C14 2D/3D Imaging for Forensic Ballistics Comparison Assessment

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Learning Overview: After attending this presentation, attendees will be familiar with various comparison techniques used in the field of forensics firearm examination that are currently based on analysis of 2D and 3D imaging of cartridge cases and bullets. This presentation will attempt to standardize all the existing solutions by presenting a simple but schematic view. All the techniques will be presented, organized in various categories, and the pros and cons will be exposed considering the practical application scenarios.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by bringing attention to innovative techniques in support of forensic ballistics analysts.

The main steps of a firing process of a self-automatic gun are: loading a round of ammunition into the chamber, shooting the bullet through the barrel, and ejecting the spent cartridge case. During this process, the class and individual characteristics of the gun are transferred from the hard surface of the weapon to the softer surface of the bullets and cartridge cases as a unique fingerprint. When a firearm is used to perpetrate a crime, bullets and cartridge cases will be found in the collected evidence on the scene; it is possible to then identify both the class (make and model) and the individual weapon that was fired. Currently, the collected bullets and cartridge cases on the crime scene are analyzed using an optical comparison microscope. The main limitation of this method is that the overall forensic evaluation made by experts, in some cases, could make it difficult to report the value of the scientific findings in terms of balance, logic, robustness, and transparency.[1]

The possibility of representing cartridge cases in 2D images, topography images, or in 3D point clouds has opened up new research challenges as well as the opportunity to move from manual optical comparison techniques to more sophisticated semi-automatic digital techniques, with the aim of obtaining objective assessments.

In 2015, the National Institute of Standards and Technology (NIST) standardized the forensic ballistics comparison analysis by introducing the Congruent Matching Cells (CMC).[2] Exploiting this method, based on the principle of discretization of cartridge case images, it is possible to obtain an accurate identification process and, consequently, an estimation of the error. In late 2016, the NIST Ballistics Toolmark Research Database (NBTRD) was published as an open-access dataset containing 2D and 3D acquisitions of bullets and cartridge cases fired by different guns.[3]

The ballistic comparison based on 2D images is very sensitive to lighting conditions and, consequently, some important details for the comparisons could be lost. These anomalies do not occur if one considers a representation of cartridge cases and/or bullets as point clouds in 3D space. In this way, it is possible to reconstruct the geometrical structure of the element itself and obtain a more accurate ballistic comparison.

This presentation will show techniques based on 2D images up to those that work on 3D point clouds.

Taking advantage of 3D representations of cartridge cases, in recent years, several very useful solutions have been implemented to obtain an accurate result. Giudice presents a technique that identifies the primary keypoints in order to perform a good alignment operation between the 3D point clouds.[4] Excellent results has been obtained exploiting the neural networks as described in Giudice et al.[5] By means of Siamese Neural Network, the distance between point clouds in 3D space is calculated for classification tasks (type and gun identification). Finally, a new "immersive 3D technology" will be presented, aimed at supporting the operator during the analysis phase.

Reference(s):

1. *ENFSI Guideline for evaluative reporting in Forensic Science*. http://enfsi.eu/wp-content/uploads/2016/09/m1_guideline.pdf.
2. Song, John. Proposed "congruent matching cells (CMC)" method for ballistic identification and error rate estimation. *AFTE J* 47.3 (2015): 177-185.
3. Zheng, Xiaoyu A., Johannes A. Soons, and Robert M. Thompson. *NIST Ballistics Toolmark Research Database.* No. Forensics@ NIST 2016. 2016.
4. Giudice, Oliver. *Digital Forensics Ballistics: Reconstructing the source of an evidence exploiting multimedia data.* (2017), PhD thesis, University of Catania.
5. Oliver Giudice, Luca Guarnera, Antonino Barbaro Paratore, Giovanni Maria Farinella, Sebastiano Battiato (2019). *Siamese Ballistics Neural Network.* 26th IEEE International Conference on Image Processing (ICIP), 2019.

Firearm Recognition, 3D Data, Ballistic Comparison

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