Computer Vision: Incisor Segmentation

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Overview

1. Preprocessing
2. Fitting models to images
    a. Initialization active shape model
    b. Multi resolution active shape model
3. Evaluation
4. Results
5. Neural Networks

Preprocessing

Goal: Make teeth more visible than mouth tissue

How:

- First, apply a Contrast Limited Adaptive Histogram Equalization (CLAHE) filter
- Then, apply bilateral filtering to filter noise created by CLAHE
- Apply both filters once again in the same order

Preprocessing: CLAHE filter

- Part of “Adaptive Histogram Equalization” (AHE) algorithm family

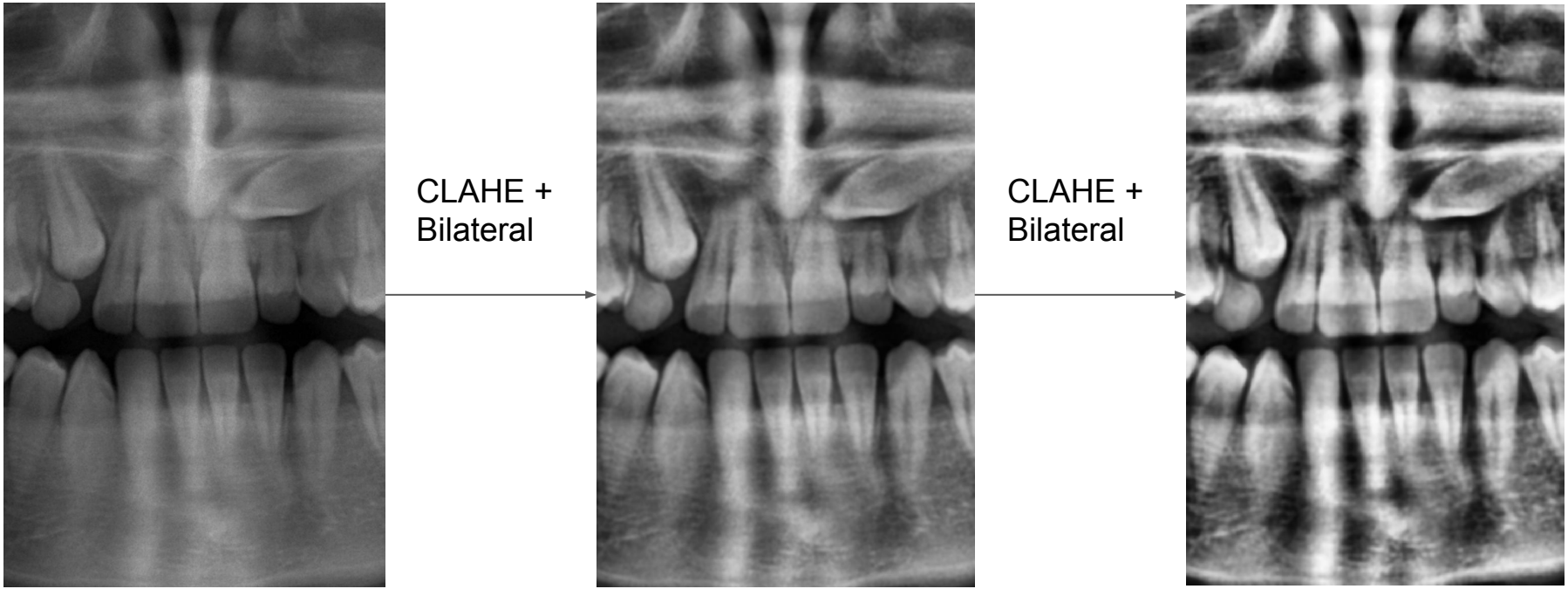
  => Different from normal histogram equalization algorithms as they compute multiple histograms for an image instead of 1

