B142 Automatic Groove Identification in 3D Bullet Land Scans Using Statistical Models

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Learning Overview: After attending this presentation, attendees will understand the principles behind some of the data preprocessing steps in bullet matching algorithms. Attendees will also see how the implementation of statistical models in the data preprocessing steps lead to increased matching accuracy in the overall matching algorithm.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by increasing the accuracy and reliability of automated bullet matching algorithms.

Automated comparison of bullet marks is an important area of current research. Success in devising such a procedure will result in robust tools and reproducible analyses for quantifying the strength of matching evidence between bullets. Recent work by Hare, Hofmann, and Carriquiry utilizing data generated from high-resolution 3D scans of bullet lands has shown promising results towards this goal.[1] In this work, the authors demonstrated the utility of statistical learning techniques for automatically comparing bullet marks and probabilistically quantifying the strength of matches between bullets. Steps involved in the preprocessing of the data are known to be integral to the success of the overall algorithm. One such step in the procedure requires identifying and removing data from the groove engraved area of the scan. Automation of the groove identification process is necessary for an end-to-end bullet matching algorithm, and while significant progress has been made towards reliable automatic groove identification, aspects of this procedure leave open the possibility that either more data are removed than is necessary, or the groove engraved area is not entirely removed. In either case, a loss of accuracy is expected. In pursuit of a more principled approach to identifying groove locations in these scans, the authors propose the use of a specific type of statistical model which combines ideas from statistical nonparametric function estimation and changepoint analysis to estimate the number and location of grooves in a 3D bullet land scan in a statistically rigorous way. Changepoint analyses have classically been used on processes changing over time to detect when some aspect of that process has changed. Examples of such applications are often found in finance, where the goal might be to detect a meaningful or anomalous fluctuation in the stock of a given company and when such a fluctuation occurred. The model results in a likelihood which is piecewise constant as a function of the changepoints, rendering maximum likelihood estimation infeasible. Thus, the authors opt for a Bayesian approach and estimate the groove locations via Markov chain Monte Carlo methods.

The authors will demonstrate the effectiveness of the proposed method on actual bullet land scans and compare the results to the current methods of groove identification. They also will explain how their procedure might be improved upon further.

Reference(s):

1. Hare, Eric, Heike Hofmann, and Alicia Carriquiry. 2017. “Automatic Matching of Bullet Land Impressions”. *The Annals of Applied Statistics* 11, no. 4 (December):2332–2356.

Groove, Identification, Bullets