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AN INTELLIGENT IMAGING APPROACH TO THE IDENTIFICATION OF FORENSIC BALLISTICS SPECIMENS

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Abstract: The characteristic markings on the cartridge and projectile of a bullet fired from a gun can be recognised as a "fingerprint" for identification of the firearm. Over thirty different features within these markings can be distinguished, which in combination produce a "fingerprint" for identification of a firearm. The analyses of marks on cartridge cases and projectiles, such as calibre, firing pin location and shape, numbers and widths of land marks and groove marks, and the direction and angle of twist of the marks, provide a precise tool for identifying the class of firearm from which a bullet was discharged.

The intelligent imaging of these class characteristics of ballistics specimens will provide the potential to identify the make and model of the firearm. Precise measurement of features on ballistics cartridge cases and projectiles allow ballistics metrics to be obtained for the identification of the weapon. The precise measurement of these features through imaging analyses will allow discrimination between the properties of the class characteristics to identify the types of weapons.

This paper will describe progress in the development of a multi-dimensional cluster analysis model for forensic ballistics specimens to identify the type of weapons that produced these ballistics specimens through intelligent imaging. The cluster analysis will provide classification that is based on scalar shape and measurement parameters for the three-dimensional features of class characteristics. The selection of appropriate class characteristics for cartridge and projectile can be mapped in N-dimensional space to provide clustering for particular weapon types. By mapping the crime scene specimen to the multi-dimensional ballistics data, the possibility of a match for identification can be achieved.

INTRODUCTION

The identification of firearms from forensic ballistics specimens requires the gathering of physical evidence in the form of toolmarks. Where tools are used in the commission of a crime, the determination of the characteristics of the tool provides a link to the suspect and the scene of the crime. The identification of the tool used in the crime is based on depressions, scratches and markings on the specimen that have been produced by the suspect tool. The combination of these various marks contribute to the *toolmark* and it is thought that every instrument can impart a mark that is unique to itself. That is, every tool applied to a surface will imprint a unique mark that has the potential to be identified [1].

Nichols [2] reported the classification by Churchman [3] for the types of characteristics of toolmarks on ballistics specimens. These types of classifications of markings on

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cartridge cases and projectiles are currently applied to forensic ballistics investigations. Churchman proposed three major categories of characteristics for examination:

- "C" type characteristics were defined as *class* characteristics.
- "A" type characteristics were defined as accidental characteristics, which are individual characteristics.
- "B" type characteristics were defined as bro ach series characteristics, with B1 and B2 sub-classes that occur on the edges of land impressions.

The investigation of class characteristics will reduce the range of suspect models of firearms and will identify those makes of weapons that exhibit the class characteristics [4,5,6]. Minute individual differences in each firearm (generally through the manufacturing process) will impose a toolmark on the ballistics specimens that can directly link the specimen to the firearm. Examples of class characteristics of projectiles include such properties as the width of land impressions, the rate of twist of land impressions, and the width of firing pin impressions [7].

This project has considered the extent of class characteristics of cartridge cases and projects with the view that multi-dimension analyses of these characteristics will contribute to the ability to rapidly identify a particular crime-scene ballistics specimen with the appropriate test specimen through matching of class characteristics.

METHODOLOGY

The application of intelligent imaging to the recognition and measurement of class characteristics features of ballistics specimens allows the development of metrics to discriminate between similar features. A selection of the metrics provides the data for possible identification of the firearm that produced the ballistics specimens.

The selection of appropriate class characteristics for cartridge and projectile can be mapped in N-dimensional space to provide clustering for particular weapon types. The approach taken by this investigation was to identify the class characteristics for both cartridge cases and projectiles, as features of the ballistics specimens that are common in the manufacturing of ammunition.

Class Characteristics

The class characteristics for fired cartridge cases have the following features both from the manufacturing process and the firing of the weapon; for example calibre, location and shape of firing pin, position of extractor and ejector marks, shape and dimensions of cartridge case, and properties of cannalure marks. Similarly, the class characteristics for projectiles from fired ammunition have the following features; for example calibre, angle and direction of twist of lands and grooves, numbers and widths of land marks and groove marks, and properties of cannalures.

The collective analyses through imaging metrics of the class characteristics of cartridge cases and projectiles assists in the identification of the model(s) of firearm that may have produced the forensic ballistics specimen.

