raymond Choo. Smart vehicle forensics: Challenges and case study. Future Generation Computer Systems. Volume 109, August 2020, Pages 500-510. DOI: https://doi.org/10.1016/j.future.2018.05.081 [in English].
Noroska Gabriela Salazar Mogollón, Cristian Daniel Quiroz-Moreno, et al. (2018). New Advances in Toxicological Forensic Analysis Using Mass Spectrometry Techniques. DOI: https://doi.org/10.1155/2018/4142527 [in English].
Open Data matters now. Artellence : website. URL: https://artellence.com/ [in English].
OpenAIRE. URL: https://www.openaire.eu/ [in English].
OpenDOAR. URL: https://v2.sherpa.ac.uk/opendoar/ [in English].
Ovsianiuk D.I., Khudenko D.M. (2023). Vykorystannia pidrozdilamy kryminalnoho analizu tekhnolohii rozpiznavannia oblych ta fenotypuvannia dnk v umovakh voiennoho stanu [The use of facial recognition and DNA phenotyping technologies by criminal analysis units under martial law] // Aktualni pytannia psykholohichnoho zabezpechennia sluzhbovoi diialnosti strukturnykh pidrozdiliv MVS Ukrainy v umovakh voiennoho stanu: materialy V mizhvidomchoho naukovo-praktychnoho kruhloho stolu (Kyiv, 20 kvitnia 2023 roku). [in Ukrainian].
Patrick H. Home, Danielle G. Norman, Mark A. Williams. Software for the trajectory analysis of blood-drops: A systematic review. Forensic Science International. Volume 328, November 2021, 110992. DOI: https://doi.org/10.1016/j.forsciint.2021.110992 URL: https://www.sciencedirect.com/science/article/pii/S0379073821003121 [in English].
Politie en NFI gaan meer wapenonderzoek doen. NOS Nieuws, Donderdag 30 september 2021. URL: https://nos.nl/artikel/2399759-politie-en-nfi-gaan-meer-wapenonderzoek-doen [in Dutch].
Pro derzhavnu reiestratsiiu henomnoi informatsii liudyny [On state registration of human genomic information]: Zakon Ukrainy № 2391-IX від 09.07.2022. URL: https://zakon.rada.gov.ua/laws/show/2391-20#Text [in Ukrainian].
Project Millennium. Interpol : website. URL: https://www.interpol.int/Crimes/Organized-crime/Project-Millennium#:~:text=Facilitating%20the%20exchange%20of%20investigative,criminal%20networks%20and%20their%20activities [in English].
PubChem. National Library of Medicine. URL : https://pubchem.ncbi.nlm.nih.gov/ [in English].
Royal Society of Chemistry. Updating Databases and Literature. URL: https://www.rsc.org/journals-books-databases/databases-literature-updates/#databases [in English].
Ruonan Wang, Zihong Huang, Lifeng Ding, Feiyan Yang, and Di Peng. ACS Applied Nano Materials 2022 5 (2), 2214-2221. DOI: https://doi.org/10.1021/acsanm.1c03901 [in English].
Schneider PM, Prainsack B, Kayser M. The Use of Forensic DNA Phenotyping in Predicting Appearance and Biogeographic Ancestry. Dtsch Arztebl Int. 2019 Dec 23;51-52(51-52):873-880. DOI: 10.3238/arztebl.2019.0873. URL: https://pmc.ncbi.nlm.nih.gov/articles/PMC6976916/ [in English].
Tikhonov S.V., Kobets M.V. (2021). Metodychni rekomendatsii shchodo zastosuvannia GPS-trekeriv u rozkrytti kryminalnykh pravoporushen [Guidelines on the use of GPS trackers in solving criminal offenses]. Kyiv : Nats. akad. vnutr. sprav. URL: https://elar.navs.edu.ua/server/api/core/bitstreams/2c421b7f-e0ad-4e98-8f8f-8d8709007c3b/content [in Ukrainian].
Transformative Technologies: How digital is changing the landscape of organized crime. Global Initiative Against Transnational Organized Crime. Posted on 29 Jun 2020. p.p. 2-3. URL: https://globalinitiative.net/wp-content/uploads/2020/06/Transformative-Technologies-WEB.pdf [in English].
UNESCO Recommendation on Open Science. UNESCO. 2021. 34 p. DOI: https://doi.org/10.54677/MNMH8546 [in English].
War in Ukraine. Clearview AI : website. URL: https://www.clearview.ai/ [in English].
What is INTERPOL? Interpol : website. URL: https://www.interpol.int/Who-we-are/What-is-INTERPOL [in English].
Zahorodnii A. H. ta in. (2025). Vprovadzhennia yevropeiskykh pryntsypiv vidkrytoi nauky v Natsionalnii akademii nauk Ukrainy [Implementation of European principles of open science in the National Academy of Sciences of Ukraine]. Visnyk NAN Ukrainy. № 1. DOI: https://doi.org/10.15407/visn2025.01.011 [in Ukrainian].

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