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Objectives and Scope

The discipline of forensic science has nurtured many publications oriented toward research and case reports, also broad-based formal treatises. Rapid advances in forensic science have created a need for a review journal to bridge the gap between research-oriented journals and reference volumes.

The goal of *Forensic Science Review* is to fill this void and provide a base for authors to extrapolate state-of-the-art information and to synthesize and translate it into readable review articles. The addition of this journal extends the spectrum of forensic science publications.

Articles bring into focus various narrowly defined topics whose literature has been widely scattered. Articles are presented to stimulate further research on one hand and worthwhile technological applications on the other. The publisher's aim is to provide forensic scientists with a forum enabling them to accomplish this goal.

Technological applications based on basic research are emphasized. Articles address techniques now widely used in forensic science as well as innovations holding promise for the future.

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Both professional review / commentary and review articles published in **Forensic Science Review** are mostly invited contributions. Review articles are peer-reviewed. The invitation process normally originates from the recommendations of the Editorial Board. Unsolicited articles from the general readership are also welcomed but should be preceded by a query letter to the Editor-in-Chief for presentation to the Editorial Board. Query letters and editorial correspondence should be addressed to: Editor-in-Chief, **Forensic Science Review**, Department of Criminal Justice, University of Alabama at Birmingham, Birmingham, AL 35294, US or preferably through E-mail to rayliu@uab.edu. Honoraria are presented to authors and reviewers upon distribution of the issue in which the article appears. All published articles represent the opinions of the authors and do not represent the official policy of the publisher or the institution with which the author is affiliated, unless clearly specified.

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Professional Review and Commentary

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Forthcoming Articles

PROFESSIONAL REVIEW AND COMMENTARY

Forensic Science in India

Forensic Science in the United States. III — Strengths and Challenges and Future Directions

Non-Alcoholic Drugs and Traffic Safety

Strengthening Medicolegal Death Investigation in the United States: Where Are We Now?

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Forensic Craniofacial Reconstruction. I: Facial Soft Tissue Thickness

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Professional Review and Commentary[a]

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[a]The views expressed are those of the authors and do not necessarily reflect the view, the position, or the policy of *Forensic Science Review* or members of its editorial board.

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Forensic Science in the United States. II: Forensic Pathology and the Medical Examiner/Coroner Systems

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This report focuses on forensic pathology (FPath) and the coroner/medical examiner (ME) system along with the challenges faced by forensic pathologists (FPs). It is the second in a series of articles on forensic science in the US. The first [1] provided a brief history and a description of the laboratory systems adopted by the different states, federal laboratories, and an overview of the private forensic laboratories. Finally, Part III will address the key strengths and challenges for forensic science in the US as well as look at future directions for the field.

Medical Examiner and Coroner Systems in the United States

The systems of death investigation utilized in the US are the ME and coroner systems. A *ME* is a physician who determines the cause and manner of death for individuals whose deaths fall within a given geographical jurisdiction. Strictly speaking, MEs are not always FPs with specialized training in death investigation but do have a medical background as a physician. Forensic pathologists in the US are physicians certified by the American Board of Pathology (ABP; Tampa, FL) in both anatomic and FPath. Thus, by definition, an FP is a physician who has formal training and certification for determining the cause and manner of death.

Coroners are public officials, either appointed or elected, who are publicly charged with inquiry into the circumstances regarding how a death occurred and for documentation of information pertinent to the death. Coroners complete death certificates, including cause and manner of death, based on information they obtain from professionals like death investigators, physicians, or FPs. A coroner may or may not be required to have a medical background. These titles, coroner and ME, are often used interchangeably, owing to either custom or an incomplete understanding of their distinctions.

The title "coroner" has existed for hundreds of years. The position traces back to at least medieval England, where the term was used to refer to an officer of the Crown whose duties included ensuring proper legalities were followed (like taxes owed) upon a death. The duties of the coroner in England eventually expanded to include initiation of formal investigation into deaths in which unnatural factors may have played a role. This is the basis for the system of death investigation employed during colonial times in the US.

In 1877, the Commonwealth of Massachusetts established a law that required physicians, rather than the lesser qualified coroners, to oversee the medical investigation of unnatural deaths, becoming the first state to adopt a ME system. Recognizing the increased efficiency and value of such a physician-centered approach to death investigation, New York adopted a ME system in 1915. The New York system included a formally designated Chief ME, the first of whom was Dr. Charles Norris. These early ME systems are the basis for modern ME systems in the US.

Currently, states employ either ME systems, coroner systems, or mixed ME/coroner systems. According to 2019 data from the Centers for Disease Control (CDC), 16 states had a centralized ME system, six states had a county- or district-based ME system, 14 states had a county-based system with a mixture of coroner and MEs offices, and 14 states had a county-, district-, or parish-based coroner system [2] (**Figure 1**). States within each of these broad four categories are not identical and can potentially be further broken down into even more subcategories.

Modern Forensic Pathology

Pathology is the study of disease and has been formally recognized as a medical subspecialty since 1936 with the establishment of ABP. In 1959, ABP began certifying FPs with additional training in the subspecialty of FPath. That year, 30 pathologists were granted certification as FPs [3]. Currently, FPs receive extensive training and are certified to oversee death investigations, perform postmortem examinations, write autopsy reports, complete death certificates, and testify about their findings in a court of law.

An FP is employed by local, regional, or state-wide governments, academic institutions, or in private practices

[a]Observations and views hereby expressed are those of the authors; none of related organizations, such as the American Board of Pathology, the National Association of Medical Examiners and Americasn Academy of Forensic Sciences, conducted a review or endorsed this report.

States with One Centralized State Medical Examiner Office
AK, CT, DE, ME, MD, MA, NH, NM, NC, OK, OR, RI, UT, VT, VA, WV, DC
States With County/District-based Coroner Offices
CO, ID, IN, KS, KY, LA, MT, NE, NV, ND, SC, SD, WY
States With County/District-based ME Offices
AZ, FL, IA, MI, NJ, TN
States With County-based Mixture of ME and Coroner Offices
AL, CA, GA, HI, IL, MN, MS, MO, NY, OH, PA, TX, WA, WI

Figure 1. Medical examiner/coroner systems for the US states.

that have contractual arrangements within jurisdictions to perform postmortem examinations. Proper death investigation is complex and utilizes information gathered from several individuals and agencies, including coroners, law enforcement, clinicians, and professional death investigators. All these components integrate in different ways from one jurisdiction to another.

Many FPs belong to one or both of two (i.e., ABP and the National Association of Medical Examiners: Wilmington, DE; NAME) prominent national organizations that advocate for disciplines in the forensic sciences. The National Association of Medical Examiners was founded in 1966 and meets at least annually to gather FPs, present lectures, review autopsy standards, and consider recent scientific advances in FP. Members of NAME include FPs, MEs, coroners, and death investigators. The National Association of Medical Examiners offers accreditation for ME and coroners offices seeking its endorsement. Accreditation involves passing an inspection that ensures offices meet practice standards in FPath. In 2022, 103 death investigation agencies were listed as accredited by NAME [4]. Similarly, the American Academy of Forensic Sciences (AAFS) has an annual meeting but has a broader scope that includes most forensic disciplines from criminalistics to handwriting analysis.

Challenges in Forensic Pathology

Shortage of Forensic Pathologists in the United States

Gauging the pulse of the FPath workforce is difficult, as there are no centralized registration processes that provide a snapshot of the strength of the national workforce from year to year. Furthermore, not all FP-trained fellows are Board-certified at the same time; some fellows and FPs opt for part-time arrangements or do not practice FPath at all; and partial and full retirements are not easily tracked. It is estimated that there are currently about 500 practicing FPs in the US, and that well over twice that many are needed to adequately meet the demands of adequate death investigation in the US [5,6].

In 2012, the National Research Council's Scientific Working Group for Medicolegal Death Investigation (SWGMDI) published a report outlining reasons for this shortage and provided recommendations for increasing the supply of FPs in the US [5]. They cited a lack of exposure to pathology and FPath among trainees at various levels of education, discrepant salaries of FPs relative to other medical specialties, and burnout within the profession, among other reasons for the shortage of FPs. Recommendations included making FPath more visible to medical students and pathology residents, implementing financial incentives specific to FPath, and increasing training programs and opportunities in FPath. A 2020 publication exploring this problem called for a renewed recognition of hospital autopsies as the practice of medicine and even reinstating reimbursement of this procedure by the Centers for Medicare and Medicaid Services (a part of the US Department of Health and Human Services) [6].

To compound this problem, the caseloads for FPs have increased dramatically in recent years [7,8]. It is well known that the alarming rise in drug overdose deaths has created an unsustainable workload for many ME/coroners' offices. The COVID-19 pandemic brought on unique challenges that modern ME offices had never faced before. Some of these are discussed in the section below on public health. During the COVID-19 pandemic, NAME temporarily withheld accreditation penalties for offices with "temporary deficiencies related to case numbers and/or report turnaround times from the direct and indirect impacts of the pandemic." [9].

In a survey attempting to explore the decline FPs in the US, allopathic students considering pathology in general cited lack of exposure to pathology and their perception of a challenging pathology job market as the reasons they steered away from choosing pathology as a career [10]. Research has also specifically explored the challenges of recruiting and retenting Black FPs, citing that less than 10% of practicing FPs are Black or of African origin [11].

Adapting to the Changing Forensic Toxicological Landscape

The standard autopsy protocol is to obtain specimens for toxicological testing in most deaths investigated by a ME's office. Common samples suitable for toxicological analysis include blood, urine, bile, vitreous solution, liver tissue, and brain tissue. FPs work in close conjunction with forensic toxicologists who analyze postmortem samples for drugs of abuse and report the presence and concentrations of toxic substances in provided specimens. Forensic pathologists interpret these results in the context of the circumstances surrounding death and their examination findings. As noted, drug overdose deaths have increased dramatically since the 2010s.

