A Prototype Automated Dental Identification System (ADIS)[1]

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Abstract

In this demonstration we present an early version prototype of an automated system for postmortem identification based on dental radiograph comparison. We overview the structure of the proposed automated dental identification system (ADIS) prototype that we are currently developing. We briefly discuss some of the techniques we use in developing the prototype ADIS, as well as initial testing results. Finally, we sketch out our research plans for completing the ADIS prototype.

1 Introduction

In 1997, The Criminal Justice Information Services Division (CJIS) of the FBI created a dental task force (DTF) whose goal is to improve the utilization and effectiveness of the National Crime Information Center's (NCIC) Missing and Unidentified Persons (MUP) files [3]. The DTF recommended the creation of a Digital Image Repository (DIR) and an Automated Dental Identification System (ADIS) with goals and objectives similar to the Automated Fingerprint Identification System (AFIS) but using dental characteristics instead of fingerprints [3]. The proclaimed dental identification system is a near fully automated system that when fed with raw subject dental records will find a minimum set of candidate reference records, ideally one, for each of the subject records. An MUP identity is determined once his/her subject record matches a reference record.

Owing to their survivability and diversity, dental features are widely accepted among forensic scientists as characteristics for establishing positive postmortem (PM) identification. Forensic odontology is the branch of forensics concerned with identifying human individuals based on their dental features [10]. Traditionally, forensic odontologists relied on the morphology of dental restorations (fillings, crowns, .. etc.) to identify victims. However, modern materials used in filling and restoration possess poor radiographic characteristics. Moreover, it is expected that contemporary generations will have less dental decay than their predecessors. Therefore, there is a need to shift towards comparison based on inherent teeth and bone characteristics, e.g. morphology of crowns and roots [3][5].

With the large volume of MUP cases, a computer aided dental identification system becomes inevitable. Dental records of MUPs contain radiographic/photographic images, as well as non-image information, e.g. age, gender, race, .. etc. Forensic experts also employ coding techniques to capture the status of the MUP teeth and record their conditions in textual or chart format. Identification of an MUP is carried out by comparison of a subject dental record against reference records that are stored in dental record

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repositories. Traditionally, comparisons greatly relied on dental work and restorations. However, modern materials used in fillings and restorations possess poor radiographic properties.

ADIS is required to speedup the postmortem identification process. It is estimated that at any point in time there are over 100,000 unsolved MUP cases in the National Crime Information Center (NCIC), 60 % of which have remained unsolved for 90 days or longer. Technically speaking, this large number of unsolved cases hinders the capabilities of search techniques currently employed. The benefit of ADIS to the society will surpass saving millions of dollars to also include psychological benefits of families of missing persons when knowing the disposition of their loved ones without having to wait extended period of time.

In this demonstration we present an early version prototype of ADIS based on dental radiograph comparison using combined techniques of digital image processing and artificial neural networks.

2 Related Work

There are several computer-aided PM identification systems. *CAPMI* [11] and *WinID* [8] are the most famous among these systems. However, these systems do not provide high level of automation, as feature extraction, coding, and image comparison are still carried-out manually. Moreover, the dental codes used in these systems capture only artificial dental work [3].

Baldi and Chauvin used neural network techniques in developing a fingerprint matching system [4], which follows a pyramidal image matching architecture, with the image regions forming the base of the pyramid, a feature extraction layer on top of the base, and a decision layer at the top of the pyramid. Match decision making is carried out in two steps: first, features from both images are extracted. Then, differences between features are fed to a binary Bayesian classifier, to determine the probability that both images belong to the same person. The coefficients of feature filters and the parameters of the classifier evolve by learning through examples.

The automated identification systems research group at West Virginia University has developed efficient parallel training algorithms for a neural network based automatic fingerprint comparison system (AFIC) that follows the same structure suggested by Baldi and Chauvin [1].

3 ADIS prototype

The conceptual framework for developing ADIS is depicted in the top-level block diagram shown in Figure 1. ADIS is composed of two subsystems: potential matches search system and dental image comparison system. Given a subject record, finding the identity of the subject is carried out in two steps:

- First, potential matches search is used to generate a list of candidate reference records, from the DIR. Potential candidates are the bearers of reference records with dental/non-dental features that are potentially close to those possessed by the unknown bearer of the subject record. At this level, only high-level dental features, as seen from dental records are examined (e.g. number of teeth). Non-dental features include- however, not limited to: age, race, and gender.

- Second, dental radiographs of the subject record are compared with those of each of the candidates. The outcome of the comparison is the probability of match between the subject record and each of the candidate reference records.

