Chapter 12
Automating Human Identification Using Dental X-Ray Radiographs

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ABSTRACT

The goal of forensic dentistry is to identify individuals based on their dental characteristics. This chapter presents a system for automating that process by identifying people from dental X-ray images. Given a dental image of a postmortem (PM), the proposed system retrieves the best matches from an antemortem (AM) database. The system automatically segments dental X-ray images into individual teeth and extracts representative feature vectors for each tooth, which are later used for retrieval. This chapter details a new method for teeth segmentation, and three different methods for representing and matching teeth. Each method has a different technique for representing the tooth shape and has its advantages and disadvantages compared with the other methods. The first method represents each tooth contour by signature vectors obtained at salient points on the contour of the tooth. The second method uses Hierarchical Chamfer distance for matching AM and PM teeth. In the third method, each tooth is described using a feature vector extracted using the force field energy function and Fourier descriptors. During retrieval, according to a matching distance between the AM and PM teeth, AM radiographs that are most similar to a given PM image, are found and presented to the user. To increase the accuracy of the identification process, the three matching techniques are fused together. The fusion of information is an integral part of any identification system to improve the overall performance. This chapter introduces some scenarios for fusing the three matchers at the score level as well as at the fusion level.

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INTRODUCTION

Human identification is a fundamental activity at the heart of our society and culture. For many applications, ensuring the identity and authenticity of people is a prerequisite. Biometrics identification refers to identifying an individual based on his or her distinguishing characteristics. It is being accepted by government and industry alike that automated biometric identification will become a necessary fact of life.

Forensic identification is typically defined as the use of science or technology in identifying human beings in the court of law. It has a wide area of applications in criminal investigations, court evidences and security applications.

Forensic identification may take place prior to death and is referred to as ante mortem (AM) identification. Identification may as well be carried out after death and is called postmortem (PM) identification. While behavioral characteristics (e.g. speech) are not suitable for PM identification, most of the physiological characteristics are not appropriate for PM identification as well, especially under severe circumstances encountered in mass disasters (e.g. airplane crashers) or when identification is being attempted more than a couple of weeks postmortem, because of the decay of soft tissues of the body. Therefore, a postmortem biometric identifier has to survive such severe conditions and resist early decay that affects body tissues. Because of their survivability, the best candidates for postmortem biometric identification are the dental features and now the importance of using dental records for human identification is well recognized (Jain, & Ross, 2002).

Forensic odontology (Brogdon, 1998) is the branch of forensics concerned with identifying humans based on their dental features. Dental identification is a comparative technique, where the PM dental records are analyzed and compared against AM records to confirm identity and establish the degree of certainty that the dental records obtained from the remains of a decedent and the AM dental records of a missing person are for the same individual. Currently the identification is carried out manually by comparing extracted features from a postmortem (PM) dental record to extracted fractures from a database of ante mortem (AM) records. According to forensic experts (Brogdon, 1998), dental characteristics preserve their shape after death for a long period of time. Several individual teeth may get missed or filled after its AM record is taken, hence dental features need to be recorded based on the contour/shape of individual teeth rather than the contour of the whole jaw. This would require reliable automatic segmentation techniques that can extract the contour of each individual tooth for latter retrieval purposes to allow for retrieval based on teeth shapes.

The objective of our research is to automate the process of forensic odontology using image processing and pattern recognition techniques. There are several advantages for automating this procedure. An automatic system can perform identification on a large scale database while a manual or semi-automatic system is useful for verification on a small data set. Also, automating this process will come up with an ordered list of closest matches that we may refer to in order to decide the best match. Accordingly, this will facilitate for forensic odontologists to only manually verify through this best match short list instead of manually searching a large number of AM records. In order to achieve this goal, we need to automate the process of segmenting the dental radiographs and to separate each individual tooth. For the automated identification, the dental records are usually available as radiographs. An automated dental identification system consists of two main stages: feature extraction and feature matching. During feature extraction, certain salient information of the teeth such as contours, artificial prosthesis, number of cuspids, etc. is extracted from the radiographs.