- AHE tends to overamplify noise in homogenous regions

  => Solution: CLAHE

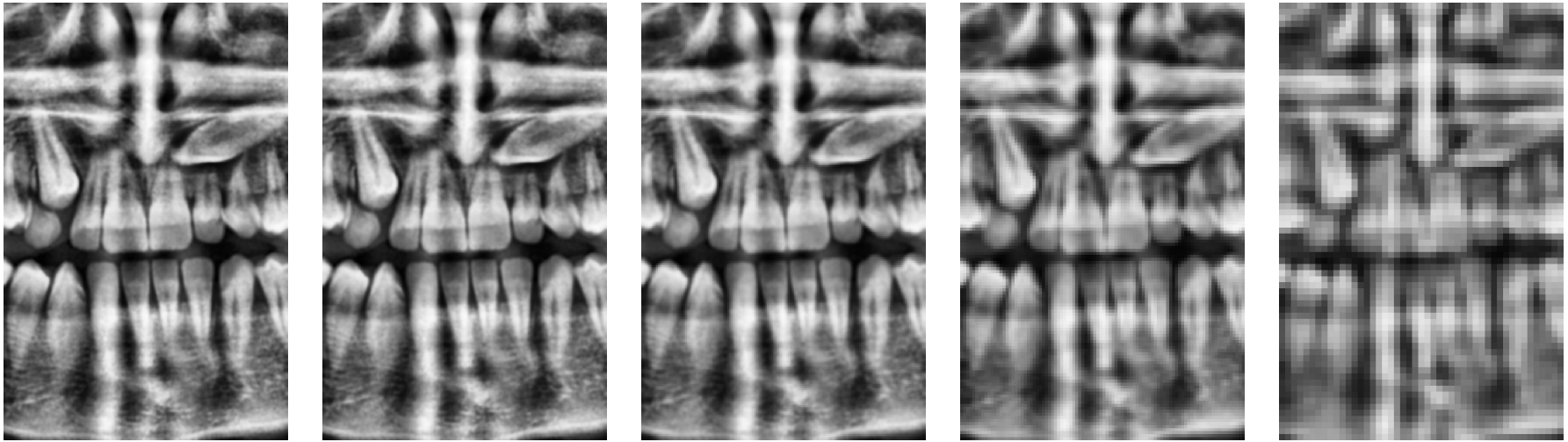
- CLAHE puts a threshold on the histogram. The part of the histogram that goes over this threshold will be evenly distributed over the whole histogram

Preprocessing



Preprocessing

Gaussian pyramid for multi resolution active shape model
Store each radiograph at multiple resolution levels



Level 0 Level 1 Level 2 Level 3 Level 4

Fitting models to images

Two approaches:

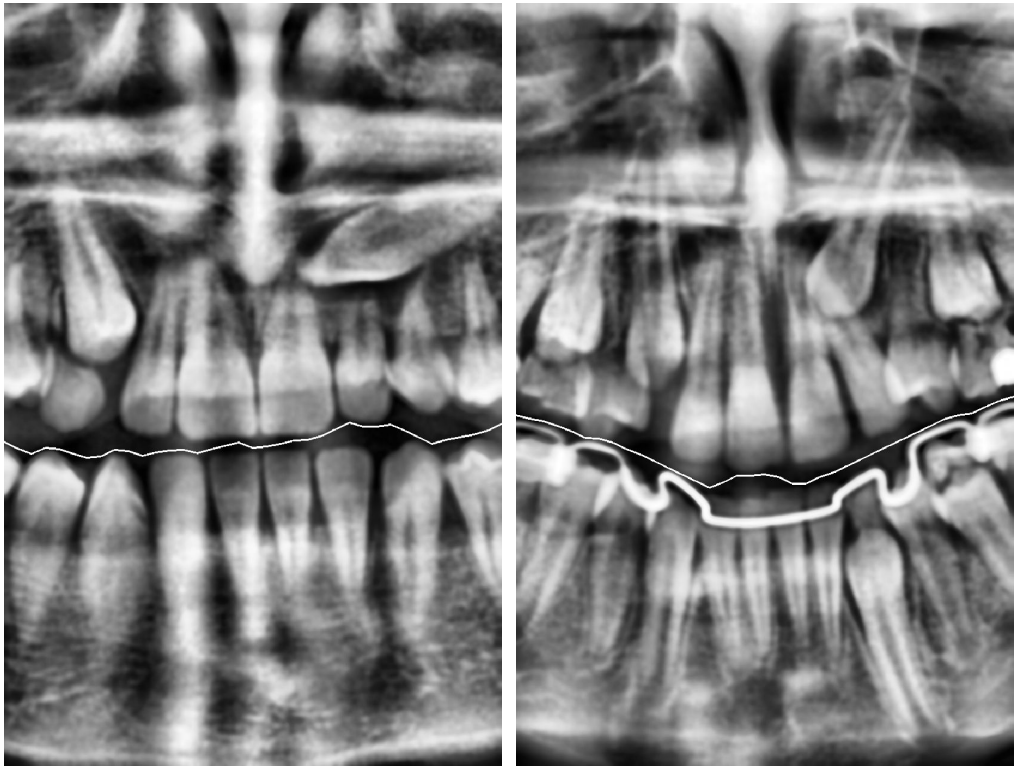
1. Separate active shape models for jaws for initialization + individual tooth models for fitting
2. Multi resolution active shape model handles both initialization and fitting

Both approaches rely on finding a line that splits the jaws first

Fitting models to images: jaw split line

To split jaws, we look for the darkest line that goes from one side of the mouth to the other

Jaw split lines are found by **Viterbi**



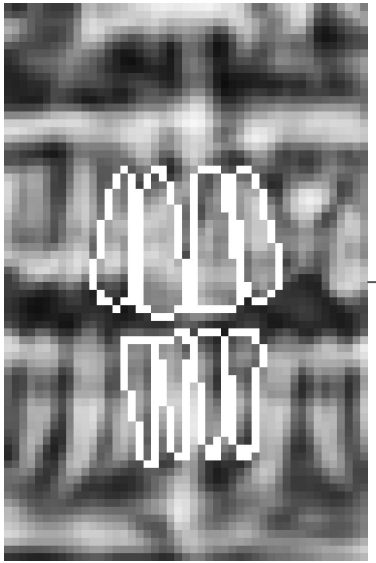
Fitting models to images: approach 1

- Create statistical (initialization) models for upper and lower incisors
- Place them both on the center of the mouth found by Viterbi
- Use the ASM algorithm to improve them iteratively until convergence or 10 iterations
- Then, initialize individual tooth models at the correct locations in the converged model
- E.g. the individual tooth model of the first upper incisor will be placed at the center of the first incisor in the upper initialization model

Fitting models to images: approach 2

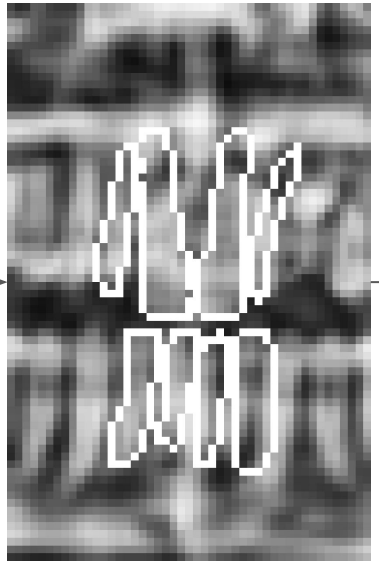
- Multi resolution active shape model is trained for all eight teeth at once
- Grey level models are built for each Gaussian pyramid level
- Search starts at the highest pyramid level (= lowest resolution image)
- The initial model position is determined using the jaw split line
  - x = middle of image in x dimension, y = mean of jaw split line
- The model is improved iteratively at each pyramid level until convergence or 20 iterations
- Whenever the model converges at a level, it is scaled up and placed on the level below it
- When the model converges at the lowest pyramid level, the search has finished

