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FORENSIC MULTIDIMESNIONAL RECONSTRUCTION AS BASED ON POST-MORTEM IMAGE EXAMINATION AND SPHERICAL PHOTOGRAPHY

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Abstract:

The aim of the paper is to present the methods of creating multi-dimensional reconstructions used in modern forensic medicine and state-of-the-art autopsy technique. Making use of the computer tomography technology and sophisticated software by the forensic pathologists allows a new standard of quality to be introduced into the forensic medical examination and hitherto unprecedented effects to be obtained. These developments significantly enhance the information available to the expert, particularly in case where an incident involved the use of firearms, the presence of foreign object in the body of the deceased, or advanced decay of the corps. Furthermore, the paper touches upon a subject of attempting a spatial photographic reconstruction of the scene of incident using the techniques applied in spherical photography and commercial-off-the-shelf compute software. Irrespectively of the advancements in the forensic techniques, it is worth taking a look at the proposed changes of the forensic paradigm relative to data analysis. The novel methods expand the scope of the detection process which, in turn, can contribute to increase of crime fighting efficiency.

Keywords:

forensic medicine, crime scene photography, 3D, Virtopsy, data analysis, forensics

INTRODUCTION

From time immemorial man attempted to capture an image which would reflect reality as accurately as possible. Photography itself made its appearance in forensics as early as in 1841, which is two years after it had been patented as an original invention. It was used in the area of police photographs (booking photographs) which record the

images of criminals, where it is still being used today [6]. Constant technological progress, clearly visible in the recent years due to the wide access of the population to electronic devices, stimulated the use of digital photography, scanners and dedicated software in search of new research methods in forensic science. However, not only the photography itself has undergone significant changes in the recent time, changes which have an impact on the course of the proceedings. Also forensic medicine started to make use of the benefits of new technologies, which enabled modification of the post-mortem techniques developed as early as in 19th century by Rudolf Virchow [13]. At the beginning of the 19th century the forensic pathologists initiated the search for new solutions that would utilize the achievements in the area of radiology and x-ray diagnostics as well as the methods of data recording and analysis. The multidimensional imaging methods inspired the development of new solutions in the area of documentary photography used to record the course of procedural measures at scene of incident using the commercial-off-the-shelf computer software. Regardless of the progress in the field of forensic techniques, it is worth focusing on the development perspectives of the forensic science as a whole and on the new approach to the work of the police force and development of the information analysis methods, in particular criminal analysis and investigative analysis. The novel approach towards forensics allows for the assumption that investigations can be pursued is a more efficient manner, contributing to the increase of the detectability of criminal offences and obtaining of high quality evidence.

1. METHODS OF POST-MORTEM IMAGING ANALYSIS

Post-mortem 3-D imaging consists mainly in utilising the data collected from the surface or from within the corpse using such tools which would enable scanning of the corps via spectroscopy, photogrammetry, magnetic resonance (MRI) or computer tomography (CT) [11]. The scientists from the University of Bern working on a project entitled “Virtopsy” (from: virtual autopsy) became pioneers in this area [10].

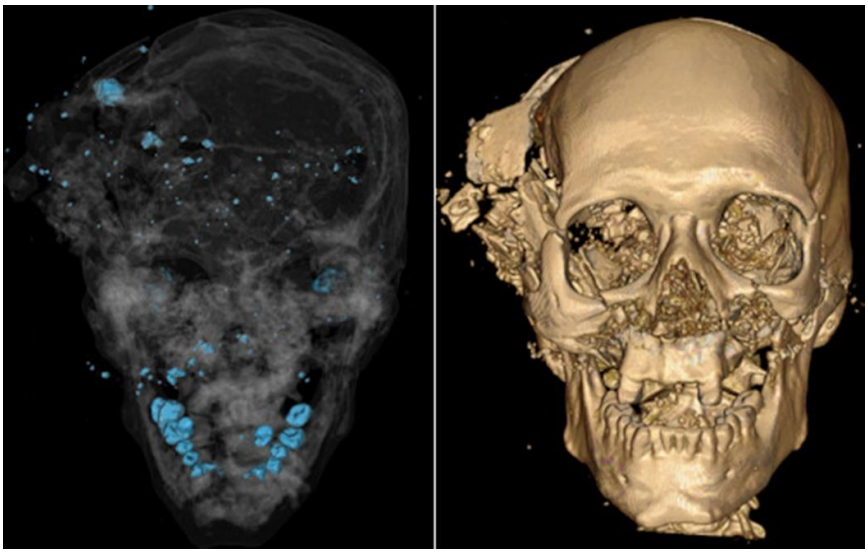

Fig. 1. Computer tomography images

Source: Lee S., Advances in forensic imaging bring new opportunities for radiology, 2013