Illicit drug manufacturers have focused attention on developing novel processes for manufacturing illicit substances. Due to increased potency and ease of production relative to natural-based opioids, deaths due to fentanyl and fentanyl analogues began to account for most overdose deaths in many jurisdictions beginning in about 2016 [12]. Some of the fentanyl analogs as well as other novel psychoactive substances (NPS) are not detected by many traditional analytical methods. This creates a unique challenge for toxicology laboratories, and laboratories are inevitably chasing rapidly evolving and moving targets [13]. Identifying novel chemical structures, developing reference standards, and increasing sensitivity of detection assays are just a few of the challenges laboratories face in detecting the ever-expanding family of NPS.

There are several systems that alert laboratories to current drug trends, allowing them to better focus on analytical methods that are most sensitive for the drugs that are more likely to be present. The United States partners with several other countries to report NPS use trends through an early warning system managed by the United Nations Office on Drugs and Crime (UNODC). The UNODC Early Warning Advisory (EWA) was established in 2013 and “aims to monitor, analyze and report trends on NPS, as a basis for effective evidence-based policy responses.” [14]. Other real-time surveillance systems include the US’s National Drug Early Warning System (NDEWS), initially funded by the National Institute on Drug Abuse (NIDA) in 2014 [15]. The NDEWS gathers information from scientists and other members of communities to report weekly updates on drug trends. These reports and relevent data are publicly available [16].

Public Health Opportunities and Challenges

Forensic pathologists play a vital role in contributing to public health initiatives. Information from death certificates provides a tool to monitor disease and death in a population and for epidemiologists seeking data to use in mortality-related research. For example, FPs will work as parts of inter-disciplinary teams interested in studying and reducing death in specific populations. Information from the medicolegal investigation and postmortem investigation of unexpected infant deaths was used to enhance physicians’ understanding of sudden infant death syndrome (SIDS). In the 1980s, medical societies began advocating for supine sleeping positions for infants to mitigate this risk factor for SIDS. In 1994, the National Institute of Child Health and Human Development launched the Back to Sleep campaign, a multi-organizational advocacy program designed to promote safe sleeping habits for infants. Since then, medicolegal investigations have led to a more precise understanding of many elements associated with an unsafe sleep environment, including bedsharing and excess bedding in cribs [17].

The COVID-19 global pandemic introduced new public health challenges that required rapid adaptation from ME’s offices. In the initial phases of the pandemic, one prominent report predicted as many as 2.2 million deaths from an unmitigated COVID-19 epidemic in the US [18]. This projected volume of mortality would have greatly affected ME offices that would be responsible for handling a much greater volume than to which they were accustomed. Furthermore, the pandemic was associated with increases in drug-related deaths, in addition to homicides in many cities. In one study of homicide data from 34 cities, researchers reported a 30% rise in homicide rates [19]. They cited increased stress among vulnerable populations and inhibition of outreach efforts needed to curtail violence.

Medical examiner offices play a vital role in early assessment of severity and characteristics of infectious disease outbreaks. Autopsy findings were used to understand the pathology associated with SARS-CoV-2, the virus that causes COVID-19 [20,21]. These findings were used to help inform clinicians' treatment decisions for patients with COVID-19 [22]. The logistics of examining bodies infected with a poorly understood virus associated with a global pandemic creates important considerations regarding postmortem examination. Protocols must be developed and followed to minimize the possibility of pathogen transmission during a postmortem examination. For example, CDC indicates that “postmortem activities should be conducted with a focus on avoiding AGPs [aerosol-generating procedures] and, if aerosol generation is likely (e.g., when using an oscillating saw), ensuring that appropriate engineering controls and personal protective equipment (PPE) is used.”

The COVID-19 pandemic also highlighted the need for continued education on proper death certification by physicians, MEs, and coroners. Errors in death certification are harmful to efforts to monitor and study disease and mortality [23]. Proper death certification in the middle of a pandemic is of paramount importance for public health surveillance organizations like the National Center for Health Statistics (NCHS), which reports data that guides policy decisions during a pandemic. During the COVID-19 pandemic, the NCHS provided comprehensive guidance for physicians on how to properly certify deaths from COVID-19 or from which COVID-19 was considered a contributing factor [24].

Forensic Pathologist Independence

Forensic pathologists work closely with other professionals, including members of law enforcement, clinical professionals, politicians, and attorneys. In some cases, these interactions introduce the potential for external influence on cause and manner of death determinations. The National Association of Medical Examiners stressed the significance of ME, coroner, and FP independence in a 2013 administrative position paper, wherein they assert that FPs should be permitted to objectively produce opinions on cases independent of various external influences [25]. This position stems from research including a survey finding that "over 70% of survey respondents had been subjected to pressures to influence their findings, and many had suffered negative consequences for resisting those influences." Other organizations like the National Research Council of the National Academies also emphasize the importance of independence of forensic science laboratories [26].

Demonstrations or assertions of undue external influence in FPath undermine confidence in FP's conclusions. This validates the need for organizational positions, as described above, and research on how external factors influence FPath decisions. Akin to laboratory error where error may occur in pre-analytical, analytical, and post-analytical phases of testing, FPath errors can occur before postmortem examination, during postmortem examination, or after postmortem examination. In any of these phases of postmortem death investigation, pressure from outside forces could contribute to compromised decision making and, ultimately, errors in interpretation and communication.

Peripheral to FPath independence is how contextual biases affect FPath decision making. Implicit biases have been shown to affect professional decision making in an extensive list of forensic science disciplines [27,28]. However, FPath is also unique among the forensic disciplines in its reliance on contextual information to generate opinions on manner of death. More research needs to be done to elucidate when and how errors in complex decision making occur in FPath. One proposed solution to minimize bias is utilization of techniques like Linear Sequential Unmasking, a technique that involves exposure of task-relevant information at strategic points in a forensic investigation [29]. The practicality of this sort of technique, and the method by which this could be applied to FPath, requires additional research.

Conclusions

Modern death investigation finds its roots in systems that operated in medieval and colonial times. It has changed over the years (**Figure 2**), and the most efficient death investigation systems today employ FPs and teams of investigators in ME systems where professionals work together to gather the information necessary to determine cause and manner of death. Data from medicolegal death investigation, including FPs' findings, are paramount to the needs of families of deceased, researchers, epidemiologists, and public health organizations. Challenges will always be present, and FPs must keep abreast at recognizing them and working toward viable solutions in order to best serve their communities.

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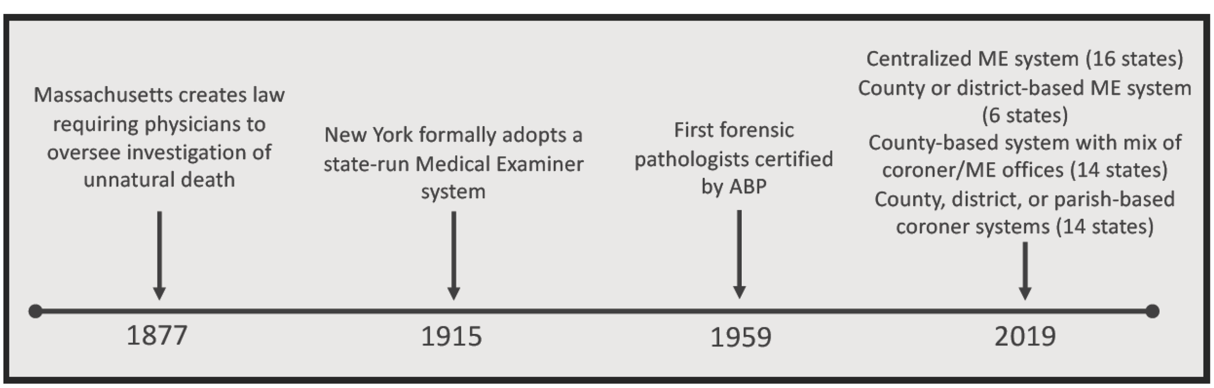

Figure 2. Timeline showing some events in the development of the coroner's/medical examiner's systems.

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Upcoming Events

American Academy of Forensic Sciences — 75th Annual Meeting (*https://www.aafs.org/*)
Feb. 13–18, 2023; Rosen Shingle Creek Hotel & Convention Center
Orlando, FL, US

The 2nd International Congress on Clinical Trials on Cannabis
(*https://ct-cann.com/*)
Feb. 15–16, 2023; Hilton London Canary Wharf
London, UK

PITTCON Conference and Expo
(*https://pittcon.org/exposition/*)
March 18–22, 2023; Pennsylvania Convention Center
Philadelphia, PA, US

DATIA 2023 — Annual Meeting of the Drug & Alcohol Testing Industry Association
(*https://datia.memberclicks.net/*)
March 21–25, 2023; Bally's Hotel
Las Vegas, NV, US

2023 American College of Medical Toxicology Annual Scientific Meeting
(*https://education.acmt.net/products/2023-acmt-annual-scientific-meeting*)
March 31–April 2, 2023; Marriott La Jolla
San Diego, TX, US

International Association of Chemical Testing — 2023 Annual Conference
(*http://iactonline.org/*)
April 16–21, 2023; Charleston Marriott
Charleston, SC, US

American Society of Forensic Laboratory Directors — 50th Annual Symposium
(*https://www.ascld.org/ascld-annual-symposium/*)
April 30–May 5, 2023; Renaissance Austin Hotel
Austin, TX, US

Southern Association of Forensic Scientists — 2023 Annual Meeting
(*https://safs1966.org/annual-meeting/*)
April 24–28, 2023; Lodge at Gulf State Park, a Hilton Hotel
Gulf Shores, AL, US

California Association of Criminalists Seminar
(*https://www.cacnews.org/events/seminar/seminars.shtml*)
May 8–12, 2023; Whitney Peak Hotel
Reno, NV, US