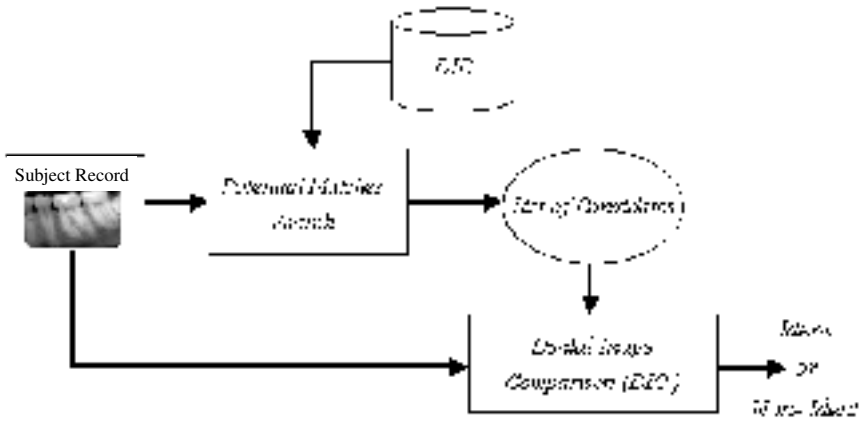

Figure 1: Top-level block diagram of ADIS.

In this demonstration we focus on the dental image comparison system. The input to the image comparison system is a pair of dental radiographs whose probability of match is to be estimated and output from the system. Figure 2 shows the decomposition of this system into two stages: the preprocessing stage and the decision-making stage. Following is a brief functional description of both stages:

- The preprocessing stage receives an input pair of radiographs, one from the subject record and the other from a candidate reference record. An input pair is prepared for comparison through a series of steps that: reduce the noise content and improve definition of teeth with respect to their surroundings (Enhancement), extract regions of interest that possess highly distinctive features (Segmentation), align the extracted subject regions of interest over their respective regions in the candidate image (Alignment), and finally remove some redundancy from the submitted pair to cut down on the computational complexity for pair matching in the decision-making stage (Compression).

- The Decision-making stage extracts low-level features from compressed region of interest pairs, and measures the differences between respective features and finally uses the measured differences to come up with an estimate of the matching probability between the submitted pair.

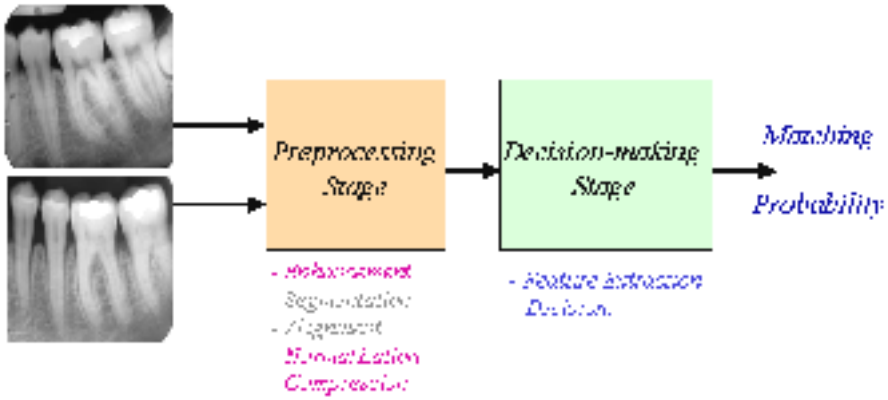

Figure 2: Block diagram of the image comparison system.

We started the development of the image comparison system by building the decision-making stage, as it is the most critical component in the image comparison system. We have also conducted some research on the preprocessing stage, particularly in enhancement, normalization and compression.

We carried out several experiments to develop the decision-making stage using techniques proposed by Baldi and Chauvin. However, owing to differences between fingerprint images and dental images, primarily those pertaining to object sizes relative to image size, the mathematical models used by Baldi and Chauvin as well as the standard back propagation training technique failed to produce any satisfactory results.

Upon modifying the mathematical models used in building the classifier, we observed some improvement in the results. Yet, the convergence rate was still very poor. The next step for us was to use a training technique that will out perform the standard back propagation technique that we initially used. We adopted one of the known strategic searching algorithms [7] and introduced some modifications to it so that it better adapts to the dynamics of our system training. Thenceforth, we obtained excellent training convergence results in terms of both accuracy and speed. The technical details of the research we conducted are beyond the scope of this brief demonstration description. The interested reader may find more details in [1] and [9].

We conducted several experiments to test the decision-making stage using thousands of automatically generated test pairs. We verified through test results that decision accuracy is quite high (greater than 97%).

4 Conclusions and Future Work

In this demonstration description, we briefly discussed the structure of the prototype Automated Dental Identification System (ADIS) that we propose to show an early working version of. Hybrid techniques of digital image processing and artificial neural networks were used to build the decision-making component of ADIS. The training and testing results are promising. Our plan for future work focuses on developing advanced techniques for the preprocessing stage, as well as more directed testing towards sensitivity of the system to variations in gray-scale levels, scaling and misalignment of objects.

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