

# **Snijtand Segmentatie**

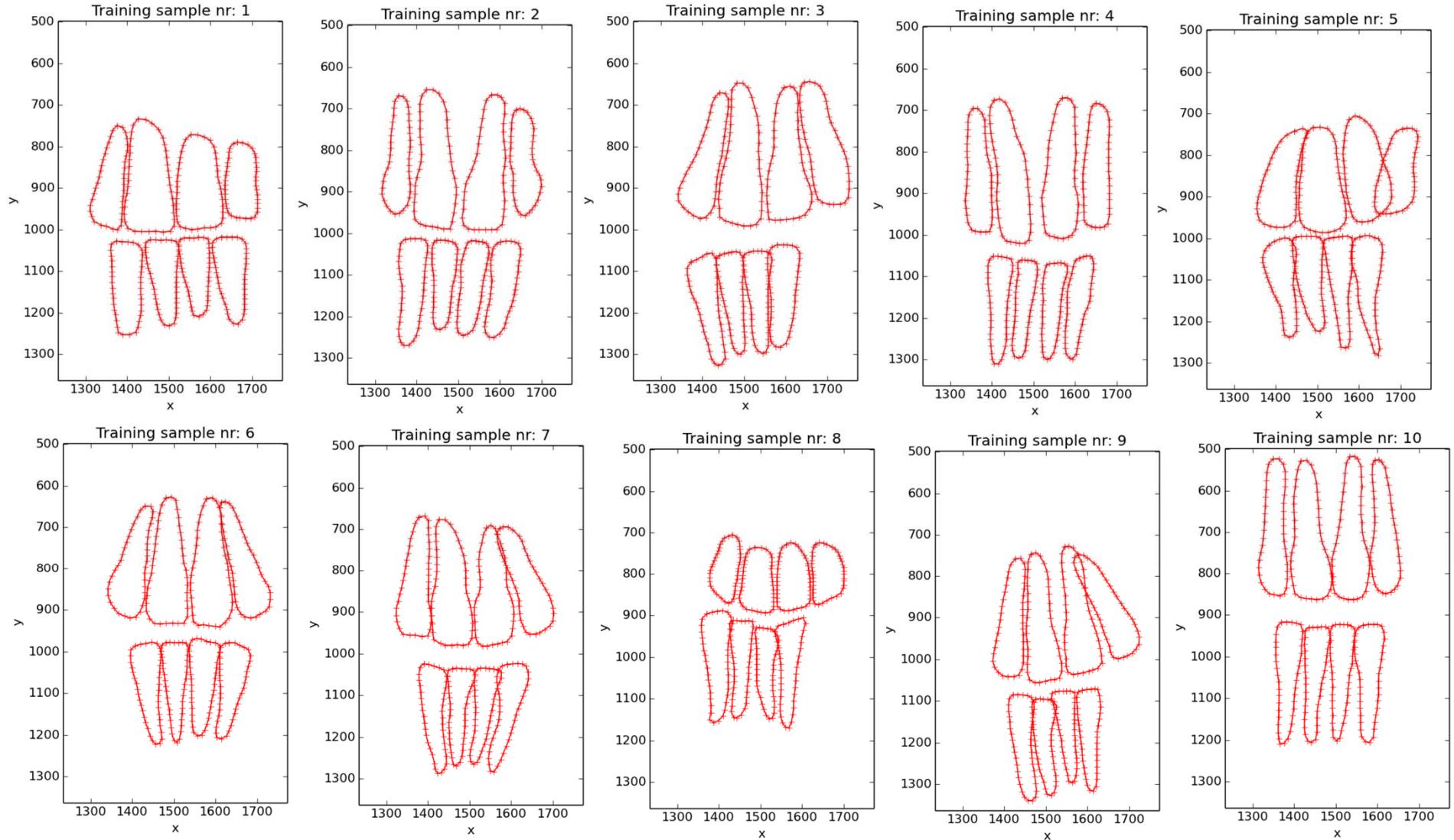
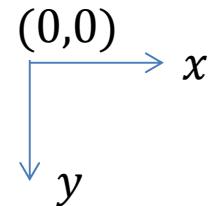
## **Computer Vision [H02K5a]: Finaal Project**