Mid-Atlantic Association of Forensic Scientists — 2023 Annual Meeting
(*https://www.maafs.org/annual-meeting*)
May 16–19, 2023; DoubleTree by Hilton Hotel
Baltimore, MD, US

176th American Psychiatric Association — Annual Meeting (*https://www.psychiatry.org/psychiatrists/meetings/annual-meeting*)
May 20–24, 2023; Moscone Center
San Francisco, CA, US

The Association of Firearm and Tool Mark Examiners — 54th Annual Training Seminar
(*https://afte.org/meetings/annual-seminars*)
May 21–26, 2023; Renaissance Austin Hotel
Austin, TX, US

71st ASMS Conference on Mass Spectrometry and Allied Topics
(*https://asms.org/conferences/annual-conference*)
June 4–8, 2023; George Brown Convention Center
Houston, TX, US

IACP Impaired Driving & Traffic Safety Conference
(*https://www.theiacp.org/IDTSconference*)
Aug. 9–11, 2023; Anaheim Convention Center
Anaheim, CA, US

2023 AACC Annual Scientific Meeting + Clinical Lab Expo
(*https://meeting.aacc.org/about*)
July 23–27, 2023; Anaheim Convention Center
Anaheim, CA, US

International Association for Identification — 107th Educational Conference
(*https://theiai.org/conference.php*)
Aug. 20–26, 2023; Gaylord National Resort and Convention Center
National Harbor, MD, US

TIAFT 60th Annual Meeting of the International Association of Forensic Toxicologists
(*https://www.tiaft2023.org/*)
Aug. 27–31, 2023; Auditorium Conciliazione
Room, Italy

2023 International Conference on Forensic Nursing Science and Practice
(*https://www.forensicnurses.org/page/2022AnnualConference*)
Sept. 27–30, 2023; Sheraton Phoenix Downtown
Phoenix, AZ, US

Southwestern Association of Forensic Scientists — 45th Annual Conference (*http://swafs.us/*)
Oct. 1–4, 2023; Houston CityPlace Marriott at Springwoods Village
Spring, TX, US

Northeastern Association of Forensic Scientists — Annual Conference
(*https://www.neafs.org/additional-annual-meetings*)
Oct. 6–10, 2023; Mystic Marriott
Groton, CT, US

ADVANCING THE PRACTICE OF FORENSIC SCIENCE IN THE US

Digital (Multimedia) Evidence and Computer Forensics — A Holistic View

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We live in a society that is more connected to the World Wide Web than ever before. Digital devices are everywhere in the current world, assisting people in communicating locally and globally with ease. Technology has become embedded in everyone's daily life. But unfortunately, these inventions could be used in a negative way.

New types of computer technologies have emerged since 2015, introducing new challenges for investigators in capturing and acquiring digital evidence [1]. Conventional crimes with digital evidence have been increasing rapidly. Digital evidence can be applied to any crime because electronic devices can be used in any crime and are not limited to cybercrime only.

Computer forensics is exploding in detail and need. It is not only helpful for solving computer crimes like child pornography, child exploitation, or hacking, but has also been used to solve other crimes such as terrorist attacks, drug trafficking, robbery, organized crime, tax evasion, robbery, and homicide.

Computer forensics is a fast-growing discipline and practice that blends many areas of expertise together. It includes investigating cyber crimes, terrorism, child pornography, fraud, e-scams, network intrusion, drug/human trafficking, and traditional crimes. Computer forensics is a part of forensic science that focuses on legal procedures and evidence as applied to computer/electronics-related devices or attachments. In 1920, Dr. Edmond Locard developed a theory called Locard's exchange principle, which indicates that whenever a perpetrator comes into contact with a victim/person or an object, a transfer of evidence happens. In the same light, crimes committed with or against digital devices also leave trace evidence.

Digital (Multimedia) Evidence and Devices

The National Institute of Justice (NIJ) defines *digital evidence* as information and data of value to an investigation that is stored on, received, or sent by a digital-related device or attachment [2]. This evidence can be collected when digital-related devices or attachments are seized and secured for examination.

Digital evidence has the following features:

- Is latent (hidden), like fingerprints or DNA evidence;
- Crosses jurisdictional borders quickly and easily;
- Can be altered, damaged, or deleted with little effort; and
- Can be time-sensitive.

Digital evidence is also referred to as any electronic data saved or sent using a computer-related device that supports or refutes a theory of how an offense occurred or that addresses critical components of the offense, such as intent or alibi [1]. Digital evidence involves data on computers, video recordings, audio files, and digital photos. This evidence is essential in computer and cyber crimes or even traditional crimes but is also valuable for facial recognition, crime scene photos, and surveillance tapes/hard drives.

The details of digital-related devices or attachments will be discussed later. Since crimes are trending toward those which involve evidence such as video clips and audio recordings taken by smartphones, or video footage from surveillance DVR (digital video recorder) systems, we may focus the evidence into digital multimedia evidence (DME).

Digital (Multimedia) Evidence

The Scientific Working Group on Digital Evidence and the Scientific Working Group on Imaging Technology (SWGDE/SWGIT) define DME as any information of probative value that is either stored or transmitted in a digital form, including but not limited to film, tape, magnetic, and optical media, and/or the information contained therein [3].

When DME is needed in the legal process, *data integrity* and *data authentication* are significant during the forensic procedure. These two terms are usually interchanged and can be confusing. SWGDE/SWGIT defines those terms as follows:

Data integrity. The process of confirming that the data presented is finished and untampered with from the time of collection. What must be determined with data integrity is whether the DME has been tampered with or changed since it was originally made. Changing the data is not necessarily contraindicated for preserving evidence reliability. In some cases, DME, especially for video evidence, will need to have the image aspect ratio calibrated or have the colors/

brightness of the images corrected or sharpened. Each procedure could change the data of the evidence but not the validity of the data representation [3].

Data authentication. The process of substantiating that the data is a precise representation of what it purports to be. DME displays virtually, not physically. For instance, in some video evidence, there may be some aspect ratio errors or color errors. Data authentication needs to verify the following possible questions:

- Does DME precisely represent what it purports to be?
- Pertaining to video evidence, is what happened in front of the surveillance camera the same visual representation in time and space as what was recorded on the DVR?

Digital-Related Devices or Attachments

The digital evidence can be collected/extracted when digital-related devices or attachments are seized and secured for examination. The following is a list of digital-related devices or attachments:

Smartphone. A mobile phone with an advanced mobile operating system that combines features of a personal computer operating system with other features useful for mobile or handheld use. The most important information on phones usually includes text messages, emails, social media messages, contact lists, pictures, appointment calendars, GPS (Global Positioning System) data, and calling history.

Tablet PC. A wireless, portable personal computer with a touchscreen interface. The tablet is typically smaller than a notebook computer but larger than a smartphone. The most common type of tablet is the slate style, like the Apple iPad, Microsoft Surface, Amazon Kindle Fire, or Samsung Galaxy (Android). Tablets may contain information like photos, video and audio files, address books, appointment calendars, notes, and emails.

Digital watches. Several types are pagers that store digital messages, and they may contain address books, appointment calendars, notes, and emails.

Global Positioning System (GPS). Provides information on previous travel; some automatically store the previous destinations, which include travel logs.

Gaming consoles. Xbox, Switch, PlayStation game consoles, and other devices provide a convenient means to store data of all kinds, including images, video, audio, and text files.

iPod/MP3 player. Handheld music device that holds calendar entries of dates of crimes or evidence related to crimes, the contact information of perpetrators or victims, and stores photos and documentation.

Smart card. A small handheld device containing a microprocessor that is capable of storing a monetary value, digital certificate, encryption key, or authentication information (password).

Dongle. A small device that plugs into a computer port that contains similar information to a smart card.

Biometric scanner. A device connected to a computer system that recognizes an individual's characteristics such as voice, fingerprints, and retina.

Answering machine. Part of the telephone using magnetic tapes or a digital recording system. Most machines have caller IDs, names, and telephone numbers of callers, as well as deleted messages, last number called, and memos.

Digital camera. Camera that transfers images and video to computer media, allowing for potential evidence such as images, removable cartridges, sound, time and date stamp, and video.

Personal Digital Assistants (PDA). A small device used as a personal organizer which synchronizes data with other computer systems by use of a cradle and is able to include computing, telephone/fax, paging, and networking features. A PDA could contain an address book, documents, appointment information, email, passwords, telephone numbers, text messages, and voice messages.

Memory card. A removable electronic storage device that can store hundreds of images or other data and is used in computers, digital cameras, and PDAs, and does not lose information when power is removed.

Modems. The device used to facilitate electronic communication by allowing the computer to access other computers and/or a network via a telephone line, wireless, or other communication mediums.

Network components. Local Area Network (LAN) card or Network Interface Card (NIC) used to connect to computers and allow for the exchange of information and resource sharing.

Routers, hubs, and switches. Used in a networked computer system to provide a means of connecting different computers or networks.

Servers. Provide services for other computers connected to it via a network in order to share resources such as file storage or email.

Network cables and connectors. Connect components of the computer network, removable storage devices, and media that store magnetic, digital, or electronic information; examples are floppy disks, CDs, DVDs, cartridges, and tape.

Pagers. Handheld electronic device that contains telephone numbers, voice mail, and email.

Printers. Contain a memory buffer allowing them to receive and store multiple page documents while they are printing; some models contain a hard drive. It is possible to get network identity or information, superimposed images on the roller, time and date stamps, and a usage log from the printer.

Scanners. An optical device that is connected to the computer and scans images to the computer as a file, used to convert documents and pictures to electronic files that can be viewed or transmitted and manipulated on a computer.

Telephone. Connected directly to a landline system or remote base station that is part of a telephone system or wireless cellular two-way communication system using landlines, radio transmission, cellular systems, or a combination. Telephones contain caller ID, emails, pages, and text messages.

