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Short communication

Forensic 3D surface documentation at the Institute of Forensic Medicine in Zurich – Workflow and communication pipeline

L.C. Ebert [a,*], P. Flach [a,b], W. Schweitzer [a], A. Leipner [a], S. Kottner [a], D. Gascho [a], M.J. Thali [a], R. Breitbeck [a]

[a] Institute of Forensic Medicine, University of Zurich, Zurich, Switzerland
[b] Institute of Diagnostic and Interventional Radiology, University Hospital Zurich, Zurich, Switzerland

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ABSTRACT

This educational article is an introduction for forensic pathologists to the use of structured light scanners for the documentation of bodies, living persons and objects. We discuss the general layout of the relevant parts for Virtual Autopsy at the Institute of Forensic Medicine in Zurich, the communication organization and the embedding of scanning into the general workflow. A brief introduction on the processing of compiled data for use in incident reconstruction is also provided.

1. Introduction

Medical imaging modalities, such as post-mortem computed tomography (PMCT) and post-mortem magnetic resonance imaging (PMMRI), provide detailed information on the internal anatomy and pathologies of the bodies. Therefore, these imaging modalities are a valuable tool in medico-legal investigations [1–3]. These radiological methods provide modality-specific information on anatomy, injuries and pathologies, but a forensic setting also frequently requires digital documentation of the surface topology, which may be relevant for reconstructive purposes [4]. PMCT and PMMRI lack the exact resolution to assess the morphology of small surface changes pertaining to skin injuries and other changes, such as imprinted foreign objects. PMMRI and PMCT also lack color information, which may be relevant for assessing the degree of injury severity or distinguishing between a tangential, grazed or orthogonal impact.

Modern surface documentation techniques were primarily developed for quality control in industrial settings, but these techniques may be used to provide surface scanning that is superior to radiological imaging. Surface-scanning techniques provide a three-dimensional (3D) documentation of the body surface, injuries and objects that are relevant for a case examination. The Virtopsy team currently uses a surface scanner that provides a scan resolution of up to 30 μm, which is considerably higher than the approximately 0.4 mm of standard computed tomography (CT) scanners. Most surface scanners are sufficiently mobile for direct use at incident scenes.

The surface documentation procedure at the Institute of Forensic Medicine in Zurich is embedded into a general workflow that contains several imaging modalities for virtual autopsy (Virtopsy). PMCT is routinely performed on each body admitted to the morgue, and other procedures, such as PMCT-angiography (PMCTA), PMMR, PMMRA and surface scans, are performed on case-based indications that are negotiated with the investigating state attorney.

Surface documentation of bodies is a standard procedure in Switzerland, and it complements conventional photography. Surface documentation is used to document relevant cases, and the data may be used for reconstructive purposes. Digital reconstructions of the sequence of event is rather complex and requires expertise from different fields [5]. Forensic pathologists, radiologists, radiographers, engineers and reconstruction experts of the Swiss Cantonal Police gather data independently. Finally, all evidence is combined to achieve an entire reconstruction of an incident [6,7].

* Corresponding author.
E-mail address: lars.ebert@virtopsy.com (L.C. Ebert).

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Digital data capture and subsequent event reconstructions are a new field in forensic science and forensic pathology. This educational article is an introduction to the use of structured light scanners for the surface documentation of bodies, living persons and objects for forensic pathology. The article describes the embedding of the scanning process into the standard forensic workflow at the Institute of Forensic Medicine Zurich.

2. Materials and methods

This section discusses the general layout of the relevant parts of the Institute of Forensic Medicine Zurich, the organization of the scanning workflow and communication processes and the performance of actual scans. These topics are explained for scans on bodies, living patients and small objects. Large objects and event scenes are not included in this article because these objects are scanned by the police using different techniques. Lastly, we introduce the processing of the compiled data for use in incident reconstructions.

3. Facility plan

Fig. 1 displays the floor plan of the Virtopsy and autopsy facility at the Institute of Forensic Medicine Zurich. The primary features are the short distances between the body refrigerators, the adjacent autopsy suites, and all the radiological imaging, scanning and data interpretation facilities. There are two dedicated rooms for post-mortem imaging, a CT and an MRI room. The CT room is equipped with a dual source CT scanner (Somatom Definition Flash, Siemens Medical Solutions, Forchheim, Germany) and includes the necessary provisions for PMCTA and post-mortem ventilation. It also contains the integrated Virtobot system for automatic surface scanning and PMCT-guided biopsy (Fig. 2). The MRI room contains a 3 T MRI scanner (Achieva 3.0 TX, Philips Medical System, Best, the Netherlands). The electrical sources for both scanners are connected to the University's main switches for emergencies, alarms and maintenance. Both rooms are shielded accordingly, and the entire installation was approved for post-mortem scanning by the Swiss Federal Office of Health. All captured data from the CT or MRI are stored in the Institute's PACS (Picture Archiving and Communication System) and backup systems. A reading room with access to the PACS and case database is connected to both scanner rooms. The autopsy rooms are also equipped with PACS access and ceiling-mounted screens for image access during autopsy. This setup minimizes distances and results in shorter communication pathways and a more efficient workflow, which are vital for productive interdisciplinary interactions.