Matthias Moulin (R0255811) & Milan Samyn (R0264118)

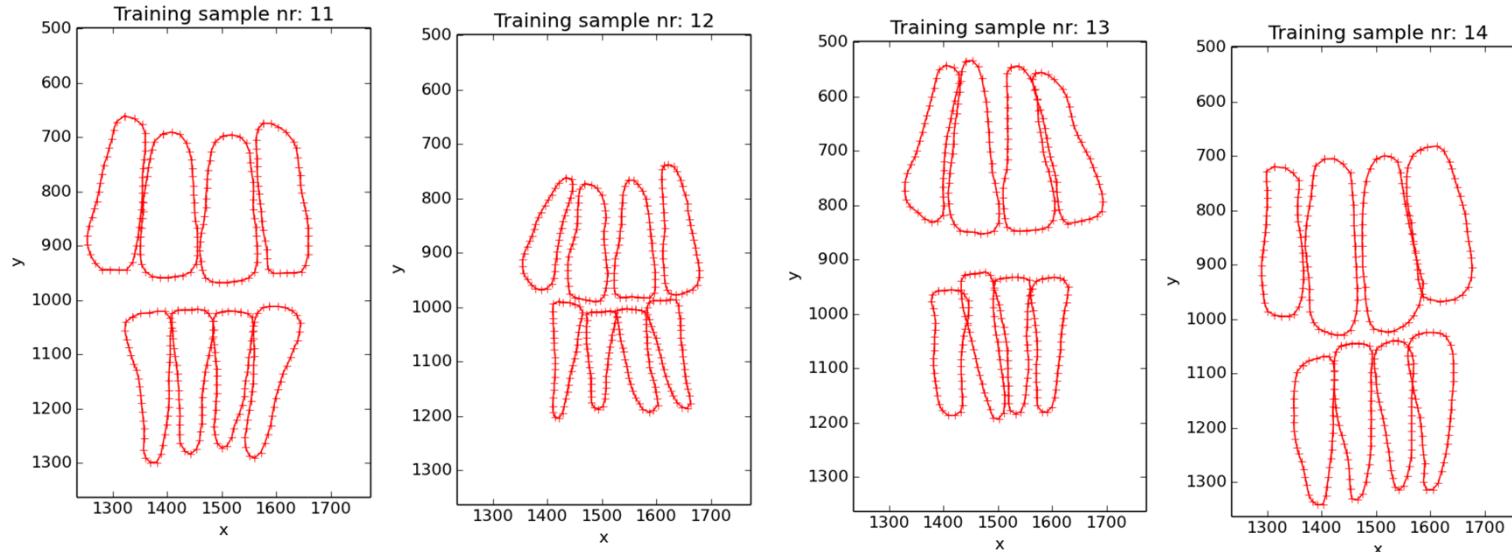
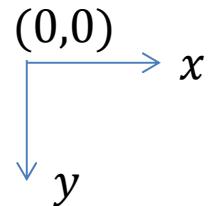
1<sup>ste</sup> Master Computerwetenschappen: Mens-Machine Communicatie