Cell phones. Use cellular systems for communication. The most important data includes contact lists, pictures, appointment calendars, GPS data, and calling history.

Copiers. Contain user access records as well as the history of copies made.

Credit card skimmers. Used to read the information contained on the magnetic stripe on plastic cards, including the expiration date, user's address, name, and card number.

Facsimile machine. Can store preprogrammed telephone numbers and the history of transmitted and received messages; some machines have the ability to store hundreds of faxes, either incoming or outgoing, or at least a log of the faxes.

Computer hardware components:

- **CPU (Central Processing Unit).** It is also called the microprocessor or central processor, and executes all the calculations that happen inside a computer. The CPU is a very efficient calculator because it is designed to handle numbers. The CPU is responsible for processing a sequence of stored instructions called a program. Every CPU has a make, a model, a speed, and a package type.
- **RAM (Random Access Memory).** Stores programs and data currently being used by the CPU. The maximum amount of data that RAM can store is measured by bytes. The modern computer is usually measured in billions of bytes, called gigabytes (GB). RAM is a volatile memory that loses its data when the computer's power is turned off. RAM allows data to be stored and retrieved on a computer.
- **ROM (Read-Only Memory).** It is mainly used to store firmware. ROM is one kind of non-volatile memory used in computers and other digital devices. ROM is a significant part of the computer BIOS (Basic Input/Output System). ROM is computer memory on which data has been prerecorded.
- **HD** (**Hard drive**). Hard drives keep data or computer programs that are not currently being used by the CPU. The hard drive is an essential part of a computer's storage. Internal hard disks are installed in a drive bay, attached to the motherboard using an IDE, ATA, SCSI, or SATA cable, and are powered by a connection to the Power Supply Unit (PSU). The drive-to-drive evidence acquisition is relatively fast. It is not recommended to boot via a suspect computer. If you are booting to your computer forensics workstation, install the suspect's hard drive on your workstation. You will need to configure your new hard drives so that both the suspected HD and your HD are each cabled and pinned as masters (if they are IDE HDs). Master-to-master data transfer should provide a better acquisition performance.

Processing and Collecting Digital (Multimedia) Evidence

Processing Digital Evidence

The TWGEDE (Technical Working Group for the Examination of Digital Evidence) suggests that there are four steps to processing digital evidence [2].

- **Evaluation.** Computer forensic scientists should assess digital evidence completely with respect to the scope of the case to determine the course of action to take.
- **Acquisition.** Digital evidence, by its very nature, is fragile and can be tampered with, damaged, or ruined by improper handling or examination. An examination is best conducted on a copy of the original evidence. The original evidence should be acquired in a manner that preserves and guards the integrity of the evidence.
- **Examination.** The purpose of the examination process is to extract and analyze digital evidence. Extraction refers to the recovery of data from its media. Analysis refers to the interpretation of the recovered data and putting it in a logical and useful format.
- **Documentation and presentation.** Actions and observations should be documented throughout the forensic processing of evidence. This will conclude with the preparation of a written report of the findings.

Digital evidence may come into play in any serious criminal investigation like homicide, aggravated assault, rape, stalking, carjacking, burglary, child abuse or exploitation, counterfeiting, extortion, gambling, piracy, property crimes, drug trafficking, and terrorist acts. Since digital (multimedia) evidence is hidden data, the most important thing is to know how to collect it properly.

With current technology, handheld devices can transmit encoded messages between criminals. Even newer household appliances, such as a refrigerator with a built-in TV, could be used to store, view, and share illegal photos. It is vital that crime scene investigators be able to recognize and properly collect potential digital evidence.

Originals vs. Copies

In the analog world, the determination of originals versus copies is clear-cut. An *analog signal* is a continuous signal which contains time-varying quantities. We actually live in the world of analog. There are infinite colors to see, unlimited tones to hear, and infinite smells to sense. An analog system can build up noise or distortion during duplication; it creates **degradation,** which leads to the loss of quality of an electronic signal during the duplication process. In other words, there is original data that owns the top quality of the signal, and the first-generation copy of data which has lower quality than the original. The loss of quality increases with each newly generated copy.

A *digital signal* is a discrete value at each sampling point. It could be represented by computer sample data which would be established with a series of bits that are either the number 1 (referred to as ON) or the number 0 (referred to as OFF), so that there are NO fractional values. A digital signal is good for computer processing as it is more reliable. The technology quickly replaces a large number of analog applications and devices. During the process of duplication, it simply copies the computer data into a new digital media. Therefore, regardless of how many generations of copies are made, each copy of the data is exactly the same as the original one, so that even the thousandth copy will be as good as the original. There is no differentiation between originals and copies.

Performing an analog-to-digital conversion is called **sampling** or **digitization**. **Nyquist's theorem** indicates that, in order to reconstruct the original analog signal into digital data without any information loss, the sampling rate must be at least twice the bandwidth of the signal. If not, then **aliasing** will happen, which leads to a distortion or artifact when the signal reconstructed from samples is different from the original continuous signal.

Hashing

Everyone has a unique fingerprint to be identified. But in the virtual world, how do people differentiate digital files? There is a way, which is called **hashing**, used to validate digital evidence. Basically, hashing is the process of using a mathematical algorithm that calculates against a stream of data for which a hash value will be generated and used to identify the file. A hash value is a document's identifying fingerprint. Hashing is able to confirm whether a digital file has been tampered with or not.

When we deal with digital evidence duplication, all efforts should be taken to ensure that the working copy of the original does not insert any new data or reduce information that could alter the meaning of the original evidence. Hashing is a method of ensuring that the working copy is the same as the original.

Validating digital evidence requires the use of a hashing algorithm tool, which is able to generate a unique hexadecimal number to represent a digital file; this is the hash value. We may call that unique hash value a **digital fingerprint**. Normally, if two documents have the same hash values, we may say they are statistically identical, even when those two files have two different filenames. Making even a minor alteration to one of the documents (such as adding or replacing a single bit of data) will lead to a completely different hash value. There are two computer forensic hashing algorithms recognized in the forensic community:

Message Digest 5 (MD5). MD5 is a mathematical formula that processes file data into a hexadecimal code or a hash value. If even a single bit in the data has been updated, the hash value will also be changed. MD5's hashing function has a 128-bit value that is unique to the stream of data. The odds of any two different documents having the same MD5 result are one in 2^{128}.

Secure Hash Algorithm version 1 (SHA-1). The second hashing algorithm (a newer one) was created by the National Institute of Standards and Technology (NIST). SHA-1's hashing function has a 160-bit value that is unique to the stream of files. The odds of any two different files having the same SHA-1 result are one in 2^{160}. SHA-1 is gradually replacing MD5, even though MD5 is still widely used [4].

Digital Evidence Chain of Custody

In order for any digital evidence to be accepted by the court, the proponent must authenticate the evidence. That means the party must show that the evidence truly is what it purports to be. One of the more important rules that needs to be highlighted when dealing with digital evidence is the chain of custody. In simple terms, the definition of digital evidence chain of custody is a timeline that depicts how digital evidence was seized, analyzed, and preserved in order to be shown as evidence in court. For any further forensic analysis, work should not be done on the original evidence but on a copy version so that the duplication of digital evidence maintains its untampered content in an unbroken chain of custody which shows electronic file preservation and the reliability and accuracy of it. As a legal procedure, hash values of seized digital evidence are no different than photographing a crime scene. The entire hard drive and relevant documents or any other storage media should be hashed as soon as possible.

Building a sound chain of custody is imperative since digital evidence could be easily changed. Maintaining a chain of custody for digital evidence, at a minimum, must ensure that the following procedures were followed:

- A complete copy was made with hash verification;
- All digital media was secured; and
- No data has been altered.

Chain of custody documentation should be preserved for all digital evidence so that a record of the relevant hash values can be referred to the court. By comparing two hash values, the digital evidence will be authenticated and admissible, and a clear chain of custody documentation can be presented to the court.

Forensically Sterile Conditions for Courtroom

Prior to any further forensics analysis on suspect digital devices, we are required to sterilize all media that will be used in forensic imaging (duplication). Since we are only allowed to work on a copy version of suspect digital evidence (not on original evidence), the condition of any new media should be forensically wiped and verified prior to analysis. This procedure could obstruct data corruption from previous analysis or possible data contamination from destructive computer programs.

Analysis of Electronic Data

Any analysis applied to digital evidence must take place on a copy of the original. If the original evidence is being processed, there will be no way to reproduce the results. The original evidence furnishes the function of control, much the same as any control used in forensic scientific examination. Without any effective control, any summaries drawn from the digital evidence will be suspect [5].

Unallocated File Space & File Slack

Under Windows-based computer systems, when files are deleted, the content of the data is not truly erased. Data from the "deleted" file remains intact in an area called unallocated space. Unallocated file space and file slack are both significant sources in computer forensics. Unallocated file space potentially includes intact files, remnants of files and subdirectories, and temporary files which were made and erased by computer applications and also the operating system. All such files and data fragments could be sources of digital evidence and also pose a security risk to sensitive information.

The file system utilizes fixed containers or blocks named **clusters**. In Windows-based systems, they are normally write in 512-byte blocks called **sectors**. Clusters are groups of sectors that are used to allocate disk storage space in Windows-based operating systems. Brifly, Windows systems allocate disk space for files by clusters. If a new file is assigned a number of clusters, then the total file size will be equal to or smaller than the number of clusters multiplied by the size of one cluster. Since file sizes rarely match the size of multiple clusters perfectly, there is a tiny space in which the data could reside between the end of a logical file and the end of a cluster. This is called **drive slack**.

Two types of drive slack are **RAM slack** and **file slack**. A simple two-sector cluster will be used to illustrate slack space. A simple example is to use Notepad to type "CSI" and save the file. The file size is 3 bytes since there are only three letters in the document.