Photogrammetry is an imaging technique which enables creation of spatial models out of two-dimensional photographs; MRI – a non-invasive method of obtaining images of the insides of the scanned objects; CT can be characterised as a non-invasive diagnostic method of obtaining either cross-sectional images (2D) or spatial images (3D). When we talk of the non-invasiveness of the tests, it is worth mentioning that this idea is true in relation to the corpses examined, however if the MRI or CT scans are used on a living organism, the radiation can have an adverse impact on the patient's health. The non-invasiveness in relation to the post-mortem examination should be narrowed and defined as a procedure which does not disturb the structure of the body, as compared with the traditional autopsy methods. The CT test itself enables spatial documentation of the injuries done to the layers (integuments) of the body; attempts at reconstructing the causes of injuries are being made, and thanks to the studies conducted and the University of Bern, results are being validated by the practice of the justice system. The method of the post-mortem CT imaging examination used increasingly frequently by the Cathedral and the Forensic Medicine Department of the Jagiellonian University's Collegium Medicum enables first and foremost precise analysis of the bone structure, its breakage, fracturing and individual traits. Furthermore, it impacts the possibility of precise characteristics of a gunshot wound passage or the possibility of specifying the area containing gasses or specifying the level of fluids in the body of the deceased (as the result of with cardiac air embolism of death by drowning), the presence of foreign objects in the tested material/evidence, analysis of the image of the corpse in the state of decay and, lastly, it facilitates analysis in cases where there are no direct grounds for a medico-legal autopsy [14]. Although undoubtedly this ground-breaking method offers a multitude of benefits providing the user with a lot of information crucial for the authorities conducting criminal preparatory proceedings, it should be remembered that it does have some drawbacks, among which is the cost of the highly-specialized equipment and software, the technical and logistic difficulties, as well as the lack of wider access to the computer tomographs for medico-legal purposes [9]. Nevertheless, it is worth noting that the research centre in Cracow has conducted over thousand examinations using this technique so far.

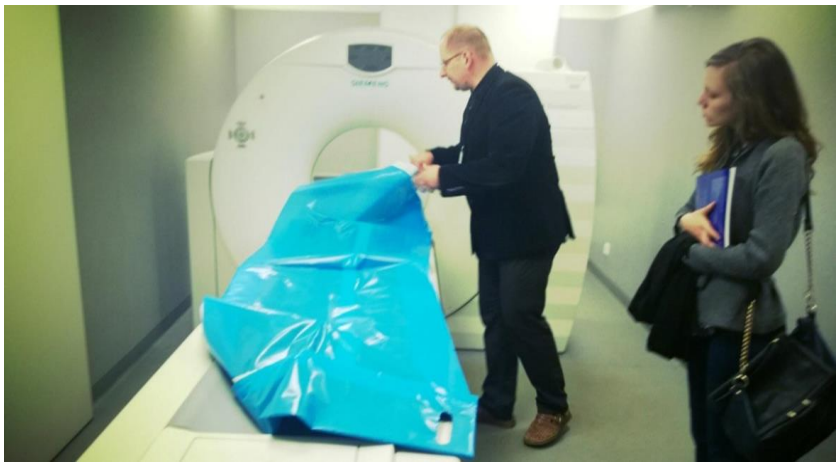

Fig. 2. Computer tomograph used in the Cracow forensic medicine centre

Source: own archives

It is also worth remembering that the use of the discussed techniques allows for the creation of a three-dimensional spatial models and the possibility of printing those models using the increasingly popular 3D printers. This suggests that in the future the typical super projection procedure used in forensic anthropology [5] up to this point will be superseded by the imaging methods described above.

