F30 Evaluation of Affine Methods in Bitemark Analysis: Why Mathematical Models of Distortion Correction Should Be Used With Caution

H. David Sheets, PhD, Canisius College, Department of Physics, 2001 Main Street, Buffalo, NY 14208; Peter J. Bush, BS, Laboratory for Forensic Odontology Research, School of Dental Medicine, SUNY at Buffalo, B1 Squire Hall, South Campus, Buffalo, NY 14214; and Mary A. Bush, DDS, SUNY at Buffalo, B1 Squire Hall, 3435 Main Street, Buffalo, NY 14214*

This goal of this presentation is to describe a range of Affine mathematical methods and demonstrate how these methods relate to bitemark analysis.

This presentation will impact the forensic science community by providing an understanding of the limitations of mathematical distortion correction of a digital image of a bite mark, as well as a method for comparing the quality of the attempted distortion correction.

The biomechanical properties of human skin allow for a wide range of distortions in a bitemark. This deformation may be varied within the bite itself, so that distortion is not uniform across an image. The largest factor responsible for localized distortion is the anisotropic nature of the tissue. Since skin is anisotropic, the tissue possesses varying degrees of tightness. This will cause the non-uniform degree of distortion typically seen within the bitemark.

Attempts have been made to try to describe and quantify this distortion mathematically in anticipation of scientifically matching a dentition to a bitemark. Affine transformations have been suggested as a possible method to achieve this goal. However, if skin is anisotropic, affine transformations may not be an entirely effective method of analysis and subsequent correction of the distortion. A range of affine methods are examined as well as approaches to quantifying attempts at removing distortion.

The set of affine transformations of a plane (2D) image are all the deformations of that shape that leave initially parallel lines parallel after the deformation. There are six possible affine transformations (vertical, horizontal, rotation, scaling, stretching, and shearing). A study of the effects of using three distinct combinations of affine approaches (fixed scale, variable scale, and full affine) to match dentitions to bitemarks was undertaken.

Human subject review exemption was granted for all phases of this project. Thirty-six bitemarks were inflicted on unembalmed cadavers. The bites were created with a set of epoxy resin dental models that were mounted onto a hand held vice grip. All 36 bites were made with this single dentition.

The bites were photographed with a #2 ABFO scale in place. The set of dental models that inflicted the bites were scanned on a flat bed scanner at 300 dpi, also with a #2 ABFO scale in place. Using freeware, landmarks were placed on the resultant digitized bite images (300 dpi) as well as that of the dentition.

The following criterion for matching a dentition to a bitemark was adopted. If the Euclidean distance D between dentition and the bitemark is greater than twice the RMS scatter value for repeated measures of the bitemark after an affine matching procedure, then the difference between the bitemark and the dentition could not be reasonably attributed to chance (with a p-value of roughly 5%), and the two do not match. If the dentition is within twice the RMS scatter, than the difference may be attributed to measurement error, and the two are a match.

The digitized results of the thirty six bitemarks were then compared to the digitized dentition that created the marks, to determine if affine transformations could explain the distortion in the bitemarks on skin.

Results showed that high levels of distortion in the bitemarks were not attributable to affine deformations or measurement error, suggesting that non-uniform anisotropic properties of skin mostly contribute to the distortion seen, thus concluding that bitemark distortion cannot be corrected by using affine transformations.

Bitemarks, Bitemark Research, Affine Transformations

 ** Presenting Author*