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Technical Note

Multi-camera system for 3D forensic documentation

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ABSTRACT

Three-dimensional (3D) surface documentation is well established in forensic documentation. The most common systems include laser scanners and surface scanners with optical 3D cameras. An additional documentation tool is photogrammetry. This article introduces the botscan© (botspot GmbH, Berlin, Germany) multi-camera system for the forensic markerless photogrammetric whole body 3D surface documentation of living persons in standing posture.

We used the botscan© multi-camera system to document a person in 360°. The system has a modular design and works with 64 digital single-lens reflex (DSLR) cameras. The cameras were evenly distributed in a circular chamber. We generated 3D models from the photographs using the PhotoScan© (Agisoft LLC, St. Petersburg, Russia) software.

Our results revealed that the botscan© and PhotoScan© produced 360° 3D models with detailed textures. The 3D models had very accurate geometries and could be scaled to full size with the help of scale bars.

In conclusion, this multi-camera system provided a rapid and simple method for documenting the whole body of a person to generate 3D data with Photoscan©.

1. Introduction

Three-dimensional (3D) surface documentation is well established in the field of forensic documentation. Crime scenes and corpses are scanned using laser scanners or surface scanners with optical 3D cameras, and photogrammetry is an additional documentation tool [1–6]. The 3D results provide investigators with important additional information in many cases [7–10]. Some data are used for 3D comparisons between patterned injuries and the presumed injury-causing instruments.

Even in cases with living persons, including suspects and victims, 3D documentation using 3D scanning or photogrammetry is steadily increasing [11,12]. One example application is the determination of the body stature of a suspected person for the police [12]. At our institute, we also use 3D photogrammetry to document patterned injuries during physical examinations following assaults.

Regardless of the system used, the main difficulty in documenting living persons is movement. Movement may result from respiration, bloodstream motion, shifts in position or balance control [13]. The larger the area to be documented, the greater the influence of movement on the accuracy of the documentation. In rare cases, suspects who are aware of these limitations attempt to interfere with surface scans by moving their facial muscles. Due to the above-mentioned difficulties of documenting living persons, an alternative documenting procedure is needed. This procedure should meet the following requirements: short documentation times (ms rather than s) making the measurements more robust in the presence of motion, the requirement of a low number of scans to capture the whole body, and an accuracy that is comparable to that of existing procedures.

In 2013, the company botspot (botspot GmbH, Berlin, Germany) introduced a 3D documentation system that utilizes synchronized digital multiple single-lens reflex (DSLR) cameras to document the whole body in one shot for the production of 3D prints [14].

This article introduces the botscan© multi-camera system for the forensic markerless photogrammetric whole body 3D surface documentation of living persons in standing posture.

2. Technique

2.1. Hardware

The 3D scanning system developed by the botspot company is called botscan©. The system has a modular design and consists of

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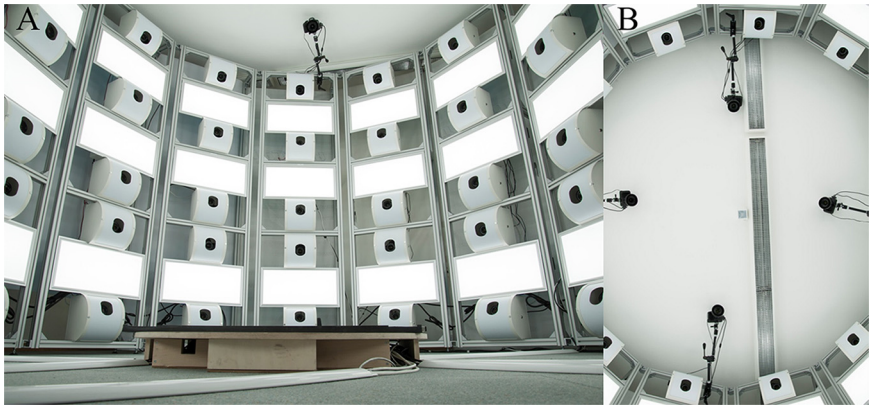

Fig. 1. View on the botscan© multi camera system. (A) Figure illustrating the seven panels of the modular chamber with the cameras and LED panels. The platform is shown in the lower middle. (B) Figure illustrating the four cameras on top of the chamber.

12 panels forming a cylindrical chamber with a diameter of 3.35 m. One of the panels serves as an entry door. A total of 64 cameras are used, with 60 cameras distributed evenly – five placed vertically on each panel - and four cameras placed on top of the chamber (Fig. 1). This setup allows for 360° recording of any object placed in the center of the cylinder. The cameras are Canon EOS 1200 Ds (Canon Inc., Tokyo, Japan) and are pointed toward the center of the chamber. Each camera is equipped with an 18–55 mm Canon Zoom Lens EF-S. For lighting, each panel has three 300 mm × 600 mm LED panel lights with color temperatures of 6000–6500 K each, with the exception of the door panel that has five LED stripes with color temperatures of 6000 K. In the middle of the chamber is a platform on which the person is positioned (Fig. 2). Additionally, the recording area is equipped with scale bars, which are necessary to generate 3D models that are true to scale. The scanning volume of the system ranges from 200 mm × 200 mm × 200 mm to a maximum of 1000 mm × 1000 mm × 2100 mm, according to the manufacturer's specifications.

All 64 cameras are connected to a workstation, and the camera release is a synchronized remote release via universal serial bus (USB). The data transmission is also provided by USB.

2.2. Software

The workstation for the camera control is equipped with the DSLR Remote Pro Multi-Camera© software (Breeze Systems Ltd., Camberley, UK). This software is used for the synchronized camera release. Additionally, the 64 recorded images are directly transferred to the software and organized in a digital folder. The output data are images in jpeg format. Furthermore, the focus settings of the cameras are set manually within the DSLR Remote Pro Multi-Camera© software with regard to the size of the object or person to be scanned [15].

The photogrammetry software PhotoScan© Professional Edition (Agisoft LLC, St. Petersburg, Russia) is used to create textured 3D models. This 3D reconstruction software automatically generates textured polygonal 3D models using the digital photographs [16]. PhotoScan© works with common image formats such as jpeg, tiff, png and bmp [17].

PhotoScan© was originally developed to process various images taken with a single camera. Therefore, the software takes into account the different camera settings for each photo. The software divides the loaded images into calibration groups according to the camera settings in the metadata and estimates the orientation and position of each camera from those settings. Images with the same metadata are placed in the same group.

The software works without markers. It uses pixel color information to detect mutual landmarks and to fuse the provided images.

The generated 3D models can be exported for further use with other 3D software solutions. PhotoScan© supports common export formats, such as stl, obj, ply and wrl. The export formats for the textures are jpeg, png, tiff and exr. Furthermore, it is possible to generate 3D PDFs with the 3D model and to export only the dense point cloud without a mesh in the txt or e57 formats.

Fig. 2. Person positioned on the platform. The markings on the platform are used for guidance to ensure a uniform procedure. Additionally, the platform is equipped with scale bars.