- **RAM Slack.** As indicated above, Windows-based systems usually write in 512 bytes per sector (like a container). That means whenever the operating system (OS) wants to save a file into the file system, it would write in blocks of 512 bytes with a minimum of at least one container size of 512 bytes. So, if there is not enough information to fill the last sector of the file in the last cluster, the OS will write random data from computer RAM (Random-Access Memory) to the unfilled area in the last sector of the file. Login account IDs, file fragments, deleted photos, emails, notes, and passwords are often discovered in RAM. That sensitive information could possibly reside in RAM slack. The file shown in **Figure 1** contains one cluster with two sectors.

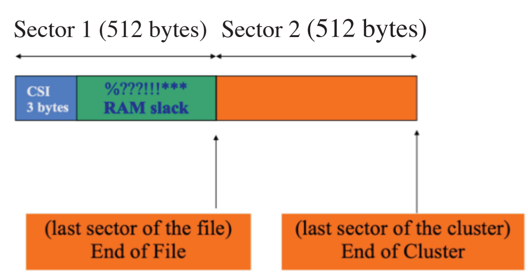

Figure 1. A file with only one cluster and two sectors showing RAM slack.

- **File Slack.** As in the example above, RAM slack covers the last sector of a file only. Notice the remaining sector (which is still affiliated with the last cluster) is assigned to the file but has not been given any data. Since there is no new data to rewrite into this remaining sector, it could preserve remnants of previously erased files or the data which existed before. This space is called file slack. The file shown in **Figure 2** contains one cluster with two sectors.

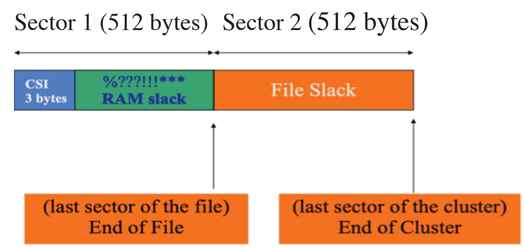

Figure 2. A file with only one cluster and two sectors showing RAM slack and file slack.

Deleted/Undeleted Process

Computer forensics can recover deleted files. We may say that this is an undeleted process. When a computer OS deletes a document, it does not erase or remove the data. It simply deletes the pointer to the document and informs the file system that the document is no longer available and the space is now open for any new data for storage. For instance, in the FAT (File Allocation Table) file system, when a file is deleted, the computer OS will replace the first character of the file name with hex code E5, which displays as a lowercase Greek letter sigma (σ). The sigma symbol is a marker that advises the OS and file system that the document is no longer available and the space is now open for any new file to be written into the same cluster location. The area of the space where the deleted files are located becomes **unallocated file space**. You may say the unallocated space is like a junkyard waiting for recycling. The unallocated space is now available to accept new data from newly made documents or other files needing more space.

Usually, deleted files could affect the culpability of perpetrators by showing their willful behavior, which was used to cover their negative intention.

Concluding Remarks

Computer forensics is an evolving discipline that is gaining traction and expanding. While the Internet of Things might well be the coming storm, computer evidence associated with criminal cases will be overwhelmingly common in our daily life.

Our world has changed tremendously since the invention of the Internet and digital devices. The internet has practically led crime patterns to a new transformation, previously unheard-of crimes that transcend all continents and continue to evade law enforcement and prosecutorial measures that have traditionally been used to investigate, prosecute, and punish criminal action [6]. Nowadays, law enforcement will need to unlock digital encrypted gadgets to uncover potential evidence. Crime scene investigators will need to apply unique methods to catch bad guys hiding behind the dark web's anonymity [1], and forensic examiners will need to validate AI generative adversarial networks' (GAN) deepfake images. As digital technologies keep advancing, there is an urgent need for continuous development of advanced practices in digital data collection and analysis tools for computer forensics.

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NEW BOOKS AND BOOK REVIEW

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A. Barbaro, A. Mishra, Eds
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Forensic Microscopy — Truth Under the Lenses
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Book Review

Mildred Trotter and the Invisible Histories of Physical and Forensic Anthropology

Emily K. Wilson
CRC Press: Boca Raton, FL, US; 2022

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The book *Mildred Trotter and the Invisible Histories of Physical and Forensic Anthropology* by Emily K. Wilson is a collection of topics related to the life of renowned female anthropologist Mildred Trotter. Wilson describes the book as a history of forensic anthropology as a growing discipline rather than a biography of Trotter in chronological order. The book relates the life events of Mildred Trotter, supplemented by her portrait in almost all chapters of the book. The book also examines the status of women and marginalized people within the discipline, and the sexism, scientific, and social racism they experienced.

In Chapter 1, *Introduction*, Wilson discusses the history of physical anthropology and the life of Mildred Trotter, from her childhood to becoming the first female president of the American Association of Physical Anthropologists (AAPA; now the American Association of Biological Anthropologists), written from the facts extracted from various sources. The author describes Mildred Trotter as a celebrated anthropologist and an accomplished anatomist who excelled in the male-dominated field of forensic anthropology. Through limited documentation, the author explores Trotter's childhood in Pennsylvania, her educational achievements, and the academic position she held at the Washington University School of Medicine (St. Louis, MO). Wilson describes her as the founding mother of physical anthropology, as she was one of two women among the founding members of AAPA, owing to her contributions to making the discipline a global one.

In Chapter 2, *Hawaii and the Army*, the author narrates Trotter's experiences while serving in the US Army, conducting biological profiling of remains of World War II victims housed in a Hawaii laboratory. Mildred Trotter's military service brought her to prominence within the field of physical and forensic anthropology, and it established her identity as a renowned forensic anthropologist for her contributions to maintaining scientific integrity and validity. Her job was to identify padlocks, identify casualties, write critiques to Army officials, and most important of all, conduct comprehensive stature estimations of skeletal remains of fallen soldiers from World War II with the cooperation of the American Graves Registration Service (AGRS). Remains that reached her laboratory facility were ones that had already proven difficult or impossible to identify. Trotter and her team processed the skeletal remains to determine a biological profile and other observations that could prove helpful, such as antemortem fractures, evidence of surgeries, dental work, and pathological conditions.

The chapter highlights various instances when Trotter proved her scientific acumen for identification strategies of unknown human remains retrieved from various military operations, natural disasters, or documented skeletal collections. Wilson describes instances when Trotter faced difficulty at work due to pressure from officers to sign reports which she did not scientifically agree with, though the issues were resolved eventually. The author mentioned that no female remains came to the Hawaii laboratory during her service, so sex determination was never attempted or performed. Wilson also reviews Trotter and Goldine Gleser's stature estimation research and states that it finds mention in more recent popular writings in forensic science. Trotter and Gleser generated formulae based on measurements of the Terry Collection of long bones and used these to input measurement data from unknown skeletal remains, which provided reliable stature estimates within ranges.

In Chapter 3, *The Tibia*, Wilson tries to determine the exact process through which a measurement mistake was committed by Trotter and Gleser (1952) for stature estimation of World War II and Terry Collection skeletons from lengths of tibia bone; she could not find any satisfactory or conclusive answers to the tibia mistake. The inconsistencies in the range of 5.6–7.68 cm were reported between tibia lengths of Korean War dead (Trotter and Gleser, 1958) and World War II and Terry Collection skeletons (1952) measured with and without tibia malleolus. Other users of the Trotter and Gleser stature estimation formulae did not notice the fundamental problem for decades. The problem arose due to a discrepancy between the procedure cited for tibia measurement and the way she actually measured the tibia. Though they themselves highlighted the discrepancy in a 1958 paper, the error was observed by Richard Jantz et al. (1995) when they measured the same tibia bones using systematic references. Trotter and Gleser faced much criticism and difficulties in justifying their stature estimation results owing to various factors. They underlined the secular and age-related changes along with population-specific variations in bone dimensions and proportions of tibia and other bones as the most possible factors for discrepancies in accuracies of their stature estimation formulas. The author considered the error in measuring the tibia (excluding malleolus) as intentional avoidance and inattentive neglect of available systematic references by Ales Hrdlička (1947) and Rudolf Martin (1928) for the correct procedure of recording tibia length. The tibia turned out to be the most notorious bone in her career. Trotted was accused of using multiple methods, misleading wording, and fewer diagrams in her subsequent publications to suit her immediate purposes, though the mistake was accepted in 1977 and also rectified in the FORDISC computer program. The author stated that Trotter was genuinely perplexed by the tibia problem and there was no evidence to support the assertion that she concealed any possible knowledge of her mistake; she might simply have misconstrued the measurement definition.

The author cited some valid reasons for the tibia error and inconsistency: Trotter did not have immediate access to the recent articles and books, though she tried her best by incorporating reference materials and a reference skeleton, along with the guidance of colleagues from regular correspondence with them. The author explained that mistakes in scientific research are more common than one might expect, and clearly distinguished between scientific misconduct and deliberate dishonesty, lack of rigor, or any degree of negligence as committed by Trotter in regard to the tibia problem. There is no evidence to believe that Trotter and Gleser exhibited any intentional fabrication or distortion of data to alter the results for their benefit. The author concludes that Trotter was guilty of self-deception, error, and perhaps negligence, but she should not be accused of scientific misconduct and reminded us that we are all fallible and scientific research demands a profound obligation to conduct careful and honest work.

In Chapter 4, *Life and Career*, the author presents details about the life and career accomplishments of Mildred Trotter (also depicted through various portraits and pictures), starting from her childhood days on a Pennsylvania farm, education at Mount Holyoke College (South Hadley, MA) and Washington University, her research journey from hair growth to osteology and academics, her journey from an eminent professor to the first female president of AAPA, and the first woman to receive the Wenner-Gren Foundation's Viking Fund Medal. The chain of life events presented by the author about Trotter in this chapter can deeply engross anyone curious to learn more about her role and the scientific endeavors she pursued within the masculine environment of higher education in those days.

