

Bitemark Evidence in Forensic dentistry for Human Identification using deep learning technique

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Abstract. This paper gives an idea about how the human bite mark is useful to predict mostly cases of assault for dental evidence particularly in NAI cases (Non -accidental Injury). The purpose of this study is to identify an individual by using bitemark at the crime site. Human bitemark are commonly found in child abuse cases, rape and rape homicide cases in many assaults. Bitemark is very important in forensic odontology for identification of deceased victims and also for crimes and accident. The intension of this study is to prepare a digital image processing software which will compare the suspected dental condition and bite marks present on assault and give confirmation of its identity in criminal cases. In traditional system, doctors observe the bite-mark and suspected dental condition. In this traditional way, investigation requires more time. But when using Digital Image processing software in future. Various image analysis technique such as Image Acquisition, Image pre-processing, Segmentation, Feature extraction etc. are used to identify human in lesser time .It can save the time of the investigation. In criminal court, Bitemark are counted as the most valuable form of dental evidence presented in rape cases.

Keywords: Odontology, assaults bitemark, non-accidental injuries cases, dental impression, Matlab software.

1. Introduction

Dental bitemark identification also known as biometric system of teeth. This is a useful and reliable technologies to provide a perfect decision of identification in valuable method that uses the dental radiography and measurements of the sizes of different teeth and bite-mark.

Biometric method is done by using dental radiography but identifying a bitemark is not possible in radiography techniques.

Bitemark are commonly seen at the crime site in physical and sexual assaults cases on human body (Neck, Arm, Hand, Nose, Ear, Breast, Legs, Buttocks, Shoulder, Waist, Face, Finger and Female genitals). This paper helps in identification of suspect in cases of assaults and rape Via Matlab software (Digital image processing).

The most common method of comparing bite-mark is to compare the crime site sample with the transparent overlays of the recorded bite edges of a suspect's teeth. These are often drawn on sheets of acetate, which can then be placed over one another for comparison. If possible, dental cast can be made of the bite mark so that later comparison to a suspect sample can be made. [1]
 Fig.1

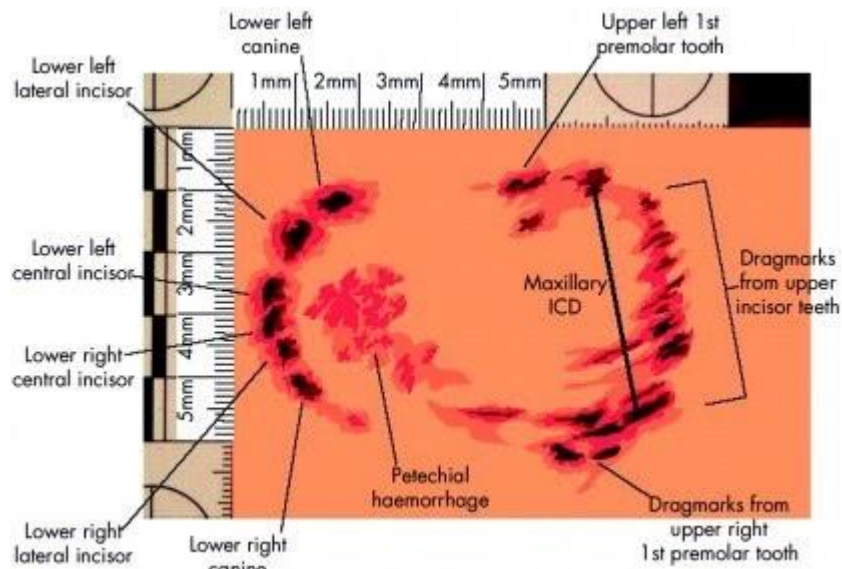


Fig. 1. Transparent overlay to record the biting edges of assault's teeth

2. Methods and Materials

2.1. Image acquisition:

1. Suspected teeth impression



Fig.2. Teeth impression

2. Victim Bitemark Images



Fig.3. Bitemark images

Teeth is the strongest part of human body. Which have ability to with stand worst scenario of accident and damages. In other condition where fingerprints and facial features (eye, hair) can get contaminated. Teeth are the only rupture which maintain their originality. Bitemark evidence is also a good and effective method to identify a human in incidents such as flood, earthquake, landslides, bomb blast, plane crashes etc.