2013-2014

**Gegeven:** Trainingsamples (1-10)  
in de afbeelding-coördinatenruimte ( $x, y$ )

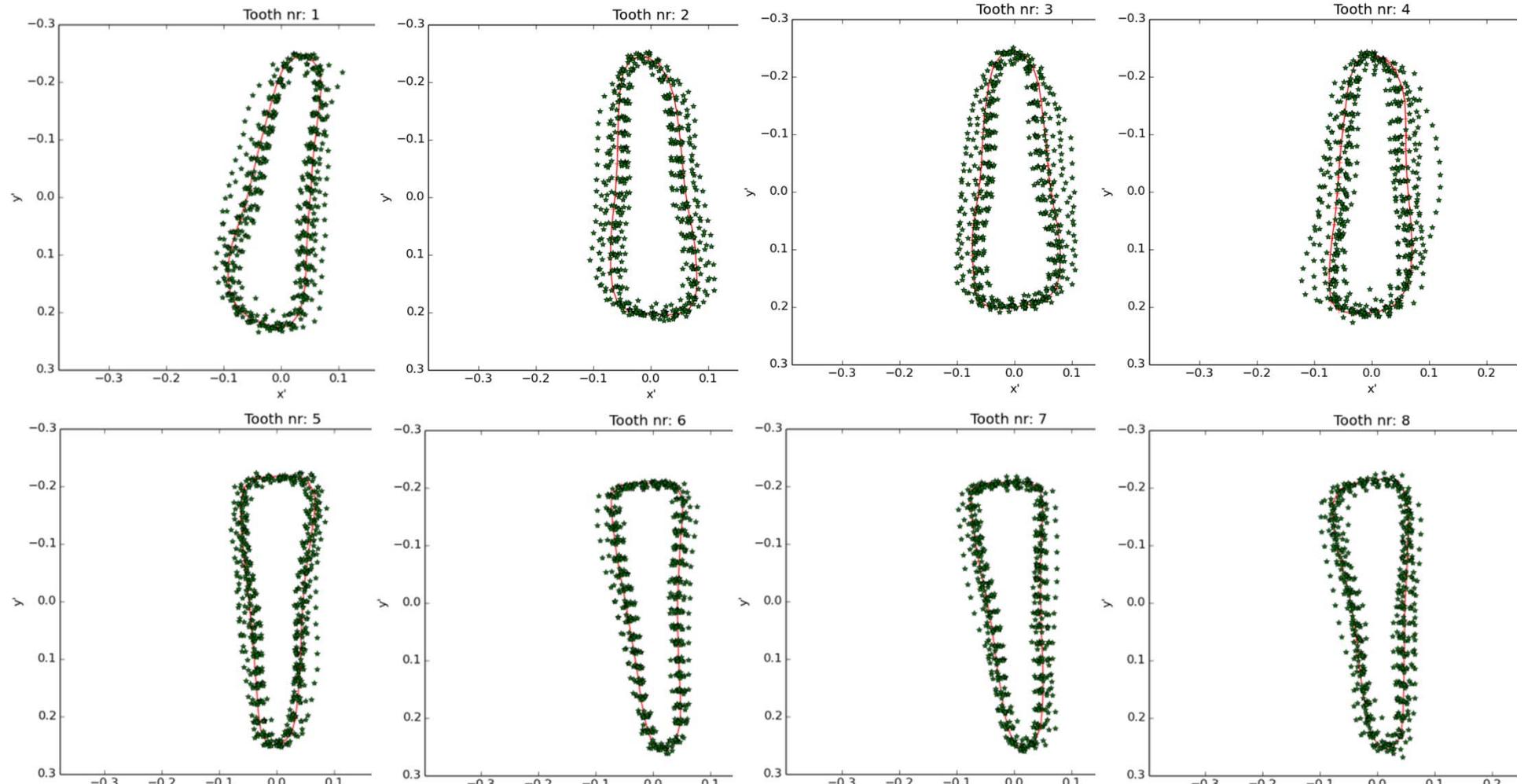
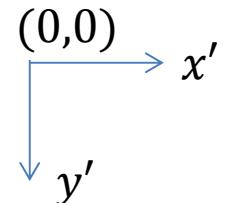


**Gegeven:** Trainingsamples (11-14)  
in de afbeelding-coördinatenruimte ( $x, y$ )



De 20 landmarks ('+' markeringen) van elk van de 8 snijanden (contouren) weergegeven in de afbeelding-coördinatenruimte ( $x, y$ ) voor elk van de 14 trainingsamples op basis van de meegeleverde landmarks bestanden.

## Procrustes Analyse: Modeltanden (1-8) in de model-coördinatenruimte ( $x'$ , $y'$ )



De bekomen modellen (contouren) en modellandmarks ('+' markeringen) voor elk van de 8 snijtanden en de trainingsamplelandmarks ('\*' markeringen) voor elk van de 14 trainingsamples weergegeven in de model-coördinatenruimte ( $x'$ ,  $y'$ ) gealigneerd met de landmarks van de tanden van trainingsample 1.

