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Personal Identification Using Radiological Technology and Advanced Digital Imaging: Expectations and Challenges

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Abstract

Novel techniques for personal identification are being researched using the latest available imaging devices. These studies may assist with disaster victim identification in future mass disasters. Studies have already been conducted on the use of advanced imaging for positive identification in forensic pathology using radiographic image recognition and other identification or authentication techniques. These techniques are based on information extracted from biological fingerprints through digital radiography and other advanced imaging techniques such as CT and MRI. Although, image matching and identification in advanced digital images is still in the initial stages of development, it has shown promising results in preventing medical accidents and for identifying specific patients. These techniques may be effective for positive identification in the fields of forensic pathology, forensic odontology, and forensic anthropology.

Keywords

Personal identification • Biological fingerprints • Mass disaster • Post-Mortem Computed Tomography (PMCT) • Magnetic Resonance Imaging (MRI) • Digital radiography

Introduction

The analysis of the bones of a deceased person or from human remains has been used in the field of forensic anthropology for more than a century. It is well known that DNA analysis, fingerprints, and dental information are effective methods for providing sufficient evidence to identify deceased persons or disaster victims. Many forensic anthropologists, forensic pathologists, and scientists in radiological technology also use bone information for age estimation and sex determination [1-3]. Medical examiners/coroners, forensic pathologists, and forensic anthropologists are continually working to establish standards and systematic analysis methods for application to unknown cases and human remains [4].

One of the ways to improve forensic personal identification is to develop a rapid and reliable identification method for use by a small number of professionals on-site after an unexpected mass disaster event. In 2000, Interpol established guidelines for Disaster Victim Identification (DVI) and noted the difficulty in identifying a disaster victim by visual recognition [5]. The Scientific Working Group for Forensic Anthropology [6] and the Organization of Scientific Area Committees for Forensic Science [7] have been working together to systematize, provide best practices for, and develop a consensus standard since 2008. The Japanese government created "The Program on Promotion of Policy about Death Investigation" in June 2014 and as a result, "The Act of Promotion of Policy about Death Investigation" was legislated in April 2020. Some of the goals of this program include the utilization of scientific methods to investigate the cause of death, establish methods for dental records, and develop databases for the identification of deceased persons [8].

It is impossible to predict when the next mass disaster will occur. Insufficient preparations for future mass disasters cause delays in identifying victims. Researchers have been extensively discussing and studying for ways to coordinate with police officers and coroners before the next mass disaster occurs. This is critical, especially after events such as terrorist attacks, earthquakes, tsunamis, floods, and wildfires.

This article summarizes the challenges of personal identification and the novel technologies being developed for radiographic identification and authorization. Detailed summaries are available in a recent review which focused on radiological technology and medical physics [9]. This review aims to follow facts and opinions regarding the development of effective and useful methodologies for forensic pathology and forensic anthropology.

Situations in Medical Imaging

Since the first successful digital radiographic device, computed radiography, was developed in 1983, recent imaging technologies in medically developed countries have become fully digital [10]. This change allows us to re-evaluate various successful methodologies that have been developed in forensic anthropology and forensic pathology.

People who live in medically developed countries may have their own images in hospitals and medical centers or may bring in their own images as recorded media. However, these images are inaccessible without special permissions and may not be reused, except for retrospective studies by a limited number of researchers. Moreover, these images may be deleted after a certain retention period as determined by the country or state law in most cases, except for clinically interesting or unusual cases. Researchers must pay attention to patients' or victims' privacy. On the other hand, the guidelines for future mass disasters should be discussed and related societies and associations should coordinate actions with coroners. Well-organized digitally acquired images such as Digital Imaging and Communications in Medicine (DICOM) formatted images can be easily shared worldwide [11].