2.2. Comparison and anomalies in the teeth



Fig.4. Spacing between teeth
Crowding of teeth

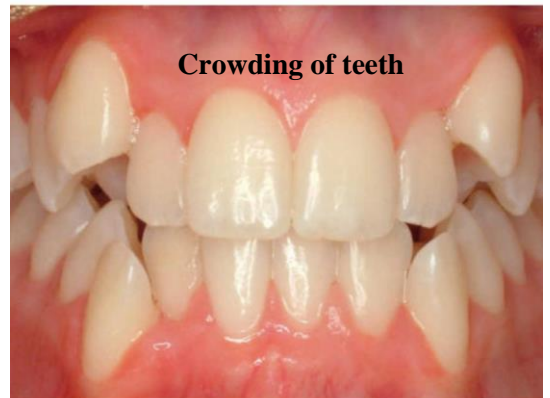


Fig.5.

1. Spacing of teeth



Fig.6. Spacing of teeth

s similar as crowding, spacing also becomes an identification point of an individual. It is the most common defect seen in Indian population.

2. Crowding of teeth



Fig.7. Crowding of teeth

Crowding is also another identification point through which an individual can be identified. Crowding and pattern of rotated teeth makes a dentist identify an individual.

3. Any kind of rotated teeth



Fig.8. Rotated teeth

Rotated teeth commonly occurs due to severe crowding of posterior teeth and make other teeth difficult to adjust in the ideal anatomic position and so it becomes easier form for identification of an individual.

4. Proclined teeth



Fig.9. Proclined teeth

Proclination of teeth is basically seen because of small size of jaw which makes difficult for the teeth to accumulate in the arch and causes anterior teeth Proclined.

A diastema means spacing between two teeth.

Crowding is the lack of space for complete teeth set to fit at its normal place in the jaws.

Teeth spacing is a condition in which the teeth are separated by large gaps.

Particular physical characteristics are present in bitemark injuries and suspect teeth which are amenable to digital measurement [4].

The Most Obvious are:-

- The distance from cuspid to cuspid.
- The evidence of a tooth out of its arch.
- Missing teeth
- Spacing between the teeth.
- Arch width.

In dental periapical films, we propose models using fast regions with conventional neural network features to locate and number teeth.

To improve search accuracy, we propose three post-processing techniques to supplement Baseline Model 1 based on specific domain knowledge.

First, a filtering algorithm is created to delete the overlapping boxes found by Model 2 corresponding to the same tooth. Next, a neural network model is applied to find missing teeth.

Finally, the Model 3 module based on the tooth numbering system is proposed to match the labels of the discovered tooth box to improve the results found to violate some intuitive rules.

The intersection-over-union (IOU) value in the detected and ground truth box is calculated to obtain accuracy and recall on the test dataset.

We propose a model that allows more rapid useful regions with the features of the convolutional neural network to find and number teeth in dental periapical films.

3. Description of our Work

Phases 1

Step 1 - Collection of Dataset

Step 2- Pre-processing of data.

Phases 2

Step 3 - Develop Modified Algorithm.

Step 4 - Analysis of the data to identify hidden pattern.

Phases 3

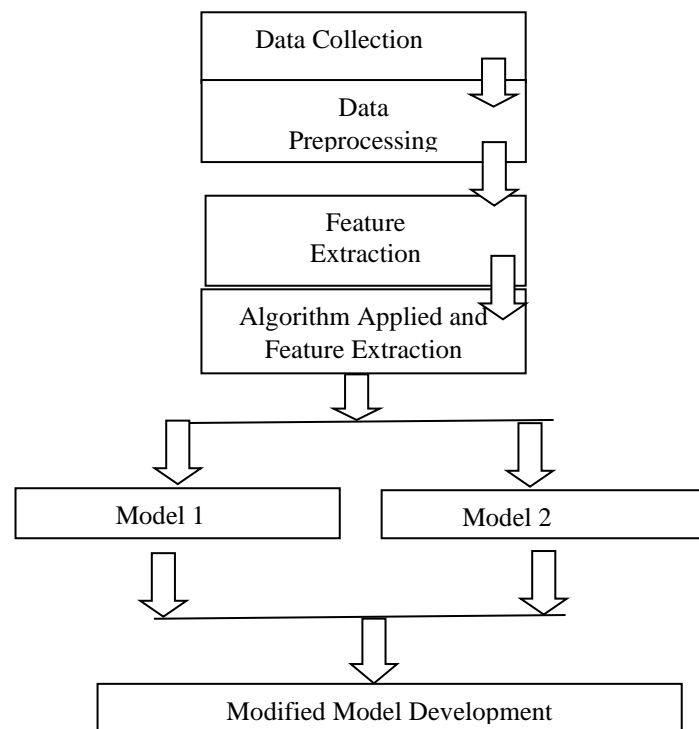
Step 5- Use Modified model.