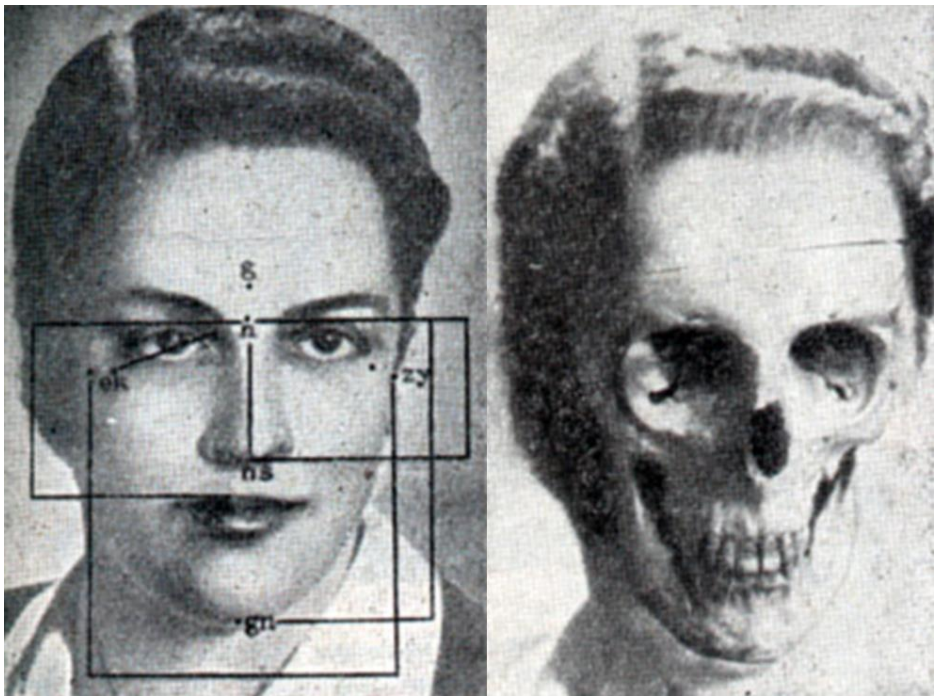

Fig. 3. Identification using the super projection method by lining up the photograph of a lost women on a photography of a discovered scull

Source: Jakliński A., Kobiela S., Medycyna sądowa. Podręcznik dla studentów medycyny, Warszawa 1975

Fig. 4. 3D print of spatially scanned human bones

Source: own archives

2. SPHERICAL PHOTOGRAPHY IN FORENSICS

Developments of modern digital photography, as well as wide access to advanced graphics processing computer software for editing of photographs allows the new solutions to be introduced to the forensic recording/capturing of the procedural measures, such as examination of the scene of incident. Pursuant to par. 143(1)(3) of the Criminal Code [12], during each examination an obligatory examination record is to be dawned up. This record is usually supplemented with technical documentation in the form of photographs, recordings or crime scene sketches which enable all the necessary information on the subject of the examination to be recorded [2].

The principle behind such panoramic photographs is relatively simple, since is it based on taking anywhere from several to a several dozen photographs around the axis of the photographer, above them (*zenith*) and under them (*nadir*) using the camera available to the forensic investigator. However, in the light of the attempts of applying 41 megapixel matrices and combining them with an advanced Zeiss optics in Nokia cell phones, taking a panoramic picture using a cell phone and Microsoft software is possible right away, although the effect is still imprecise [see more at: *www.photosynth.com*]. Using a wide-angle lens which for the same focal length could provide a much wider point of view, up to 180 degrees (the so-called *fisheye lens*), where for one panoramic photograph only 8 to 10 photographs have to be taken using a tripod.

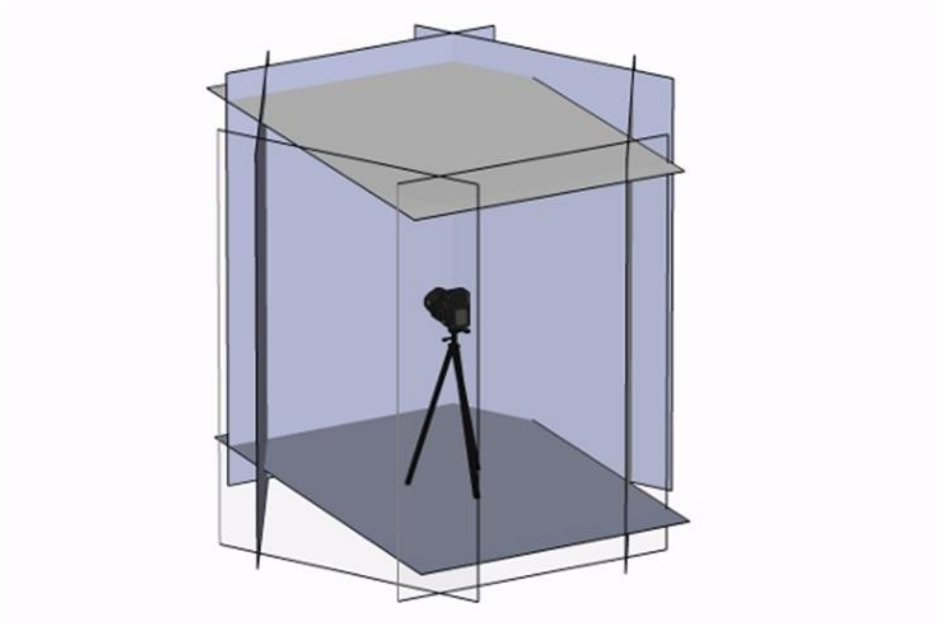

Fig. 5. Diagram of capturing frames using a Samyang 8mm f/3.5 lens

Source: www.optyczne.pl [accessed on: 15.03.2014.]