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The Need for Databases in Countries

To conduct DVI effectively after an unexpected mass disaster, researchers worldwide need various image databases. If researchers could use databases that consisted of antemortem information, positive identification would be one of the effective methods—apart from fingerprint and DNA analyses—to identify victims of mass disaster. For example, for the victims of a fire or Tsunami disaster, it is difficult to use the matching of the physique and appearance. Unfortunately, except for some local databases, open national databases do not exist due to security and ethical issues. It is also difficult to collect antemortem information from different hospitals. Currently available digital images, clinical information, and reports in hospitals or medical centers are also inaccessible due to patient privacy. Although using information from a patient's medical records is a sensitive issue, an organized digital database is needed to make it available online in the case of an emergency.

Repositioning of Head Postmortem Computed Tomography (PMCT)

PMCT scans should ideally match antemortem CT scans to determine the cause of death and compare images for identifying individuals based on anatomical information. Repositioning is required in some cases where the displacement of the anatomical position between PMCT and AMCT [12]. The frequency of use depends on the posthumous stiffness and cadaver bag. Kawazoe et al. proposed a semi-automatic repositioning method for head CT images based on an orbitomeatal line. Another possible repositioning method is based on an anthropological basal line. If the implementation of such correction and automation were realized in CT devices, it will contribute to the reproducibility of the imaging and the diagnosis of the cause of death by PMCT without affecting the deceased.

Positive Identifications using "Biological Fingerprints" in Digital Radiography

Biological fingerprints are parts of an image that provide useful information to distinguish an individual using personal characteristics. Image recognition and identification using biological fingerprints have been effective for the positive identification of filing errors in radiological technology in hospitals. In addition, it can be helpful to find lost images or similar images from a database containing many images.

Morishita et al. [13-18]. studied automated patient recognition and identification for digital chest radiographs (CXRs) based on a template matching technique of biological fingerprints on current and previous CXRs and histogram analysis of correlation values that indicate the similarity between the two CXRs. The initial study was developed to prevent accidental filing errors in environment of picture archiving and communication systems in medicine. The technique was then expanded to search for similar images in a database containing many images. This technique may replace the time-consuming task of manually finding specific images. Improved "Biological Fingerprints (BFs)" with weighting factors had an effective overall performance with up to 92.5% accuracy in identifying the same patient when top-10 similar images allowed.

Although these results are promising, there is still room for improvement in the performance of unknown cases. This technique would be one of effective methods to reduce the number of candidates for the identification of a deceased person before further detailed examination, especially in mass disasters.

Positive Identifications using "Biological Fingerprints" in Advanced Imaging

Ueda et al. [19,20]. proposed a novel technique for patient verification to confirm whether the registered patient information was correct. The study focused on positive patient verification using scout images under a routine torso Computed Tomography (CT) and brain Magnetic Resonance Imaging (MRI). CT and MRI are also useful for postmortem imaging, in addition to conventional radiography. They produce hundreds to thousands of images per examination and can reconstruct any cross sections by post-processing. The benefits of scout images as biometrics are more versatile than 3-dimensional images. Moreover, they can be automatically executed at the beginning of each examination. The use of scout images has the potential to be used for human authentication to verify or identify deceased individuals.

Therefore, these techniques are expected to extend to positive identification and postmortem imaging in the field of forensic pathology. However, in the event of a disaster, mobile CT and MRI tracks must be moved to the site of the mass disaster from other areas.

Expectations of Artificial Intelligence (AI)

AI enables precise estimation through the analysis of many selected features with incredible speed that cannot be competed with manually. AI research is rapidly being introduced in various fields; additionally, it has started to be utilized in medicine. Its potential usefulness and robustness, however, are unknown. An AI system can be designed with a mathematically suitable model for a specific subject and trained with a sufficient number of cases. It is expected that the use of AI will expand and aid forensic pathologists in the estimation of death time, cause of death, age estimation, and sex determination of a deceased individual. However, consensus and consistent agreements with experienced forensic pathologists are necessary before use.

Conclusion

In conclusion, the methods discussed in this review require further systematic studies using authorized databases with advanced digital images to improve the possibility of their use for personal identification. Moreover, these approaches can be used in combination with previously developed methods in the fields of forensic pathology, forensic anthropology, and radiographic recognition and identification techniques for personal identification in the future.

Conflict of Interest

All authors declare that they have no conflict of interest.

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