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Accuracy of Bite Mark Overlays Made by Photo Superimposition in Forensics Using a Reconstructed Model of Human Being

[1]Arash Ghodousi, [2]Parastoo Afghari, [3]Mohammad Borhani
[1]Department of Forensic Medicine, Islamic Azad University,
Isfahan (Khorasgan) Branch, Isfahan, Iran
[2]Department of Oral and Maxillofacial, Young Researcher Elite Clube,
Islamic Azad University, Isfahan (Khorasgan) Branch, Isfahan, Iran
[3]Dental School, Islamic Azad University, Isfahan (Khorasgan) Branch, Isfahan, Iran

Abstract: This research aims at finding a more efficient method using computerized image superimposition with MATLAB Software in identification of bite-marks on a reconstructed model of human being. Total 34 participants were used as the sample of the study. Their bite-marks on the wax were photographed and the impressions of their upper jaws were made. Then an algorithm was designed obtaining 33 characteristics from each sample using MATLAB neural network tool box. To match the waxes and the impressions MATLAB artificial neural network tool box were used and the results were reported accordingly. Of the 34 sample impressions fed in the artificial neural network, the system could match 94% (32) cases properly with the bitten waxes. Based on the obtained results, the efficiency of photo superimposition made with MATLAB was shown.

Key words: Superimposition, identification, MATLAB Software, forensic, Iran

INTRODUCTION

Forensic dentistry involves dental and legal issues which are outlined in identification based on bite-marks. Human being dentition is unique to each person as are fingerprints. Each individual has a set of 32 teeth, some of which might have been deformed or missed. Environmental factors such as nutrition and drugs might have certain manifestations on tooth. Moreover, each race has certain appearance characteristics in dentition. Also, some interventions such as dental restorations reinforce its specialty. Accordingly, tooth is one of the most durable parts of the body compared to other parts which is more resistant to deterioration (Nedhi and Prem, 2014; Franco *et al*., 2015).

Bite marks can be detected on the skin of a victim or on other objects at crime scene. Bite marks analysis has been utilized as an efficient tool in forensic research for many years and the 1st records go back to 1870 in the United States (Pierce *et al*., 1990).

Many different methods have been suggested for the analysis of the bite-marks on the scene of crime. These include computer-based, radiographic, xerographic and hand-traced methods. The details of the accessible data about bite-marks and dental records are critical in forensic dentistry investigation as comparative studies done using different methods indicate (Nedhi and Prem, 2014; Sweet and Bowers, 1998). Thus, the less intervention of human being in these types of investigations, the higher will be the accuracy of the data and the less probability of making errors (Van der Velden *et al*., 2006).

MATLAB is Software commercially named after Mathworks, Inc. USA. This software is a programming system which contains specific tool boxes. MATLAB is gaining ground in all fields of sciences and engineering. Based on the achievements made so far one can anticipate that his complex software can be helpfully utilized in forensic issues, too (Tutuncuc *et al*., 2008).

As the general view of the most odontologists is that many of the outcomes of bite-marks in violent crimes are ignored and this matter is reflected in the reported statistics in different parts of the United States (Pretty, 2003) in the present study, attempt was made to test the accuracy of the MATLAB Software used for identification via dental characteristics.

MATERIALS AND METHODS

The present analytical research was conducted on 34 participants (17 males and 17 females) who had no dental anomaly or tooth loss. The participants' age ranged between 25-45 and they were all Iranians. Following the

Corresponding Author: Parastoo Afghari, Department of Oral and Maxillofacial, Young Researcher Elite Clube,
Islamic Azad University, Isfahan (Khorasgan) Branch, Isfahan, Iran

necessary instructions to the participants, they bit wax in similar positions. Then the upper jaw was photographed in such a way that the teeth between the right canine to the left one could be clearly seen.

The impressions of the jaw were taken using alginate and then poured with plaster. Following this, the cast was photographed with high resolution so that the teeth cusps could be clearly seen. The images were fed into MATLAB Software and saved for further processing. The transferred images were in RGB format. Before any processing, the images were changed to binary format. Using some of the MATLAB instructions, 33 characteristics of each wax and impression were extracted as in the following. In order to measure each characteristic, the obtained measures were placated in the relevant formulae and the scaled were obtained.