The photographs need to be edited in a special panorama editing programmes, such as *Microsoft Image Composite Editor* (free software) [see more: *http://research.microsoft.com/en-us/um/redmond/groups/ivm/ICE/*], *PanoTour* (commercial software) [see more: *http://www.kolor.com/ptp2*] or *Photosynth* (free, but available only in a digital cloud). What is an undutiful advantage of photographs made using spherical photog-

raphy technique is its application as a photograph which simultaneously presents the general-, situational- and detailed views, as it allows for free manipulation of the captured images in every direction, as well as its zooming in and out.

6) **7)** **8)**

Fig. 6, 7, 8 General, situational- and detailed views as extracted from spherical photography

Source: own archives

Spherical panoramic photography can play a significant role in crime scene documentation for example in case of traffic accidents, where the examination is conducted sector by sector, there is the need to photograph a fairly large area and mark the location of vehicles, bodies and road marks in relation to one another. It can also be used in cases, where the investigation relates to a smaller area with a lot of marks or traces and their spacing on a sketch can be problematic. Undoubtedly, faced with frequently intelligible sketches contained in case files, the ability of recreate the scene of incident in multidimensional space can signify improve the process of keeping the necessary records (documentation), and also, for example, provide an opportunity for the court to acquaint itself with the essence of a case in an accessible and readable form. That, in turn, effectuates in higher degree of impartiality in the investigation of a problem. The very form of spherical panorama is a slight impairment, as it is impossible to recreate it on paper due to its digital character. Further, while each individual photograph taken by the technician in order to create a panorama will be characterized by its own checksum which is verified when the photograph is developed and which testifies to the photograph not being tampered with, creating the panorama out of the already taken photographs *de facto* involves the generation of a new digital object, the checksum of which will not be a match to any photographs constituting the panorama. Moreover, a file exported out of the programs which create panoramas automatically should be attached to the main case files, along with its copy on a CD-ROM, memory cards or pen drives, depending on technical and financial capabilities, by the authority conducting preparatory proceedings. It should be noted here that limited file export capabilities without interfering in structure of the files are significant obstacles, as is the presence of cloud computing solutions which are incapable of providing sufficient security due to the encryption options for the access to the photographs taken being

too modest. That can preclude spherical panoramas from being considered procedural documentation [7].

It should be remembered that the copy of a digital record is made in the same format, in which the record had been made either on the primary or secondary medium, with no file splitting and with no changes whatsoever being introduced into the record recorded during the procedural step. This unilaterally points to the impossibility of introducing any changes, which would violate/disturb the integrity of primary photographs. However, it is right to say that the human factor is particularly worth paying attention to. This is mostly the forensic investigator, who could edit the evidence for the purpose of in a proper manner and in a lossless way, while respecting the principles of basic objectivity and integrity [8].

Veering away from technical matters, it is worth to take time and reflect on practical application of spherical photography in the scene of incident investigation. Using this technique is of great advantage, while documenting those scenes of incidents which involved great change in the surroundings and require detailed analyses at the stage of the process of establishing the facts, such as in sites of fire, which is illustrated below.

Fig. 9 Site of incident following fire along with an overhead view map

Source: www.vpix.net/index.php?tour=9784

It should be noted that the photography does not always correspond with visual perception of a human being [3], nonetheless it needs to be observed that improvement of image geometry allows the decision-making process to be developed further in order as a protective measure against threats and the increase of image quality may contribute to a more natural reception of visual stimuli by a human being [1].

CONCLUSIONS

Undoubtedly, galloping technological progress in each area of life poses a number of new threats but presents a spectrum of new-fangled possibilities which could be applied in the broader fight against crime. What is particularly worth pursuing, is continuation of the work connected with the use of computer tomograph during the medico-legal examinations.

We all should be glad that the Cracow forensic medicine centre is intensely moving forward with its research using the specialist equipment and software and creating modern standards of preparatory proceedings. The results obtained by the Cracow scientists manifestly testify to the fact that the path that they had selected, the path which changes the hitherto autopsy technique, should be pursued in all the other forensic medicine centres in Poland.

Similar methods of spatial imaging but used in crime scene photography have a chance to support the procedural proceedings at the scene of incident markedly. What speaks in favour of using spherical photography in forensic science, is its very low cost and the fact that it requires only basic knowledge and camera skills, which can be acquired by any police forensic investigator, as well as free access to the necessary computer software.

What is also worth noting is that the progressing computerisation forces the law enforcement authorities not only to use new, sophisticated tools in the sphere of forensics, but also impacts the methods used in investigative operations and other types of operations. One can hardly leave out here the role of forensic data analysis, including the forensic analysis and investigative analysis, in particular due to the necessity of using these analyses in countering the corruption, terrorism and operation of organised crime groups. The tools described in the paper should with all certainty be deemed as having an immensely positive impact on the preparatory proceedings, which makes them worth being popularised in the criminal procedure.

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