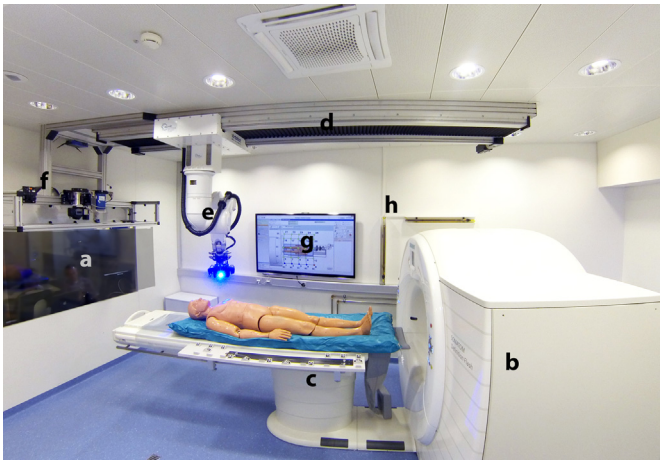

Fig. 2. CT room with Virtobot installation. a: Workstation area. b: Dual-source CT scanner. c: CT table with marker board attached to side rails. d: External rail of the Virtobot. e: 6-axis robot arm with mounted surface scanner. f: Tool stand with digital photo camera and biopsy module. g: Presentation and Observation screen. h: Safety light fence for device protection.

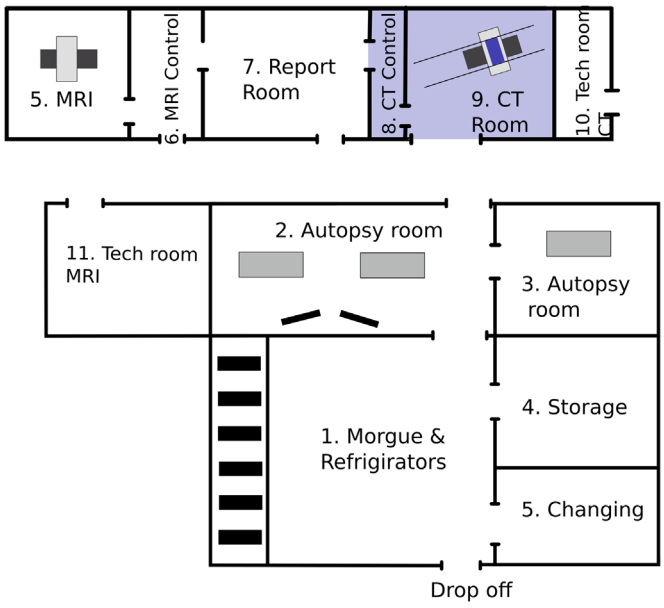

Fig. 1. Layout of the examination rooms (not true to scale). The Morgue (1) is directly connected to the autopsy rooms (2,3), as well as storage and changing facilities for the staff. Imaging facilities with automation equipment, CT and MRI (5,6,8,9) as well as the tech rooms (10,11) are easily accessible. In addition, the report room (7) is centered between the imaging rooms and equipped with different PACS workstations.

4. Workflow and communication pipeline

Proper communication and workflow definitions are crucial in complex cases where different disciplines closely collaborate. This section focuses on the interaction of the forensic pathologists who handle the case, the engineers who perform the surface documentation, the forensic pathology and radiology specialists who read the images and the radiographers who operate the CT scanner.

The forensic pathologist in charge performs an external examination of the body after delivery to the morgue if this examination was not performed at the incident scene. The radiographer performs a routine PMCT [8]. The forensic pathologist is the case manager who contacts the legal authorities and discusses the types of additional examinations that are required for the case. The case manager, in conjunction with the engineer and radiologist in charge, coordinate the case-based method recommendations. If the team concludes that additional examinations are required (e.g., surface documentation, PMCT ventilation [9], PMCTA [10–12], PMMR [13], PMMRA [12,14] or image-guided biopsy [15–18]), then further imaging modalities are discussed between the involved specialists and the case manager, who discusses the extent of the allowable and required documentation with the legal authorities in charge.

The radiographer acts as an interface between autopsy technicians, engineers, radiologists and forensic technologists and coordinates the entire imaging procedure.

A routine PMCT scan was determined to be standard procedure by the head state attorney of the Canton of Zurich and the head of