Fitting models to images: approach 2

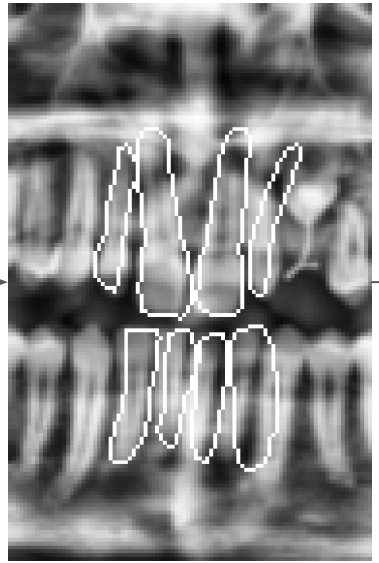


Initial model placed on pyramid level 4

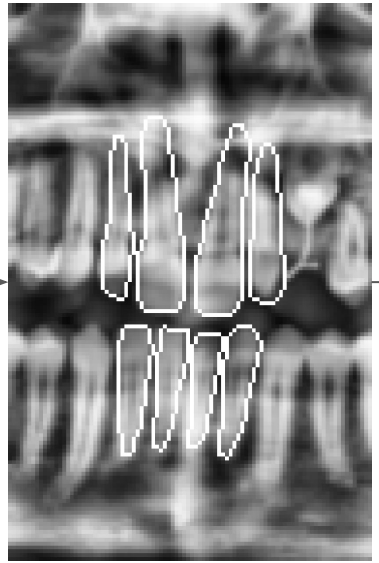
Location determined after Viterbi search