Step 6- Object recognition

As per the following step of the research work the methodology are as follows:

3.1. Dataset and data collection

We have taken thousands of different people's teeth impression using alginate materials on metal perforated trays from which we made dental cast using dental stone material.[Fig.11] With this dental cast we made bitemark impressions on modelling wax.[Fig.12]



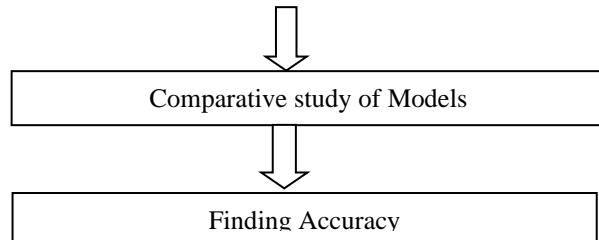


Fig. 10: Flow Diagram of our Work

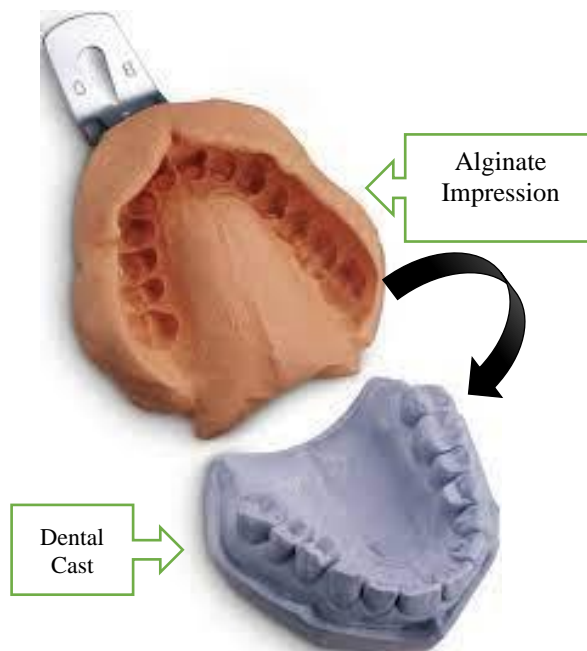


Fig 11. Impression and Cast

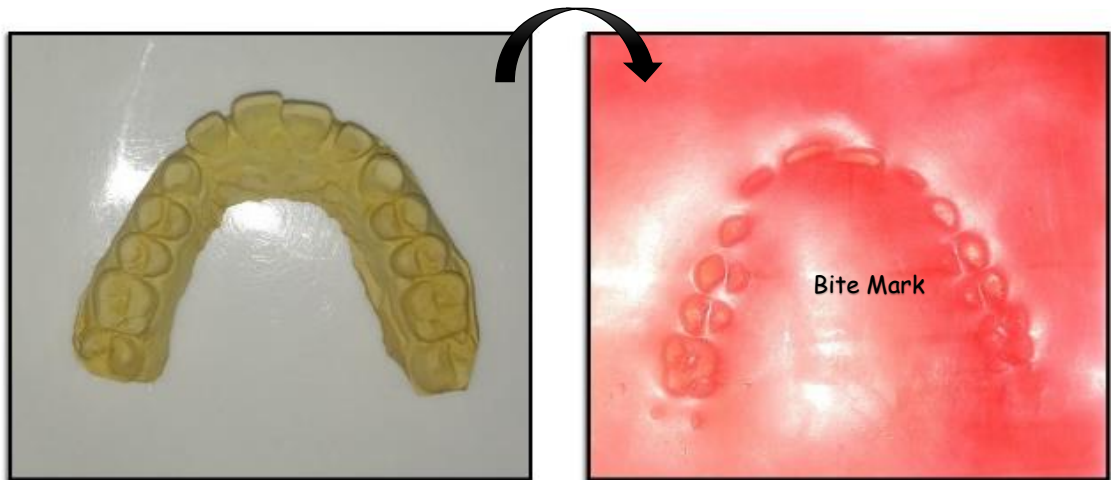


Fig.12. Bitemarks on Modelling wax.

