BITE MARK ANALYSIS AND COMPARISON USING IMAGE PERCEPTION TECHNOLOGY

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ABSTRACT

To analyse and compare a bite mark left on human skin with a suspect's dentition is a difficult procedure. The assumption that the human dentition is unique plays an important role in this process. However it is near impossible to prove that a particular bite mark was produced by a specific dentition. Key elements to analyse a bite mark are the amount of detail available in the information about the bite mark and the suspected biter's dentition. Both are of vital importance to the investigating forensic odontologist. In this article a new method of analysing bite marks using image perception technology is described. With this technology it is possible to artificially colour areas with equal intensity values and depict a 2-D image as a pseudo-3-D surface object. The use of image perception technology may allow visualization of a degree of detail unavailable with any other method.

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Key words: Bite marks, comparison overlays,forensic science, forensic odontology, image perception technology

INTRODUCTION

Bite mark analysis and comparison is a complicated matter. The standard techniques for examining bite marks are based upon interpreting photographic evidence in which a bite is compared with the models of the teeth of suspects.[1] The quality and angle of the bite mark photographs and the precision of the impression of the suspect's dentition is of extreme importance to the forensic odontologist. Rawson investigated the uniqueness of the human dentition mathematically using a precise method of measurement.[2] The uniqueness of a bite mark, however, is not such a clear-cut issue. Human skin is a very poor bite registration material.[3] Bite marks may disclose individual tooth imprints. They may appear as a double arched pattern, or even a homogeneous bruise.[4] Bite marks can be distorted by the elastic properties of the skin tissue or by the anatomic location. Also the pressure of the bite and the angle of the maxilla and mandible can change the appearance of a bite mark. The position of the body at the time the bite was inflicted may also play a part.[5]

The process of comparing bite marks with a suspect's dentition includes analysis and measurement of size, shape and position of the individual teeth.[6] Most comparison methods involve the fabrication of overlays.[7] There are a number of different ways to produce overlays from a suspect's dentition: hand-tracing from dental study casts,[8] hand-tracing from wax impressions,[8] hand-tracing from xerographic images,[9] the radiopaque wax impression method[10] and the computer-based method.[11] Sweet and Bowers studied the accuracy of these bite mark overlay production methods and concluded that the computer-generated overlays provided the most accurate and reproducible exemplars.

This article describes a new method of comparing and analysing photographs of bite marks with overlays of a suspected biter's dentition using image perception software.

MATERIALS AND METHODS

The computer hardware used with this research includes an Intel® Pentium CPU PC running at 3.06 GHz, with 1.00 Gb RAM,* Microsoft® Windows® XP home edition operating system,** a 15 inch colour monitor,† an HP PSC 1350 Printer‡ and an Epson Expression 1680 Pro flatbed scanner.§

Photographs of bite marks were resized to 1:1 scale using Photoshop® of Adobe Systems.®§§ Dental study casts were scanned using the flatbed scanner. Hollow and compound overlays were produced from

* Fujitsu, Siemens Computers, Munich, Germany
** Microsoft Corp., Redmond, USA
† Fujitsu, Siemens Computers, Munich, Germany
‡ Hewlett-Packard Company, Palo, Alto, USA
§ Seiko Epson Corporation, Tokyo, Japan
§§ Adobe Systems Inc, San Jose, USA

these casts. The methods used for both procedures are described by Bowers and Johansen.[12] The life-size photographs were imported into the image perception program¶ and processed. With image perception software, it is possible to make 256 different greyscale values visible by rendering intensity information as surface height by mapping individual pixel intensities to the z-axis. Areas of equal luminance can also be artificially coloured to enhance the image information that facilitates the recognition of the individual tooth impressions in the bite mark area and thus improving diagnostic procedures.

Image perception software procedure

A photograph of a bite mark is opened with the image perception software, and a region of interest is then selected (Fig.1). After such selection, one can add colour to different greyscale areas of the image. The assigning of selected colours to levels of grey values enables the forensic odontologist to select regions with similar grey values or to enhance subtle differences of grey values in the picture. The human eye can only distinguish about 40 shades of grey in a monochrome image, but can distinguish hundreds of different colours.[13] This will make it easier to establish which regions of pixel intensity are part of the bite mark and which are not. By omitting certain areas of pixel intensity, it is possible to isolate the region of the image which shows the bite mark.