Ballistics Metric Data

Fourteen common types of cartridges and projectiles were optically examined and measured for the class characteristics for cartridge cases of calibre, firing pin impression, firing pin shape, extractor mark, ejector mark, bolt/breach mark, length of cartridge case, cartridge case neck diameter, cartridge case shoulder diameter, cartridge case base diameter, and cartridge case rim diameter. Again, the class characteristics of projectiles for these analyses were selected from calibre, direction of twist, land and groove count, land mark width, and groove mark width. These class characteristics have been chosen as optically measurable parameters of ballistics specimens through intelligent imaging for discrimination between weapons and ammunition.

3-D PLOTS OF N-DIMENSIONAL DATA

Eleven class characteristics for cartridge cases were selected to provide multidimensional space for the plotting of individual types of ammunition for identification. That is, the fourteen cartridge cases that were selected can be plotted in 11-D space to provide spatial discrimination between these specimens. The Figure 1 shows the 3-D discrimination between the fourteen cartridge cases for the three variables of *calibre*, *firing pin shape*, and *length of cartridge case*.

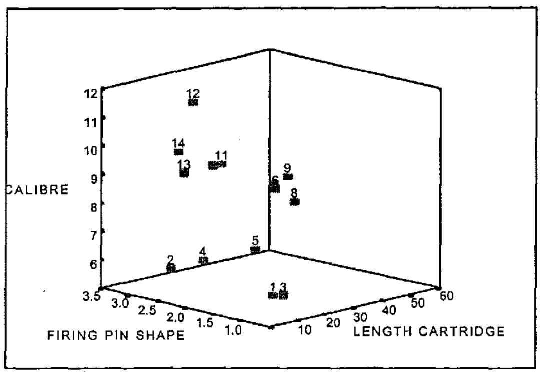

Figure 1: 3-D spatial distribution of calibre, firing pin shape and length of cartridge case for the fourteen cartridge cases. [**1** = .22 short, **2** = .22 long, **3** = .22 long rifle, **4** = .22 Magnum, **5** = .223 Remington, **6** = .30-.30 Winchester, **7** = .308 Winchester, **8** = 7.62 x 39 mm, **9** = .303 British, **10** = .38 Special, **11** = .357 Magnum, **12** = .45 Automatic, **13** = 9 mm Luger, **14** = .380 Automatic]

The Figure 1 shows discrimination between most of the selected cartridge cases, so that a comparison of an unknown with the database of all registered cartridge cases (approximately 14,000 cartridge cases) will produce best matches for further examination.

Further discrimination between the fourteen cartridge cases can be achieved by examining another set of three variables. The Figure 2 shows the 3-D discrimination between the fourteen cartridge cases for the three variables of *neck diameter, base diameter,* and *rim diameter.*

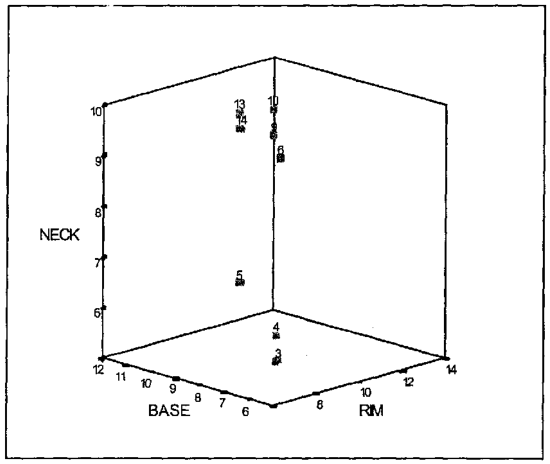

Figure 2: Profile of cartridge cases through 3-D spatial distribution of diameters of the neck, base and rim of specimens.

Again, discrimination between most specimens can be observed with the three selected variables shown in Figure 2. By selecting appropriate ballistics variables for cartridge cases, police ballisticians can readily discriminate between specimens and then identify the type of cartridge case under examination.

Similarly, the five class characteristics for projectiles were selected to provide multidimensional space for the plotting of individual makes of ammunition for identification. Again, the fourteen chosen projectiles can be plotted in 5-D space to provide discrimination between these specimens. The Figure 3 shows the 3-D discrimination between the fourteen projectiles for the three variables of *calibre, direction of twist*, and *number of lands and grooves*.

Reasonably satisfactory discrimination has been achieved for the projectiles in the Figure 3 with most projectiles showing some uniqueness to permit identification. Again, the Figure 4 shows another set of three variables for discrimination between these fourteen selected projectiles. The variables of *calibre, land mark width*, and *groove mark width* have been chosen to enhance the differences between specimens.