On switching her research area from hair growth to osteology during the height of her career, the author rightly mentions that "the trend of one's research can never be foreseen". Wilson says that Trotter's research on hair growth filled an existing gap in professional and popular scientific knowledge, which established her as an authority on the topic. In one of her recommendation letters, Trotter was described as "industrious, energetic, self-reliant and unbiased, possessing an unusually quick and clear insight into problems and having a good spirit of cooperation".

Throughout the decades of her career, she produced 100 scientific and research works covering a variety of topics. She was admired by colleagues and students for her hard work, dedication, research interest and teaching, and she was a pioneer and role model for women in science. She taught students from multiple generations of the same families and was described as a rigorous, conscientious, honest, and vigorous teacher with tremendous enthusiasm for her students.

The author enumerates some interesting shifts in her career, the hurdles and biases she faced (particularly her experiences regarding gender discrimination) and portrays her as a conscientious and effective educator and skilled researcher. Trotter complained about sexist treatment in opportunities, promotions, and salary. The author also discusses interesting facts about her persistent efforts towards the preservation and accessibility of the Terry Anatomical Skeletal Collection of cadavers for research at the Smithsonian's National Museum of Natural History.

In Chapter 5, *Women in Early Physical Anthropology*, the author presents Trotter's own descriptions of her experiences with gender discrimination. Wilson discusses Trotter's experiences as a founding member of AAPA and her interest in the history of anthropology in her later life. The author relates Trotter's concerns about the existing gender disparities and biases related to the roles and opportunities granted to women in sciences. Trotter even addressed the issue of sex discrimination and stated that women were not offered the same opportunities as men.

Throughout this chapter, the author also highlighted the writings of some other female anthropologists who were working in this field during that period regarding how they were treated based on their gender, and interprets their historical viewpoints in light of emerging evidence of persistent gender inequities. From this chapter, it is evident that these early anthropologists experienced a pattern of discrimination in education, employment, promotion, and pay. This chapter also provides a brief account of other important female members of AAPA who excelled greatly in their own unique ways and went on to hold prominent positions. Under the Contemporary Women subtopic, the author provides a compilation of secondary data sources about women who are currently AAPA members.

In Chapter 6, *Women's Experiences*, the author presents the accounts of Trotter and other female anthropologists' individual experiences related to their gender, and identified shared patterns of those experiences, in order to contextualize women's experiences in the early years of the field of physical anthropology. Wilson enumerated women's experiences during all stages of their education from different educational institutions, and also the disparities and discrimination felt by women in funding opportunities across the scientific disciplines. The author has documented several similarities between these women's experiences in the early AAPA:

- Being socially and financially discouraged at all educational levels;
- Gaining entrance into the field by studying women and children;
- Serving in temporary, lower-paying positions; working for the federal government or military;
- Leaving professional spheres early in their careers; discovering that their work has been subsumed under their male colleagues; and
- Experiencing discrimination in pay and promotion.

It is mentioned that only a few women were educated and given opportunities in disciplines like physical anthropology that were comparable to men. The author describes how women were deprived of equal employment opportunities and were forced to work on topics not of their choosing. Senior male anthropologists used to hire women and people of color just to have easy access to their preferred human subjects. Women were deprived of due credit for their work and dedication. Women had to resort to different coping methods, involving stoicism and working harder than their white male colleagues, to persist in the field. It led to greater chances of exploitation rather than providing them with necessary equality without affecting the status quo of the women as a whole. Additionally, the author presented Trotter's experiences with discrimination against women, which is not limited to discouragement but also to funding across the scientific field. The author has also portrayed some aspects of Trotter's personality in this chapter, documenting Trotter as very rigorous and firm towards women as Trotter believed that women should be more responsible and capable than men. Wilson exemplified the discrimination faced by women in detail by citing the career progression case history of Mildred Trotter. Furthermore, the author also included some details about Trotter's relationships and personal life.

In Chapter 7, *Marginalized Contemporaries*, the author summarizes the journey of other young anthropologists who were considered part of a marginalized community at that time. A detailed description of the life histories, research contributions, and racism faced by such anthropologists (including Caroline B. Day, William M. Cobb, Charles P. Warren, Tadao Furue, Wu Rukang, and Kehar S. Chouké) belonging to marginalized communities is provided in this chapter. The author illustrated the influence of racism on the emergence and research endeavors of specific sub-divisions of humankind, who attempted to persuade the scientific community to shun racist ideologies through their writings and research work. Caroline B. Day was the first Black woman to earn a graduate degree in anthropology in the US; she collected genealogies, hair samples, and anthropometric data from 346 families to demonstrate the similarities between different population groups inhabiting the country. Tadao Furue, a Japanese citizen, was among the only non-US citizen anthropologists who was a part of the multi-national team formed by the US government for undertaking the human identification work which developed the proxy method for the morphological examination and measurement of fragmentary bones.

The author discusses how short stories in popular magazines addressed the myths and discriminatory behavior faced by the Black community. Misinterpreting the terms ancestry, ethnicity, and race in forensic identification strategies of unknown human skeletal remains retrieved from different contexts and hence inconsistencies in anthropological race determination was rampant in those days, the author reminded the reader. Wilson supports these observations and interpretations by citing an example of a Sikh student from India who was forced to shun his cultural elements of his identity (beard and turban) in order to study and find job in a medical school in the US.

In Chapter 8, *Race, Sex and Research*, the author started by citing two incidents illustrating the controversial status of the race concept and racism within physical anthropology that occurred during her presidency of AAPA. This chapter covers the issues related to racism raised in physical anthropology and the social responsibility of the anthropological associations in addressing and delegitimizing purportedly scientific claims supporting racism. It is further argued in this chapter that Trotter contributed to the perpetuation of racist science and the centrality of race in anthropological studies within the discipline. Trotter termed different groups in her research and also presented racial subsamples as if they were biologically discrete racial groups. The author mentions that although Trotter did not recognize race as a discrete category of individuals, she continuously used the term race as a biological reality in her scientific research for a variety of practical purposes. Women anthropologists, who were only a few in number, readily rejected the race concept and spoke out against institutional racism, playing a constructive role in deconstructing the race concept.

Trotter's work on hair growth was criticized by recent researchers who discredited race determination by hair samples, stating that hair shape and melanosome distribution do not distinguish ancestry; the FBI also found wrongful convictions based on hair analyses for various purposes. The author stated, "Anthropology had identified itself as the authority on race, and Trotter had positioned herself as an expert on hair as a racial characteristic." The author opined that Trotter's academic and personal treatment of race and sex varied over time, as did her personal recognition of sexism. Wilson describes how Trotter's hair research helped her in forensic identification and attribution of a child to a specific population group, or to biological parents in adoption cases and foster home residents, identified on the basis of their physical, racial, and other characteristics. It is reported in the chapter that Trotter even encouraged her fellow researchers to use race as an inclusion criterion for anthropological estimations, particularly Thomas D. Stewart, who was interested in estimating the skeletal age of Korean War remains (though he rejected incorporating race as a subcategory). His act was opposed by Trotter, and she made it clear that she believed race is a meaningful biological category that is necessary for the organization of data.

Chapter 9, *Later Years,* is an excerpt from Wilson's book *Mildred Trotter*, which details Trotter's later years. Trotter was well-known for her work as an Army forensic anthropologist on a temporary assignment in Hawaii, where she identified war dead and returned them to their families as part of a nationwide humanitarian effort. This chapter is one of the most important sections of the book because it expands on Trotter's character, including her social life, her significant international travel, and her relationships with her family. Trotter was described by the author as a firm and strong personality who never hesitated to assert herself in both personal and professional matters. The author presented some of the notable documented work of Trotter and mentioned Trotter's honorary degrees, which she received from the Western College for Women (Oxford, OH; 1956), Mount Holyoke College (1960), and Washington University (1980).

The Mildred Trotter Prize was established by AAPA in her honor as a result of her noteworthy contributions to this discipline. In this chapter, the author stated Trotter's intent to stay in St. Louis for the rest of her life, and so she did. She also donated her body to Washington University. Trotter's work remains in active use, such as her stature estimation project and her foundational work in hair growth. Trotter's role as the first woman to be president AAPA and her contribution in reshaping the military's ongoing process of human identification are some of the enduring legacies which she has left behind.

This chapter also covers the post-retirement life of Trotter and how she was active in her retirement days as well. Trotter was a true visionary and left a trail so that newer topics could be discovered and taken up by future generations of researchers. She was a devoted symphony patron, active birdwatcher, and a member of the Audubon Society, where she spent many of her retirement days. Trotter actively combined travel and work even after retirement; one of those travels was a visiting professorship at Makerere University (Uganda) where she trained young surgeons. Similarly, she visited many countries, including China, Taiwan, Egypt, Mexico, Greece, and Israel. The author remarks, after decades, though most of her work has been superseded and abandoned, her research work still remains to be a guiding force in biological anthropology. The author highlights that Mildred Trotter considered research as a continuous seeking effort, and in doing so she encountered some unavoidable errors which she could not hold back from engaging in. She is still a role model for many, especially women in the field of anthropology.

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Overall, the book takes the reader on a historical journey of forensic anthropology through the life and career of Mildred Trotter, an accomplished anatomist and a role model for women in physical anthropology. Her work with stature estimation, hair analysis, and race determination leaves a trail for future research possibilities and discoveries in forensic anthropology. The life and achievements of Mildred Trotter are still with us in a modern and modified way. FORDISC, an advanced computer program which holds the key to the digitization of forensic anthropology in today's world, still functions on formulae and methodologies established by Mildred Trotter, though with slight modifications. The passion, dedication, and hard work of Mildred Trotter mark her as one the founding members of forensic anthropology in the world.

