Computer Vision [H02K5a]

Final Project: Incisor Segmentation

Introduction

In forensic investigations, dental records are often relied upon to accurately identify deceased persons. Manual comparison of ante-mortem and post-mortem records, however, is a tedious and time-consuming job. Automating this process would save the investigators a lot of time. The first step towards a comparison is segmentation of the teeth. The goal of this project is to develop a model-based segmentation approach, capable of segmenting the upper and lower incisors in panoramic radiographs (see Figure 1).

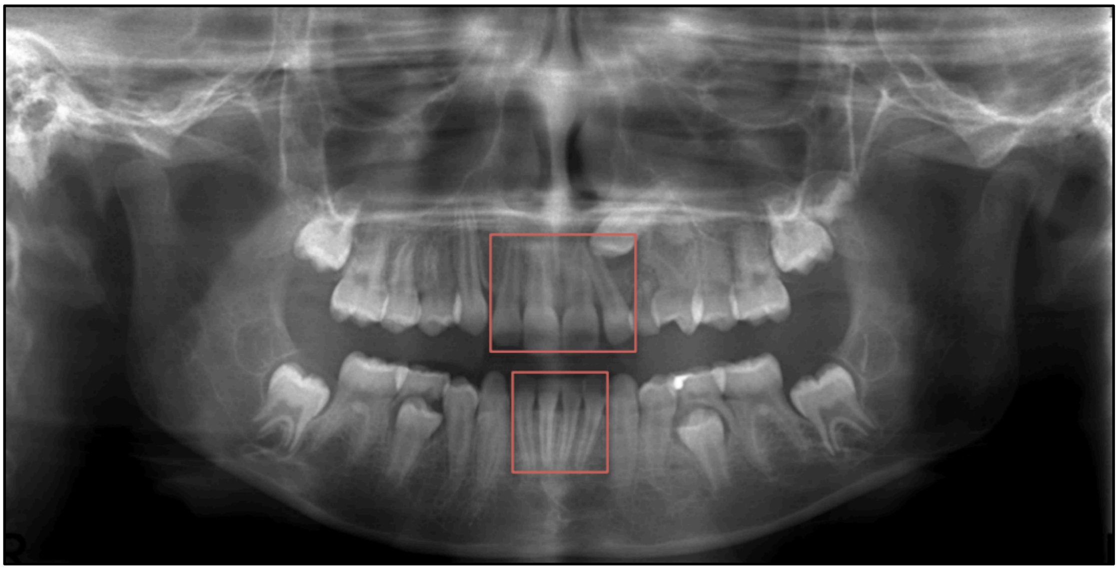

Figure 1: Bounding boxes indicating the upper and lower incisors in a panoramic dental radiograph

Project description

This project can be completed individually, or together with a maximum of 1 partner. E-mail Professor D. Vandermeulen who you are working with. The goal of this project is to write an algorithm that is capable of segmenting the 8 incisors automatically using a model based approach. The final output of the algorithm is a binary image in which non-zero values represent the incisors. Show your understanding and insight into computer vision through the design of the algorithm. A small report should also be made, covering the implemented methods (justifying your choices), after which an oral examination is held about your solution. You are responsible for contacting Professor D. Vandermeulen and arranging a meeting for your examination (during or before the examination period in June).

Project goals

1. **Build an Active Shape Model as described in the original paper by Cootes et al. (see [1] and [2])**

   1.1. Load the provided landmarks into your program
   1.2. Pre-process the landmarks to normalize translation, rotation and scale differences (Procrustes Analysis?)
   1.3. Analyze the data using a Principal Component Analysis (PCA), exposing shape class variations
   1.4. Analyze the obtained principal components

Notes:

- Think about what you are doing, and *why*. Why do we normalize? How are we going to represent our model (single tooth, multiple teeth...)?
- *Visualizing* intermediate results (aligned data / landmarks, principal components…) can be helpful in building, debugging, and analyzing your program.

2. **Pre-process the dental radiographs**

   2.1. Radiographs are inherently noisy data, and would thus greatly benefit from some pre-processing prior to fitting our model. Look up and read some literature on how we can improve the quality of (dental) radiographs. Note that choosing a pre-processing technique should be done with your fitting procedure in mind!

3. **Fit the model to an image**

   3.1. Find an initial estimate for the model in the image. The better the initial the estimate, the better your model will perform.
   3.2. Fit the model to the new image (iteratively). Fitting an Active Shape Model to an image can be performed in many ways. The original paper from Cootes et al. describes just one of many methods, and you are free to change to a different (more sophisticated?) method.

Notes:

- I strongly suggest you start by building your program with a *manual* initialization (e.g. mouse to place the model inside an image). This way, you can evaluate your fitting algorithm and initialization method separately.
- An automatic initialization method should also be developed. This can be done in a number of ways. An option would be to develop an appearance model (just like the in the face detection assignment), and use this model to find an estimate for the model. Other prior knowledge (such as the distribution of teeth locations in the images) can easily be integrated in the initialisation.

- If you have a point set, and wish to find an optimal approximation of your model to this point set, the method described in [3] can be used. The method is summarized in [4].

4. Evaluate your results

4.1. Evaluate your algorithm on the provided radiographs. Note that, since you are using a model-based approach, you cannot use the same data for learning and testing (use training and test set, leave-one-out analysis, etc.).

4.2. Clearly present your results by providing segmentation overlays, comparing the found segmentation to the ground truths, etc.

5. **Report your results**

5.1. Write a small report (+/- 10 pages) describing your methods and presenting your results.

5.2. Make a short PowerPoint presentation for the examination.

5.3. Contact Professor D. Vandermeulen and make an appointment.

Provided literature

[1] Active Shape Models – their training and application
The original paper as presented by Cootes et al. presents the main approach to ASM development, and suggests a method for applying the model to an image.

[2] An introduction to Active Shape Models
A more in-depth review of some of the methods from Active Shape Models. Note that some extensions are suggested as well (such as multi-scale approach).

[3] A statistical method for robust 3D surface reconstruction from sparse data
Original paper of the full method, summarized in [4]

[4] Model reconstruction
This document summarizes the method from [3]. This method can be used to find an optimal reconstruction from your model to a target point set.

Note: A lot of information can be found regarding Active Shape Models (or radiograph segmentation in general). Do a quick Internet search, and you will find tons of reading material, implementational issues…

Good luck!

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