2D/3D Imaging for Forensic Ballistics Comparison Assessment

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Learning Overview: After this presentation, the attendees will be familiar with various comparison techniques used in the field of forensics firearm examination which 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: 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, 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 an unique fingerprint. When a firearm is used to perpetrate a crime we will find, in the collected evidences on the scene, bullets and cartridge cases; it is possible then identify both the class (make and model) and the individual weapon that has fired. Nowadays, the collected bullets and cartridge cases on the crime scene are analyzed using the optical comparison microscope. The main limitation of this method is that the overall forensic evaluation made by experts, in some cases, could be difficult to report the value of the scientific findings in terms of balance, logic, robustness and transparency [1].
The possibility to represent 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 NIST has 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)[3] was published as an open-access dataset containing 2D and 3D acquisitions of bullets and cartridge cases fired by different guns.
The ballistic comparison based on 2D images are very sensitive to lighting conditions and consequently some important details for the comparisons could be lost.
These anomalies do not occur if we consider 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.
We will present techniques based on 2D images up to those that works 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. The PhD thesis of Giudice [4] presents a technique that identifies the primary keypoints in order to perform a good alignment operation between the 3D point clouds. 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 aiming to support the operator during the analysis phase.

Key Words: Firearm recognition, 3D Data, Ballistic comparison

Reference(s):

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[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.