## Principal Component Analysis:

Tand	1	2	3	4	5	6	7	8
#PCs	6	6	5	5	7	7	7	7

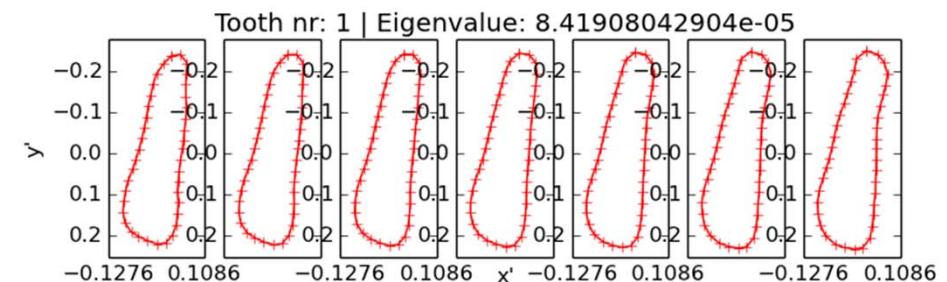
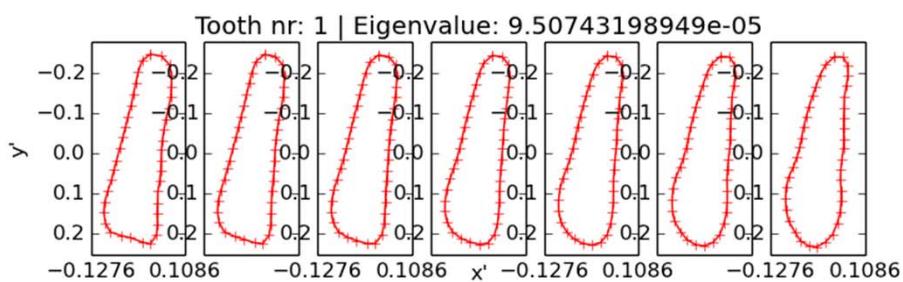
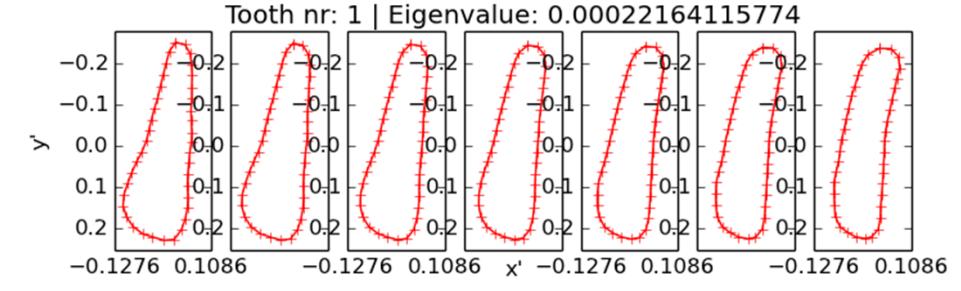
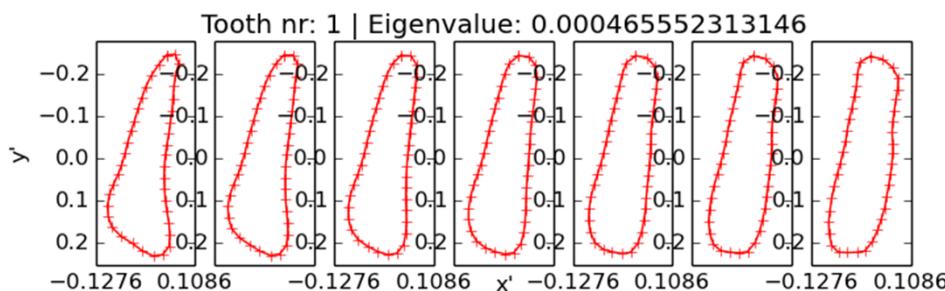
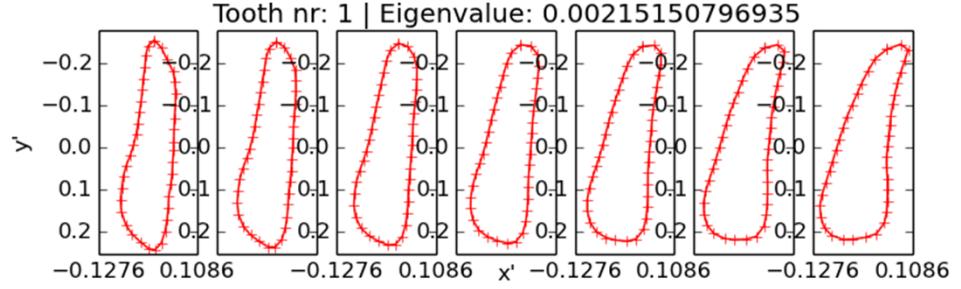
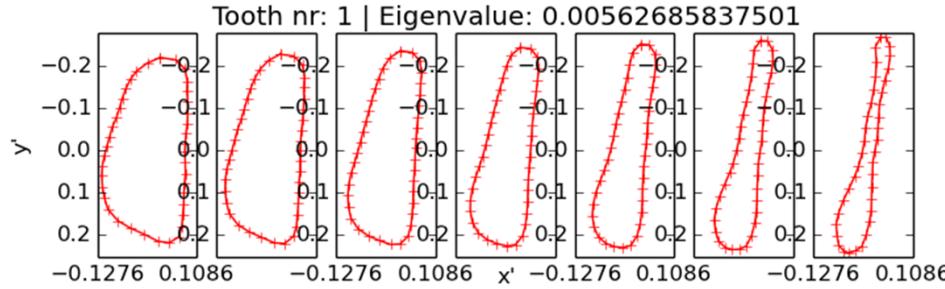
*Het aantal Principal Components voor elk van de 8 snijtanden.*