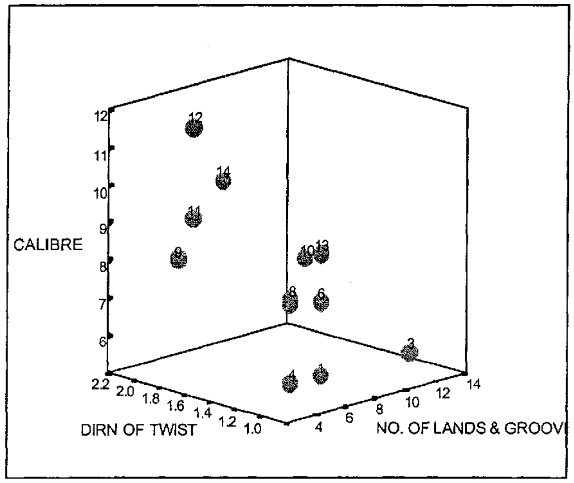

Figure 3: 3-D spatial distribution of calibre, direction of twist, and the number of lands and grooves of fourteen projectiles.

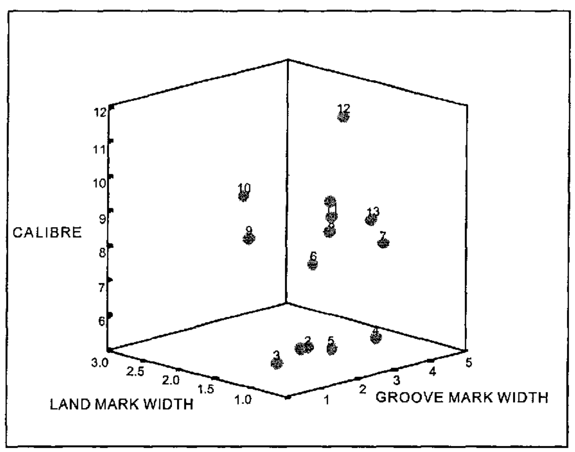

Figure 4: 3-D spatial distribution of calibre, land mark width, and groove mark width for fourteen projectiles.

Other sets of 3-D variables can be extracted from the class characteristics data and plotted to produce discrimination between specimens. The optimum set of 3-D variables will be dependent upon the measures of the ballistics specimens under discrimination.

INTERPRETATION

The mapping of appropriate class characteristics for cartridge and projectile can be achieved by measurement of the parameters for particular weapon types. However, a given weapon type firing a particular ammunition type will still produce small variations in some of the class characteristics. Accurate measurement of these class characteristics will provide a narrow range of measurements for some class characteristics such as calibre, length of cartridge case, positions of extractor mark and ejector mark, diameter of neck of cartridge case, land mark width, and groove mark width. When a large number of these *identical* ballistics specimens of cartridge cases and projectiles are accurately measured for class characteristics, the data will plot as clusters in n-dimensional space rather than as point locations. Thus 3-D variables can be selected to best discriminate between the class characteristics of ballistics specimens.

The accurate measurements of the class characteristics of ballistics specimens can be achieved with automated imaging techniques to recognise particular features and dimensions of ballistics specimens. The discrimination analysis of these features can allow comparison to data tables for identification. Three-dimensional spatial representations of these data can assist the practicing police ballisticians to optimise the variables for identification.

By introducing an unknown ballistics specimen into the class characteristics data, it will be possible to match or align the unknown specimen with n-dimensional variables for known class characteristics. The unknown cartridge cases and projectiles should plot into the clusters of known class characteristics for weapons and ammunition. This matching process provides a tool for crime scene examiners and ballisticians to rapidly determine the type of firearm and ammunition involved in the incident. Thus, by mapping the crime scene specimen to the multi-dimensional ballistics data, it will be possible to provide a rapid analysis of the involvement of the firearm.

CONCLUSION

The n-dimensional class characteristics of cartridge cases and projectiles have the potential to positively identify firearm types and ammunition types through matching of unknowns to clusters of known specimens through comparisons of class characteristics. The capacity to provide precise measurements of class characteristics will determine the ability to discriminate between similar weapons and ammunition. This investigation proposes that the measurement of class characteristics through optical imaging techniques with pattern recognition can greater reduce the analytical effort needed for identification of firearms associated with ballistics specimens.

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