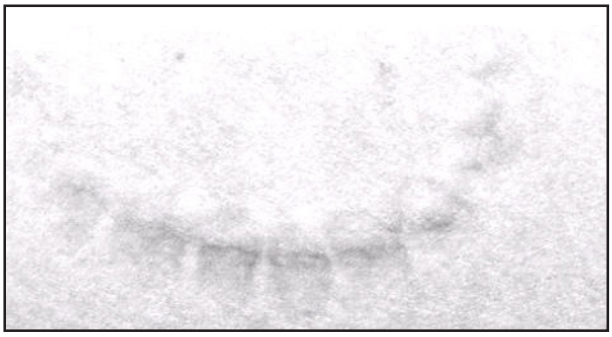

Fig.1: *Selected region of interest from original photograph*

A detailed image of the bite mark is produced (Fig.2) and the resolution of the image is then altered to be compatible with the resolution of the original photograph. Most bite mark images are scanned at 300dpi. Part of the ABFO No.2¶¶ scale has to be visible to accommodate the placement of the image over the original photograph with 100% exactitude.[14] The coloured image of the bite mark is now layered over the original bite mark photograph using Photoshop® of Adobe Systems®§§ (Fig.3).

The opacity of individual layers can be increased or decreased according to the requirements of the forensic odontologist. The enhanced image can now be used to accommodate an overlay of the suspected biter's dentition. Both hollow and compound overlays can be used, depending on the amount of incisal detail. With this improved degree of information it is not uncommon to distinguish aspects previously invisible (Figs.4A and 4B).

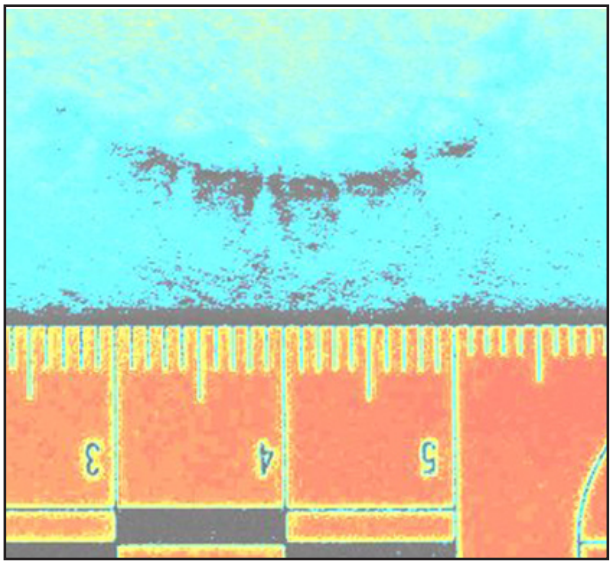

Fig.2: *Image artificially coloured with image perception technology software*

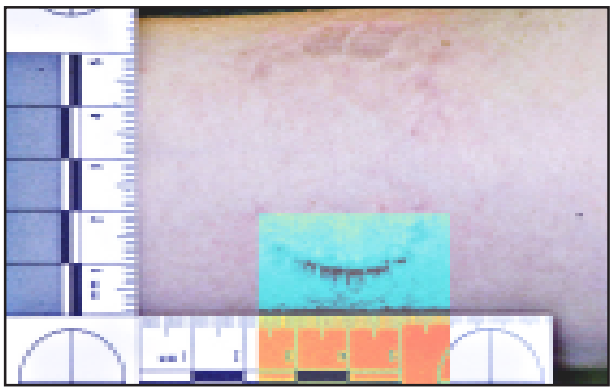

Fig.3: *Coloured image with visible incisal detail layered over original photograph*

¶ ForensicIQ, LumenIQ Inc., Bellingham, USA
¶¶ Lightning Powder Co. Inc. Jacksonville, USA