COMMENTARY

Artificial Intelligence: A Prospective New Tool for the Planning and Orgnization of Investigations

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Artificial Intelligence vs Traditional Machine Learning

Artificial intelligence (henceforth AI) is a term that is alleged to have originated at a 1956 conference at Dartmouth College (Hanover, NH). What distinguishes AI from a traditional computer is that the computer makes its decision based on the known "if-then" connection (i.e., what to answer is preprogrammed for it), while AI responds from the almost infinite number of possibilities. Artificial intelligence can acquire knowledge that has not been preprogrammed into it by the developers [1]. According to other experts, AI is a mathematical model capable of learning, created in the form of the human brain [2].

As long as humans used computers as a mere tool, there was no real difference between computers and screwdrivers, because computers only did what people asked them to do [3]. Until recently, AI systems have operated based on preset algorithms by a programmer and their behavior was completely predetermined [4]. Accordingly, there is a distinction between "weak AI" — a system that is showing intelligent behavior only in a very specific area — and "strong AI". The latter no longer simulates human thinking but also the mind itself [5]. The weak AI can develop and learn, but only based on the task profile assigned to it. Most AI systems are "weak AIs". On the other hand, the strong AI can operate outside the designated task profile, which means that its application and development options are hardly limited [1].

Trends of Artificial Intelligence in Daily Lives

Artificial intelligence is now present in many areas of our daily lives, such as the navigation system of motor vehicles, the production of animated films, and self-driving vehicles [6]. Stephen Hawking [7,8] predicted that in the next century, the intelligence of computers would exceed that of humans, and articulated the fear that AI may even destroy civilization. The preamble to the European Parliament's resolution of 16 February 2017 [9] on robotics refers to the same, i.e., in the long term, AI may exceed human mental capacity.

According to some scientists, the world market share of AI is increasing 60-fold between 2016 and 2025 (from \$643.7 billion to \$36,818.6 billion in US dollars, as shown in **Table 1**) [2].

Tilesch and Hatamleh [10] also believe that AI is the most important tool for the redistribution of power in the 21st century; all technologies will soon be AI-based.

Artificial intelligence changes the approaches that have been generally accepted for machines so far. While the traditional computers "just do what is programmed", the most advanced and most sophisticated AI systems can act autonomously, accepting and implementing their own decisions that their programmers could not anticipate [6]. Regardless of this, it remains true that algorithms do not have their own actual knowledge. The AI cannot be interpreted as a machine that thinks on its own, but it can

Table 1. Projected increase in AI market share from 2016 to 2025 [2]

Year	World market share of AI (Billion in US$)
2016	643.7
2017	1,247.6
2018	2,212.7
2019	3,733.8
2020	6,076.1
2021	9,550.7
2022	14,427.1
2023	20,792.1
2024	28,424.7
2025	36,818.6

produce reactions from unknown (not previously entered) parameters [1].

Potential Hazards of Artificial Intelligence

In 1981, a 37-year-old Japanese employee of a motorcycle factory was killed by an AI robot working nearby [3]. The robot mistakenly identified the employee as a threat and calculated that the most effective elimination of the threat would be to push him into a neighboring machine; therefore, with its hydraulic arm, the robot trapped the shocked worker in the machine, quickly killing him, then continued its duties as if nothing had happened [5].

The latest AIs are based on a so-called deep learning method. In these technologies, the process leading from inputs to outputs is impenetrable; sometimes it is not possible to deduce how the software created the final result, as it cannot be traced back to the original will of the programmers [4]. That is why the responsibility of the vehicle itself arises in terms of criminal offenses committed by fully self-driving vehicles [11].

Artificial Intelligence in Criminal Justice

It is no coincidence that the International Criminal Law Company (AIDP) organized its XXI Congress in 2024 on the subject of AI [12]. The three main themes of the conference will be:

- How can a crime committed by an AI system be attributed to man or to AI itself (if it is even possible)?
- How can AI systems help law enforcement agencies prevent and combat crime?
- Can we trust the decisions taken via AI in criminal matters?

The second of the three themes has a special significance from a forensic point of view. It is also clearly apparent from the incorporation of this theme that AI systems can be a useful adjunct to judicial missions and accelerate the work process [1]. In the future, AI will be displayed and used in almost all areas of criminalistics. Two of these many areas are listed below and will be further discussed in later sections:

- Planning and organizing the investigation; and
- Risk assessment and international criminal cooperation.

Artificial intelligence is expected to be present in all areas of criminalistics — and is already present in many areas. Handwriting analysis can be significantly accelerated by the AI system; the same can be true for ballistics or even dactyloscopy, DNA, and so forth, for identification. Artificial intelligence can be enormously faster and more accurate than a person. The installed AI software allows complex calculations to be performed faster and simultaneously [3].

Computers already outperform people in some areas of object recognition, facial recognition, facial expression analysis, speech recognition, and even emotion recognition [13]. In addition, it is necessary to use AI during DNA analyses [14], as well as for social media profiles. The advantage is that AI analysis results in a large amount of complex data, provided immediately in electronic format [15]. According to Nutter [16], AI can also be used to identify fake works of art or to recognize faces of individuals, thereby identifying a person in question more effectively than traditional facial recognition software [16].

Artificial intelligence can also be used to more effectively obtain (or keep) data from criminal records, and its capabilities can be used to analyze the data [3]. There is great potential in using AI for specific criminal technology tools, including voice identification and trapping or capturing criminals.

Artificial intelligence systems are also increasingly used to commit crimes requiring high data processing. For example, a stock market "pump and dump" scam, which causes an artificial increase in the price of securities with false, misleading, or exaggerated securities trading [4].

Planning and Organization of Investigations

According to Ligeti [15], the two main internal characteristics of AI systems are their ability to:

- Collect and analyze data from the surrounding environment; and
- Take measures to achieve the special (generally defined by man) goals of the machine.

In the field of criminal analysis, Perrot [13] points out the following applicability of AI:

- To determine the geographical and temporal hot spot areas of crime;
- To define the profiles of criminals;
- To determine the likelihood of similar crimes being committed in a particular area; and
- For certain tasks, to replace a detective with a virtual agent.

Predictive Approach

Criminal forecasting is an important area for the practical application of digital applications in criminal justice. The so-called *predictive policing* (forecast-based police work) essentially involves analyzing detailed information from police files. An example of this is the approach whereby predictable patterns are available for certain types of crime (e.g., burglary). The serial criminals have recurring patterns of behavior based on a rational selection and cost-benefit analysis of victims [1].

The predictive approach is not only used in the United States. In France, for example, National Gendarmerie developed a predictive approach to criminal risk in two years, primarily in terms of serial offenses and organized crime [13].

The essence of predictive police activities is to use statistical methods to predict the commission of a crime, and even where and when the crime may be committed. It aims to prevent crime from being committed based on this forecast. Recently, the first AI-based software has appeared using predictive methods (e.g., PredPol, Precobs, HART, X-LAW, Keycrime; the last two are used by the Italian police). These are a significant step forward in the prevention of crime, but they also raise data protection issues [6].

Ligeti expresses four main concerns about predictive policing [15]:

- Whether predictive policing may be counterproductive in that the police focuses resources on these areas, meaning less energy is spent on other areas.
- Viewing non-committed criminal offenses as suspects violates fundamental human rights (and the presumption of innocence). This issue is spotlighted by the 2002 American film *Minority Report*, directed by Steven Spielberg. In addition, it may be a problem that the defense is not in a position to challenge how evidence is collected, and the use of AI-related evidence poses a risk to the principle of equality of arms [15].
- Although it is generally assumed that the computer (and thus the AI) is objective and has neutral value, Ligeti points out that the AI machines used in the administration of justice “embed existing biases and perpetuate discrimination” because AI systems work based on data entered by people.
- Finally, due to predictive policing (and justice), there is a risk that the role of law enforcement will be much more proactive than the current (mostly) reactive one, which can cause problems, e.g., in terms of transparency of the authorities [15].

Staffler and Jany highlight two main ways of predicting crime: hot spot identification and linking crime (crime linking) [1]. In *hot spot identification*, authorities use algorithms to create geographic patterns of available data that are statistically more criminal, and on this basis, they generate a real-time warning for future criminal offences. Such a hot spot system, e.g., RTM (Risk Terrain Modeling), is an algorithm that uses data from the evaluation of various crimes to facilitate the identification of factors (such as geographic locations) to provide a statistical prediction of committing drug crimes [17]. Variables/environments, such as weak or non-operating street illumination, ATMs, money changers, the proximity of parking lots and schools, night clubs, public transport stops, train stations, and main traffic intersections, are used as the basis to create a map identifing the hot spots of drug trafficking, based on which conclusions can be drawn about the commission of anticipated offences, which then significantly affects the police’s crime prevention strategy [1].

A similar system is predictive policing (PredPol), which uses an algorithm that links different criminal statistical data files (the type, place, and time of the crime) and, on this basis, the algorithm calculates the statistical probability of each area experiencing a higher proportion of crime. Such systems are used not only in the US but also in more and more places in Europe. For example, in Italy, the XLAW software is based on the repetition of crimes against property in place and in time; while in Germany and Switzerland, the use of Pre Crime Observation System (Precobs) software is based on the same offender groups [1].

Another specific way of predicting crime is *linking crime*: a comparison of past crimes with certain persons (identified or unidentified) to predict where and when the next crime will be commited. This method focuses on serial criminals [1]. In Great Britain, a Harm Assessment Risk Tool (HART) is used to classify people according to the various risks of future crime. Data such as criminal records, risk of escape, and severity of crime are used for this purpose. The purpose of the algorithm is to help the security forces decide how long the detained person should be held or when to offer bail [18]. In Italy, the Milan police developed the Keycrime software, which was based on the observation that a large number of robbers would commit the same crimes repeatedly. The characteristics of these crimes are assigned to individual perpetrators to prepare for a prediction of the place, time, and type of the future commission of the offense [19].