3.2. Data preprocessing

In this data preprocessing includes 3 steps of digital image processing (dip).

1. Image Enhancement
One should use modified techniques that can change the brightness and contrast of the image to highlight some features that are of interest to the image.
2. Image Restoration
Improving the appearance of an image is mainly called as Image Restoration. However, image restoration is objective while image enhancement which is subjective in the sense that restoration techniques tend to be based on probabilistic or mathematical models of image degradation
3. Color Image Processing
Color image processing is an area that is gaining importance due to the significant increase in the use of digital images on the Internet. This includes color modeling and processing in the digital domain

3.3. Feature extraction

1. Wavelets and Multi resolution Processing
At different degrees of resolution, wavelets are the basis for representing images. Images are subdivided into smaller regions for data compression and for pyramidal representation, respectively.
2. Compression
At different degrees of resolution, waveforms are the basis for representing images. Images are subdivided into smaller areas for data compression and pyramidal presentation, respectively.

3.4. Algorithm applied and features

Morphological Processing:

Tools for extracting image components that are useful in the representation and description of shape are dealt by Morphological processing.

3.5. Modified Model development

Segmentation:

The Segmentation process divides an image into an object or its component parts. In digital image processing, autonomous partitioning is usually one of the most difficult tasks. The rough segmentation process lengthens the process for successful resolution of imaging problems for which objects need to be identified individually.

Accurate segmentation is a necessary step in computerized analysis. This allows to detect deformities within the physiological area of the tooth without affecting the background and other areas of the image [12].

3.6. Comparative study of mode Representation and Description

The output of the segmentation stage is almost always followed by representation and description, which is usually raw pixel data, forming either the boundary of the region or all the points in the region. Part of the solution is to select the representation to convert the raw data into the appropriate form for subsequent computer processing. Descriptions are related to the removal of properties that provide some quantitative information of interest or are fundamental to distinguishing one class of objects from another.

3.7. Finding Accuracy (Object recognition)

Recognition is the process by which an object is labeled "teeth" based on its descriptors.

4. Literature Review :

A review on various research work based on bitemark image analysis in forensic dentistry for human identification. Reading all the referral articles it seems that human identification can be made from bitemark and suspected teeth impression image analysis.

1. K. Bhargava (2012) proposed current method of data collection which says photography is the most important evidence from the bite mark victim.
2. D. K. Saja (2017) proposed biometric system for forensic human identification based dental X-ray. They made a database which contained ante-mortam dental radiographic features (AM), which they used later for matching with the post-mortem dental radiographic features (PM). Features like Standard Deviation (STD), Euler number and Area are extracted from image of type bite-wing dental x-rays.
3. R. Souviron and L. Haller (2017) Proposed a discussion of the differences between the suspect's dentistry for the purpose of analyzing the bite mark and identifying the comparison of the bite mark.
4. K. Verma (2013) aims to address the forensic aspects of bite marks evidence from the crime scene.
5. R. K. Gorea (2014) total of 188 bite marks were proposed on the clay, of which 93.34% volunteers were identified by the bite marks on the clay. 201 impressions

on the skin were studied and 41.01% of the same volunteers could be identified on the basis of the bite mark on the skin.