Converged model on pyramid level 4

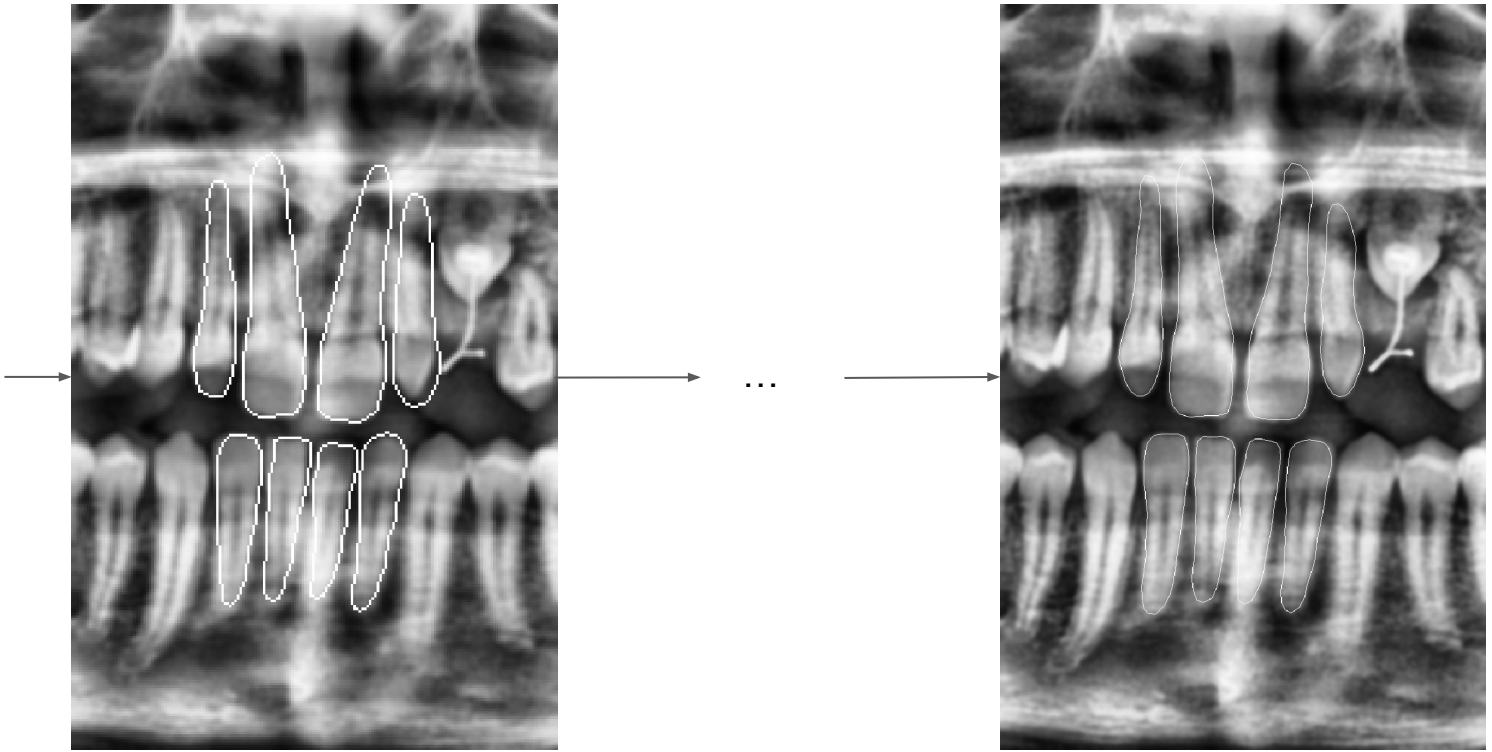


Upscaled model placed on pyramid level 3



Converged model on pyramid level 3

Fitting models to images: approach 2



Upscaled model placed on pyramid level 2

Converged model on pyramid level 0

Evaluation

Accuracy, precision, and recall are calculated using tp, fp, tn, fn:

- True Positive: The model correctly predicts that a pixel is part of the incisors.
- False Positive: The model incorrectly predicts that a pixel is part of the incisors.
- True Negative: The model correctly predicts that a pixel is not part of the incisors.
- False Negative: The model incorrectly predicts that a pixel is not part of the incisors.

Evaluation

$$accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

$$precision = \frac{TP}{TP + FP}$$

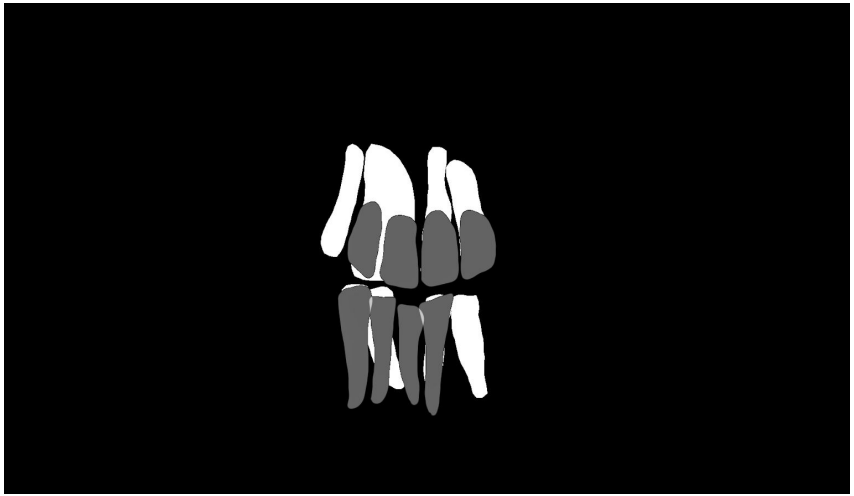
$$recall = \frac{TP}{TP + FN}$$

Results

	Initialization model			Multi resolution model		
	Accuracy	Precision	Recall	Accuracy	Precision	Recall
Average	**98.92%**	**83.77%**	**73.57%**	**98.19%**	**63.11%**	**76.97%**