Areas of Uncertainty

The AI can process a very large amount of fact data and is, therefore, able to analyze the data collected quickly and accurately with much greater efficiency [4]. This requires a huge amount of data, some of which are already available — just think of the huge dataset collected daily by GAFAM (Google, Apple, Facebook, Amazon, Microsoft) and NATU (Netflix, Airbnb, Tesla, Uber) [13]. However, the main feature of AI is the ability to self-study, which results in intellectual autonomy, thereby making it difficult to predict the cause and impact of AI activities, behavior, or specific decisions [2].

Thanks to machine learning mechanisms, the AI system can learn from experience, and as a result, AI can modify its behavior, adapting to the stimuli it has received in the meantime (e.g., completely self-driving cars, Deep-Learning learning [20]). In many cases, a cloud-based information exchange can exponentially increase AI learning [4]. Fully self-driving vehicles are causing the biggest problems in that the AI system has rules in its database that only allow it to choose between two wrong decisions [5].

In the same way, there are many dangers associated with the spread of AI in everyday life. For example, the problem of online scalping, where the AI system purchases tickets for certain highly popular events within a few minutes, then lists them on a parallel market for secondary ticket sales at a much higher price, or for abusive manipulation of the market. High-frequency merchants (HFMs) can cause a sudden and very rapid fluctuation of market prices by performing thousands of operations every second, which may even have criminal aspects, e.g., illicit market manipulation [6]. Ligeti draws attention to the threat of drug trafficking, terrorist acts, and online fraud concerning AI [15]; Borsari emphasizes the use of remote drones and submarines for these crimes [4].

Artificial intellegence cannot only be the perpetrator but also the victim in criminal proceedings. Basile raises the question of whether there is a need for the establishment of specific facts related to crime against AI systems, because the current criminal law provisions are not necessarily appropriate to deal with them. According to Basile, an example of this is the performance of sexual acts with an android that was not originally designed for this purpose, but e.g., for performing reception functions in a hotel or store [6]. It has not yet been clarified whether or not an AI robot specifically designed to satisfy sexual needs can be sexually assaulted. According to Ambrus, such a crime can have a criminogenic effect in relation to sexual assaults committed against people [21].

These threats need to be addressed, but at the same time, AI can be of great help to law enforcement.

Artificial Intelligence in Risk Assessment

One of the possible uses of AI is modeling the specific profiles of criminals. The AI is capable of analyzing a sample of many elements while examining the perpetrators' movements, place of residence, work, customs, nature of their crimes, daily activities, social networks, etc. [13].

In the context of the tactics of arrests, it is necessary to refer to the idea that, for example, the capture of dangerous criminals being performed with robots, thereby providing safety for members of the police. It may have special significance in actions against highly dangerous terrorists. In this case, AI will be ordered to intercept, but cannot investigate the illegality of the detention order; however, in the event of manifest illegality, it may be possible for it to indicate this to the ordering party in the future. In this case, Hallevy considered that there was no difference between a natural person executing the decision and an AI robot [3].

Risk Assessment

Ligeti points out that AI can help find events and places [15]. As long as most of the analyses are currently carried out by humans, in the future, a significant part of it can be automated or accelerated by machine learning [22].

In the US criminal justice system, a clear tendency has been observed in all of the more frequent applications of empirical risk assessment. There are two AI-based systems used in the US, the Public Safety Assessment (PSA) [1] and the Correctional Offender Management Profiling for Alternative Sanctions (COMPAS) [15]. The PSA system compares certain risk factors for that person with a database containing more than 1.5 million cases from 300 US judicial districts. The analysis covers nine risk factors, including age, criminal record, and previous summons or complaints, but excludes geographical origin and competition as a risk factor. After the risk analysis has been carried out, the result is indicated on a six-part scale [1].

The COMPAS system is another famous risk assessment tool in the US [15]. The program aims to assess risk in judicial decision making on accommodation, monitoring, and treatment of offenders. The risk assessment (in its basic configuration) is based on a response to 137 questions on various topics, e.g., criminal record and offenses, history of violence, relationships with other criminals, drug abuse, economic difficulties, education and training difficulties, family environment, social context, leisure, life situation, social environment, and personality factors. The questionnaire is either answered by the person concerned or completed using information from the databases of the police and the public prosecutor's office. The questionnaire also contains general issues such as "Does a hungry man have the right to steal?" to which the data subject must reply with YES or NO [1].

Despite its apparent objectivity, this risk assessment includes several risks. A problem may arise mostly in connection with the fact that it is not clear to the defense what factors the risk assessment is based on, what aspects were taken into account by the AI system, and how much the risk assessment has been individualized.

Assessment of Criminal Threats

Artificial intelligence can also be used as predictive algorithms or risk assessment tools to assess a criminal threat. This may include the applicability of the coercive measure or the possibility of the conditional suspension of the sentence or probation or its exclusion. The AI can collect and process huge amounts of data and thus create a person's profile, and even predict future behaviors, including criminal aspects. Both PSA and COMPAS can be helpful, e.g., assisting the judge to decide whether to authorize conditional release or probation [6].

Section 4 of the AIDP Congress referred to, in the introduction, an examination of some international aspects of the use of AI. In this context, this refers to evidence collection (and international cooperation in this regard), international humanitarian law, and international criminal law, in particular, the use of robots in war environments. In addition, in international humanitarian law and international criminal law, the issue of autonomous weapons systems (AWS) has recently been emphasized [15].

INTERPOL defines computer crime as any computer attack against governments, businesses, or individuals. These attacks do not know either physical or virtual boundaries and can cause significant damage to the world [5]. Cross-border replacement of evidence, in particular the acceptability and use of evidence in another State, has long been a theme of international literature. New problems with digital evidence — still largely unresolved — further complicate the situation, according to Ligeti [15]. However, the computer, the digital world, and AI can also provide a lot of help to national authorities.

The *principle of legality* forces the investigating authorities to conduct a comprehensive analysis of the entire investigation, to establish or disprove initial suspicion. It is interesting to observe that while AI systems are advantageous (compared to humans) in obtaining and comparing multiple data, without the digital detective software large amounts of data are not necessarily benefitial — their reduction and narrowness are. A research project for the Ministry of Justice of North Rhine-Westphalia, the Zentral- und Ansprechstelle Cybercrime NRW (ZAC NRW) demonstrates how such investigative software can reasonably reduce data. The software, for example, supports the fight against child pornography through AI. An unimaginable amount of research material against the distribution of child pornography content on the Internet is generated. It would be almost impossible for a person to filter out the criminally relevant data among the harmless image files. Therefore, an algorithm has been developed to distinguish harmless images from child pornography. Thereafter, the detective only needs to check a reduced series of data [1].

Legal Framework

Concerning legal frameworks, Staffler and Jany [1] pointed out that in 2002 the Ministerial Committee of the Council of Europe set up the European Commission on the Effectiveness of Justice (CEPEJ) to monitor and review the quality of the legal systems of the contracting states. With recently increased use of AI in the criminal justice system, there is concern about serious risks of human rights violations. On December 4, 2018, CEPEJ published the Ethics Charter of Usage in AI's Justice Systems, according to which human rights standards and fundamental rights should be observed, in particular the European Convention on Human Rights and the Council of Europe Privacy Convention [1]. In September 2019, the Ad hoc Committee on Artificial Intelligence (CAHAI) established by the Council of Europe started its work, which provides a legal framework for the development, design, and application of artificial intelligence. In April 2018, the committee published a European strategy for "human-centred artificial intelligence"; according to the strategy, humans should be at the heart of AI development. In December 2018, the commission announced, through a coordinated AI plan, its intention to use AI in the fight against crime [1].

Summary

Artificial intelligence is a cybernetical system other than conventional computer programs capable of autonomous, conscious-willed behaviour [2]. Many people imagine that the appearance of AI systems is the remote future. However, many examples show that this is already the present. As pointed out in a previous study conducted by this author [23], since 2012, self-driving vehicles have been authorized to participate in road traffic in 41 US member states. The use of AI systems is already a reality in law enforcement activities and is expected to increase and intensify in the coming years. In some countries, AI robots are used for various tasks, such as patrol, observation, bombing, face recognition, etc. [6]. The next task will be to develop their regulatory framework.

Most AI systems have sensory receptors and these receptors transmit the data obtained to the central processing units that analyze the data. The analysis process of AI systems is therefore largely similar to human understanding. The truly advanced AI algorithms also try to mimic human cognitive processes. Hallevy pointed out that the cognitive processes of AI and humans are not different from each other [3].

There is a great deal of fear in the context of the use of AI systems. Borsari articulates that humanity has two choices ahead: based on the *precautionary principle*, not using AI machines and thereby renouncing the benefits they provide; or the *permitted risk*, analyzing a complex balance between collective benefits and the uncontrollable risks of the various systems, then gradually introducing these systems [4].

We are still far from what an autonomous AI would do, but existing AI is a sufficient challenge to criminal law. One of the most sophisticated human-like robots in existence today is Sophia, whose system already has a rudimentary form of consciousness. To develop its learning process, Sophia needs to communicate with people and is therefore considered a "human-artificial hybrid intelligence" by its creators. In one of her public interventions, Sophia herself stated that AI systems do not compete with human intelligence, but rather complement it [5]. Saudi Arabia gave Sophia citizenship, while a Tokyo municipality has recognized the permanent residence of a chatbot, Shibuya Mirai, "whose" system can communicate with the abilities and abilities of a seven-year-old child [6].

Information that is available due to physical properties in information and telecommunication networks is exposed to the greatest risk of illegal influence caused by AI, software, and critical electronic information systems [2]. It is up to us whether we withdraw from this danger, or if we use AI to make our lives better and exploit the enormous potential that we are currently seeing as the tip of the iceberg.

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