6. C. Pereira (2009) proposed that Dental impressions and model materials are very important for preserving physical evidence on inanimate objects such as cheese, so that they can then be compared to the teeth of the suspect and conclusions can be drawn.
7. S.Jayachandran (2017) proposed digital imaging in dental complementary -metal-oxide-semiconductor (CMOS) sensors uses active pixel technology. This technology reduces the system power required for a 100 component and then eliminates the need for charge transfer. A latent image is created by the incident X-ray photon.
8. K. Krishan (2015) proposed present status of dental evidence in forensic identification for experiment, they find out age and sex of human using Polymerase Chain Reaction (PCR). Enamel protein also has different patterns in males and females can also be used for sex determination via DNA techniques.
9. A. Ajaz, Kathirvelu.D (2013) proposed method works with three main processing stages. Using mathematical morphological operations, the segmentation is carried out. Based on the features extracted in the segmentation process, creation of dental code are made.
10. K. Khandare, Dr. Ajay Gurjar (2016) proposed method of morphological image processing technique on grayscale image; The part of the highest intensity has been removed of the higher intensity.
11. Nainan, Oommen. (2015) proposed comparison of antemortem and postmortem dental records to determine human identity has long been established.
12. Bandyopadhyay, Kumar & Bandyopadhyay, Samir (2021) proposed a method from the cross section of teeth to eliminate noise spike, segmentation and contour dental x ray images.
13. Samopa, Febriliyan & Asano, Akira & Taguchi, Akira. (2009). proposed a computer-based system for extracting individual molars from dental panoramic radiographs. Molar is obtained by removing the region of interest, separating the maxilla and mandible, and removing the border between the teeth.
14. Chandran, Veena & Simon, Philomina. (2019) Reviewing the proposed general framework and research work of dental biometric system and taking into account the technological advances in the field of dental biometrics.
15. Ehsani Rad, Abdolvahab & Rahim, Mohd & Kolivand, Hoshang & Norouzi, Alireza. (2018) proposed new segmentation method based on the proposed level set (LS) is proposed in two stages; IC generation using motion filtering and back propagation neural networks using morphological information of images and intelligent level set segmentation.
16. Pushparaj, Vijayakumari & Gurunathan, Ulaganathan & Arumugam, Banumathi. (2013) proposed dental photographs are also the object of research if radiographs are not available in the perfusion. To reduce search space, teeth are initially classified as molar, premolar, and canine are numbered using a linear support vector machine and using a universal numbering system. Other issues, such as

missing teeth, are considered here as autopsy records are retained for a longer period of time. For personal identification, contour information has so far proved to be a useful solution. In addition to the contour and skeleton, the structure information of individual teeth is also included in this paper.

17. Muramatsu, Chisako & Morishita, Takumi (2020) It is proposed to develop a computerized system for finding and classifying teeth in dental panoramic radiographs for automatic structured filing of dental charts. It can also be used as a preprocessing step for computerized image analysis of dental diseases.
18. Oktay, Ayse. (2017) proposed dental panoramic radiographic images are commonly used as biometrics for human identification. In this study, a new method of identifying humans by matching 2D panoramic dental X-ray images has been introduced.
19. Joshi, Sagar & Kanphade, Rajendra. (2020) proposed radiograph-based human authentication using deep neural networks. The three-layer convolutional deep neural network architecture is used to characterize and identify hand radiographs.
20. Heinrich, Andreas & Güttler, Felix & Schenkl, Sebastian & Wagner (2020) the proposed tool is capable of filtering large databases with multiple entries of potentially matching partners. This identification method is appropriate even if dental features have been removed or added in the past.

5. Conclusion

This paper is a review on identification of suspect by observing suspected teeth impression and victim bitemark by using digital image processing. To identify an individual using this unique dental features one needs to undergo digital image processing such as Image Acquisition, Image pre-processing, Segmentation and Feature extraction etc.

Ethical clearance

We have taken some sample images and all the images which is collected from Ora-Max Oral Surgery Clinic, Satara. For study purpose. Hence, ethical approval was not required. Fig. 1 Rugae's pattern image taken from (<https://www.sciencedirect.com/science/article/pii/S2090536X15000076>)

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She has published four books in Lambert publication and in Amazon. She has published more than 64 papers in national and international journals. She has presented papers in national and international conferences, three patents and life membership of four societies. She has been awarded from four national and international bodies. She has delivered lectures as key note speakers and has been worked as session chair in more than four organizations.

Four Ph.D. scholars and Four M.Phil. CS dissertations has been awarded under her supervision. Presently guiding eight Ph.D. research scholar, and one PhD thesis has been submitted under her supervision.