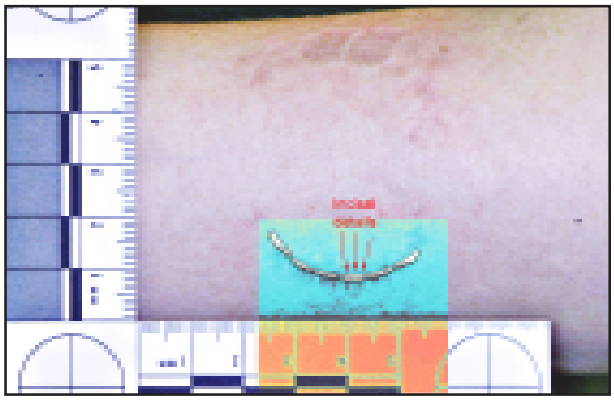

Fig.4A: *Overlay comparison*

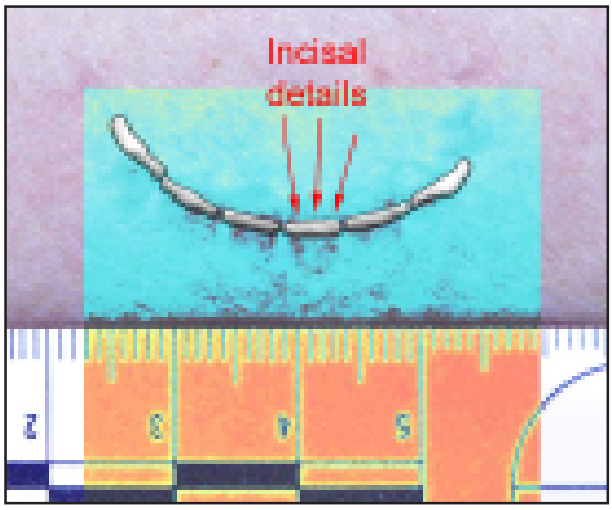

Fig.4B: *Corresponding incisal detail in bite mark photograph and compound overlay*

With image perception software it is also possible to depict a 2-D picture as a 3-D surface object. Different pixel intensities are converted to different surface heights, yielding additional information contained in 256 intensity values ranging from black (intensity=0) to white (intensity=256). The scale of the z-axis can be adjusted to create the best possible pseudo 3-D view. These 3-D images can be freely moved, rotated, or zoomed to any specific region of interest.

The forensic odontologist is now able to combine the information from conventional analysis and pseudo 3-D images to investigate the bite mark and attempt to establish its origin with a higher degree of certainty than would be possible using other methods (Fig.5).

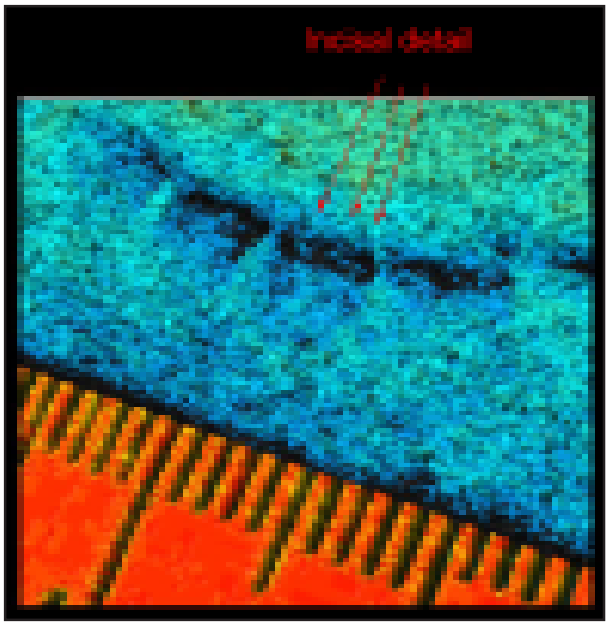

Fig.5: *Pseudo 3-D image with visible bite mark detail*

DISCUSSION

Human bite mark analysis is by far the most demanding and complicated part of forensic dentistry. There is no dependable way of stating that one or more tooth marks seen in a wound are irrefutably unique to just one person in the population.[15] Bite mark distortion through skin elasticity, anatomical location and body positioning is a recurring problem. With the recent developments regarding expert testimony, the need for accurate, reliable, reproducible and above all objective methods for bite mark analysis and comparison has never been greater. Although more research is needed to explore the possibilities of image perception technology, its possibilities to visualise more details in a bite mark photograph are promising. The availability of additional colouring of selected areas with similar intensity values as well as rendering 2-D photographs as pseudo 3-D images may enable the researcher to analyse the image more extensively and come to a more accurate conclusion regarding the source of the bite. However, bite mark analysis alone should not be allowed to lead to a guilty verdict, but it will offer the opportunity to exclude a suspect from a crime when the data do not correspond.

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