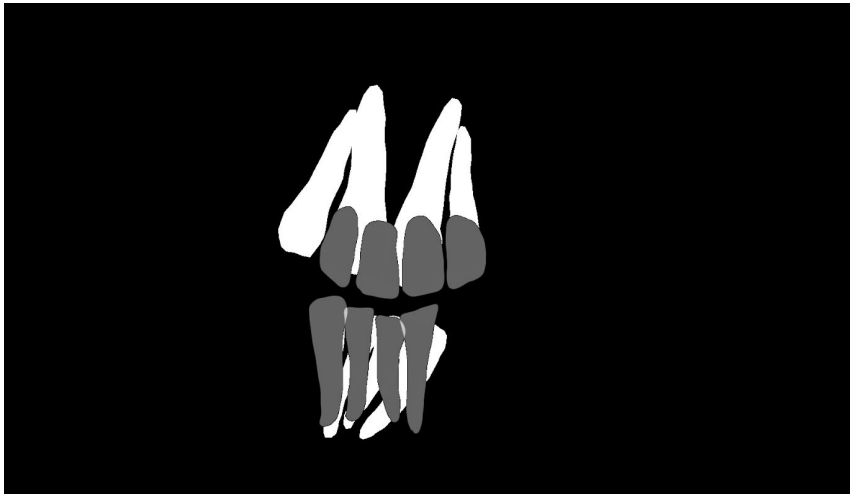
Table 1: The results of the experiments for search approaches

Results: 8.tif



Initialization model

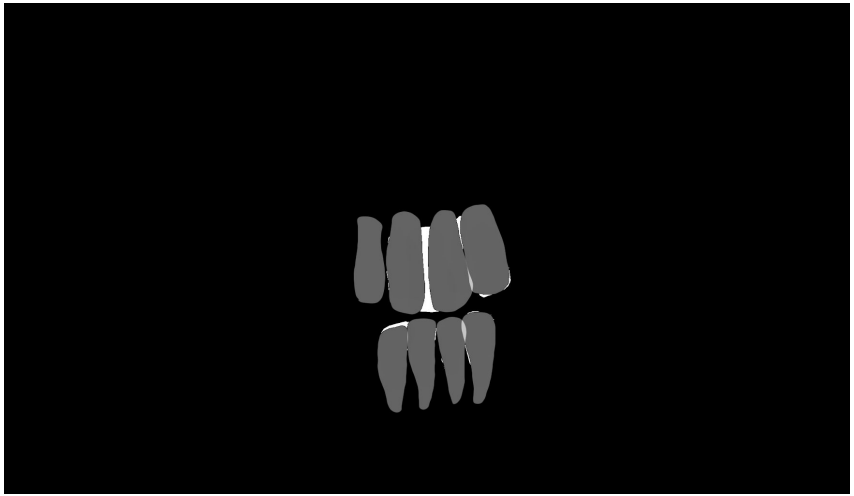
Accuracy: 98.42%
Precision: 54.02%
Recall: 74.42%



Multi resolution model

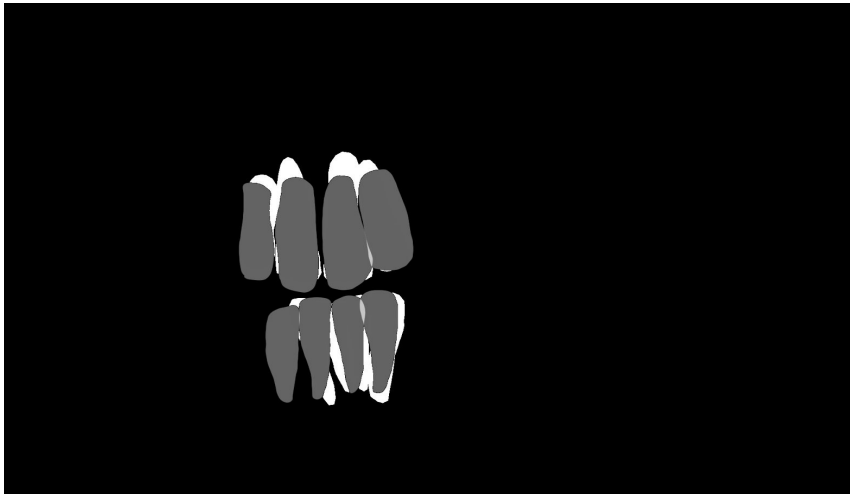
Accuracy: 98.12%
Precision: 48.16%
Recall: 77.10%