- 1: Distance between the center of the first and the sixth tooth
- 2-15: Angle between line connecting the center of the 1st and the 6th teeth and the line connecting the center of each tooth to the other five teeth
- 16: The features of the 6th anterior tooth are fed into the curve fitting tool and a parabolic curve is extracted whose concavity is indexed as the 16th characteristic
- 17-20: Distance of the center of the 2nd-5th tooth to the connecting line of the 1st and the 6th teeth
- 21-24: Distance between the center of the 6th teeth to image of the center of the 2nd-5th teeth both on the line connecting 1st to 6th teeth
- 25: Distance between the center of the 2nd tooth to image of the center of the third tooth both on the line connecting 1st-6th teeth
- 26: Distance between the center of the 2nd tooth to image of the center of the 4th tooth both on the line connecting 1st-6th teeth
- 27: Distance between the center of the 2nd tooth to image of the center of the 5th tooth both on the line connecting 1st-6th teeth
- 28: Distance between the center of the 2nd tooth to image of the center of the 6th tooth both on the line connecting 1st-6th teeth
- 29: Distance between the center of the 3rd tooth to image of the center of the 4th tooth both on the line connecting 1st-6th teeth
- 30: Distance between the center of the 3rd tooth to image of the center of the 5th tooth both on the line connecting 1st-6th teeth
- 31: Distance between the center of the 3rd tooth to image of the center of the 6th tooth both on the line connecting 1st-6th teeth
- 32: Distance between the center of the 4rth tooth to image of the center of the 5th tooth both on the line connecting 1st-6th teeth
- 33: Distance between the center of the 4th tooth to image of the center of the 6th tooth both on the line connecting 1st-6th teeth

RESULTS AND DISCUSSION

Identification of this neural network in matching bite-marks on the waxes with impressions of the participants' dentition came out to be 94% of the sample. The first characteristic shows totally different pattern as compared to the others. Thus, this can be useful. The second, third, 4th and the fifth characteristics had almost the same value but their similarity is >2nd-5th. The characteristic of the 10-15 are different from the rest. All the extracted characteristics are of distance or angle except number 16. The values are also different.

These days, the issue of forensic dentistry is gaining ground and bite-marks can be gathered in crime scenes (Franco *et al*., 2015). The very first bite-mark case was reported in the United States in 1870 (Pierce *et al*., 1990). Since then many other criminals have been identified on the basis of their bite-mark documents.

Maloth and Ganapathy (2011) concluded in their study that forensic odontologists should discontinue the use of hand traced overlays in bite-mark comparisons which supported the studies done before Flora and Blitzer, 2009) have suggested a comparison between automatic and semi-automatic methods for matching bite-marks on the corpse and on waxes. In the semi-automatic method, bite edges will be manually designed by human being and the rest of the tasks will be done through computerized algorithms. Flora and Blitzer (2009) reported that finding the bite edges manually will be superior to the method in which all the tasks are done via algorithm.

In a study done by Jayaprakash *et al*. (2001), photo super imposition was used for identifying a skull and as a result the reliability of identification achieved has been shown to be 91%, indicating the possibility of a skull mismatching with a face photograph belonging to a person other than the actual deceased.

As mentioned in the previous section, the neural network could positively perform the act of identification. The use of neural network in dentistry has been quite restricted so far. Speight *et al*. (1995) suggested a useful neural network for testing and preventing oral cancer. Brickley and Shepherd (1997) compared the effect of 3 types or oral surgery oral surgery using neural network for extraction of the 3rd molars. Park *et al*. (1999) used neural network for diagnosis of cervical lymphatic nodes pathology. They concluded that neural network may be positively used for dental diagnosis identification and

minimizing the human error in dentistry. Accordingly, neural network can help dentists to diagnose and minimize human errors, respectively.

Artificial neural networks have a high ability of prediction and disintegration if the data corpus and their quality are acceptable (Tutuncuc *et al*., 2008).

The process of instruction of the neural networks was quite proper as in the 10×10 model, the samples were thoroughly disintegrated and no two samples were superimposed. The methodology used in this research has several advantages when using judiciary pictures. First of all, after designing and instruction of the neural network, one can apply it very easily. Second, one can improve the efficiency of the network by using larger samples and thirdly, the results can be easily saved. In other words, one can save 34 cases for each individual or sample which shows his/her teeth characteristics.

The limitation of this method lies in the fact that marks of all the six teeth are needed whereas in certain situations we might not have all these six traces and thus some of the characteristics can be missing in which case the results might come out to be improperly interpreted. Of course, one might anticipate the place of these lost teeth using curve fitting tool.

CONCLUSION

In this study, the neural network could acceptably perform the act of identification in 94% of the cases. In this study, the taken images had an 1110×2079 pixel. One can improve the resolution of the graphs in future and this can probably contribute to a more efficient way of locating the bite edges. One of the main sources of errors was found when marking with waxes as the proper diagnosis of the teeth centers is difficult due to the 3-D characteristics of the images.

Although, attempt was made to minimize the errors in the images, it is not recommended that impression be used in future research studies. That is to say, one can juxtapose the images taken from the victim with the image of the suspect's bite.

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