Towards Fully Automated Dental Based Forensic Identification

E. Dranischnikow[1], E. Schömer[1], R. Schulze[2], U. Schwanecke[3], D. Brüllmann[2]

Objectives

Development of a framework, which is able to decide, whether two dental radiographs display jawbone and teeth of the same person.

This problem can be formulated with less restriction: We try to find candidates potentially matching the query radiographs.

Abstract problem definition:

1. step The radiographs for all contemplable people are collected from dentists and stored into a large database.

2. step Some radiographs (the more the better) are taken from the person which identity is unknown.

3. step These radiographs are used as database queries. The missing person is identified.

Possible application:

Large scale accidents with many fatalities (airplane crashes) or natural disasters such as the 2005 tsunami.

Previous Works

1. H. Chen: Automatic Forensic Identification Based on Dental Radiographs. (2007)
   - Contours of the teeth or of the dental work are used for matching.
   - User interaction is often necessary because of the usually bad quality of the radiographs.
   - Tests only on a small database (33 radiographs).
2. T. Lehmann et al.: A Rotation-Extended Ceptstrum Technique Optimized By Systematic Analysis Of Various Sets Of X-ray Images. (1996)
   - Pixel based approach.
   - Translation and rotation are the only transformations taken into account. This will not be sufficient for a real life application.
3. K. Ito et al.: A Dental Radiograph Recognition System Using Phase-Only Correlation For Human Identification. (2008)
   - Pixel based approach.
   - Phase-Only Correlation (POC) lacks stability for transformations other than translation and rotation.

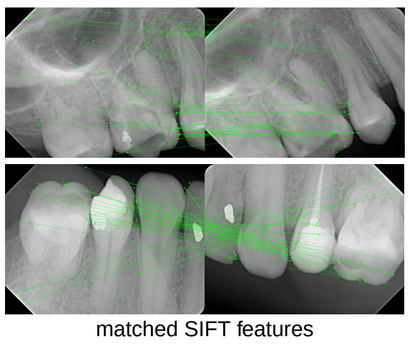
Framework

Generic Framework

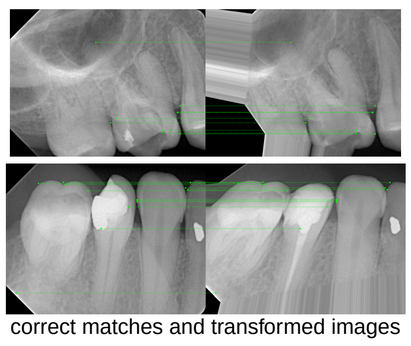
- Preprocessing: Extracting features as well as descriptions from every radiograph in the database.
  - Most important requirement: The detection of the features should be done without any user interaction.
- During the query the features are matched on the basis of the descriptors. False feature matches are filtered out: Only matches that vote for the same transformation are considered as correct feature matches.
  - Major problem: What is a suitable transformation? It is more than only translation and rotation! How many feature mappings are necessary to determine a unique transformation?
- The radiograph from the database with the highest number of correct feature matches is considered as the answer to the query.

Our Implementation

- As feature descriptors we currently use the Scale Invariant Feature Transform (SIFT).
- Assumption/Simplification: All features lie in one plane $\Rightarrow$ use projective transformations which are uniquely defined by four matching features.
- With help of RANSAC the correctly matched features are selected.



matched SIFT features

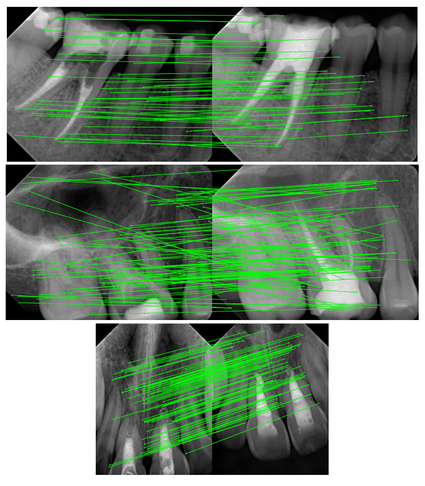


correct matches and transformed images

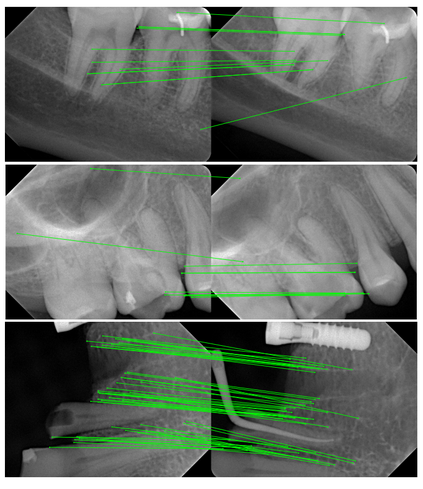
Results

For our experiments we used 60 radiographs taken over the years from 15 different patients without any constrains on the geometry of the recording system. Furthermore, some matching pairs of radiographs contained missing teeth or new implants/dental works. In our study this framework was able to detect 46% [51 out of 109] of compatible radiograph pairs which can be identified by human experts.

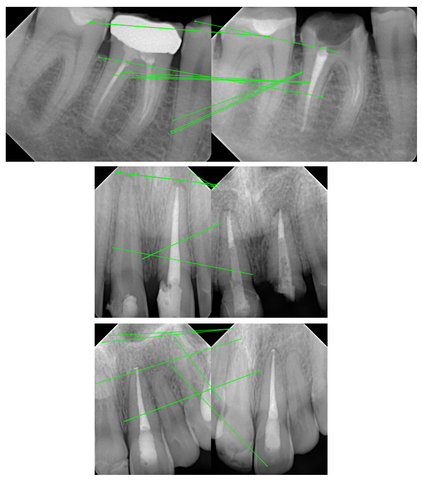
unproblematic matchings



difficult matchings



failed matchings



Outlook

Our method seems promising, but further improvements are necessary.

- Failures of our framework are mostly due to bad feature matches. SIFT features which are known to be very stable for conventional photographs seem to be less reliable for radiographs.
- Humans seem to use contours of teeth or dental works in order to determine whether two radiographs show the same jawbone. An automatic and stable extraction of these contours is difficult because radiographs are many to one mappings.
- Tests with a larger database and real life examples are needed.

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1 Institute for Computer Science, Johannes Gutenberg University of Mainz, Germany
2 Department of Oral Surgery (and Oral Radiology),University Medical Center of the Johannes Gutenberg University Mainz, Germany
3 Department of Design,Computer Science and Media, Hochschule RheinMain, University of Applied Sciences, Germany