Results: 14.tif



Initialization model

Accuracy: 98.66%
Precision: 94.61%
Recall: 63.51%



Multi resolution model

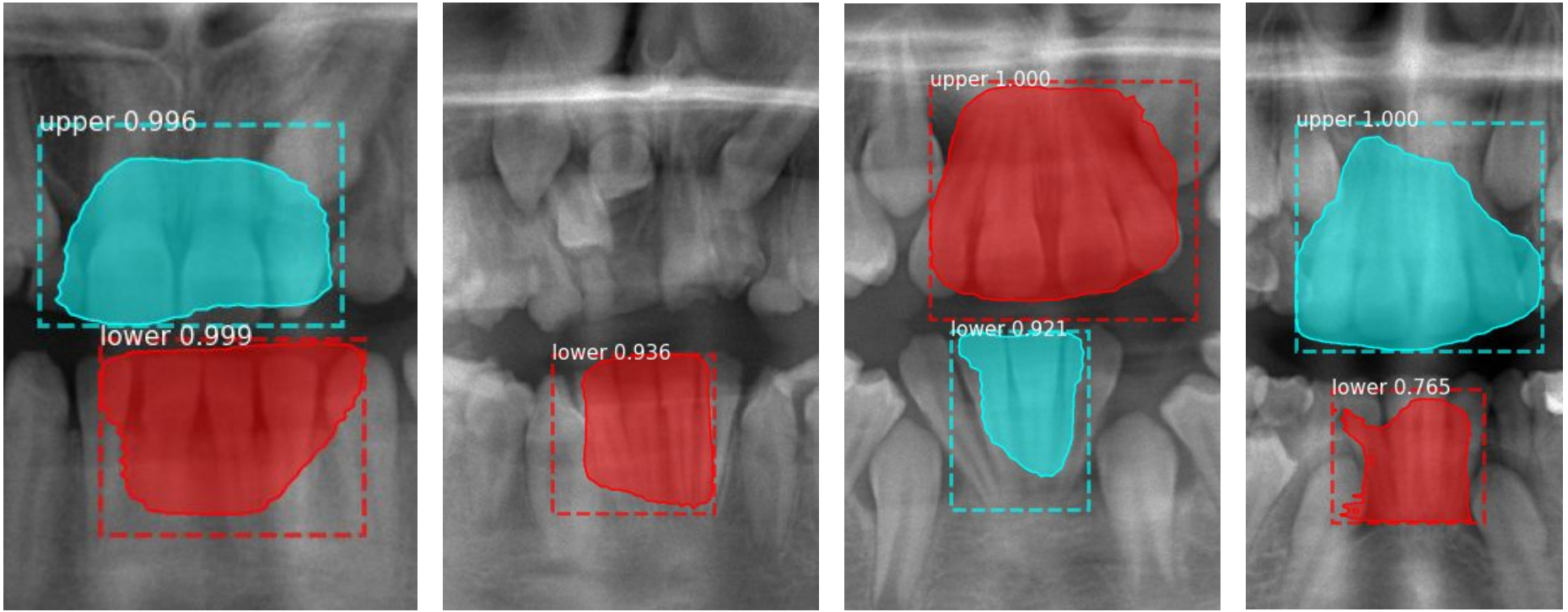
Accuracy: 98.61%
Precision: 82.71%
Recall: 74.16%

Neural networks

Neural networks were tried as well:

- YOLO
  - Didn’t really give any results
- Mask-RCNN
  - Gave interesting results even with the limited training data

Neural networks



Neural networks