*Hierbij zijn deze vormfactors in beschouwing genomen die minstens 98% van de variantie van de landmarkposities van de 14 trainingsamples*

## Principal Component Analysis: Variaties op

modeltand 1 in de model-coördinatenruimte  $(x', y')$

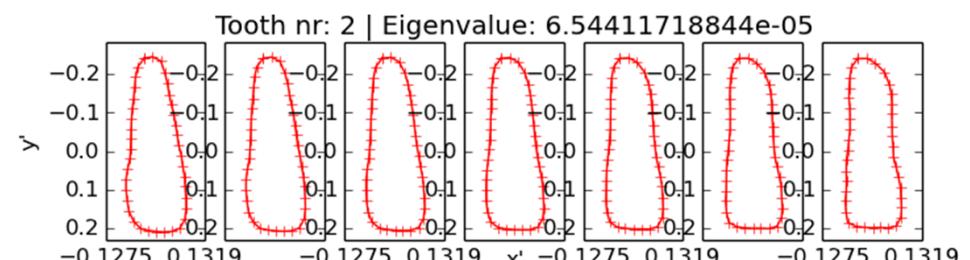
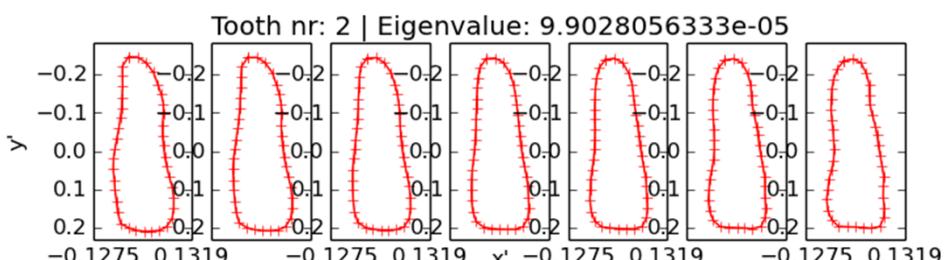
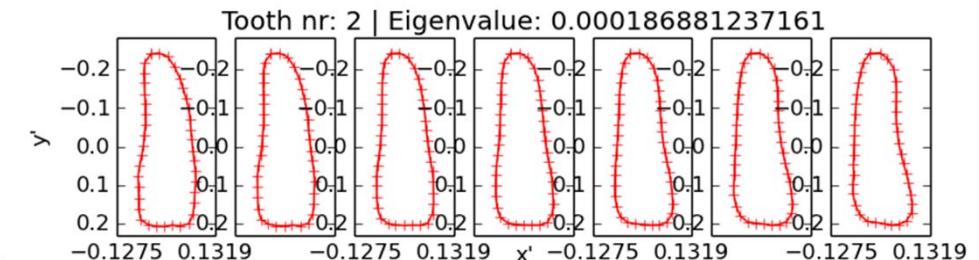
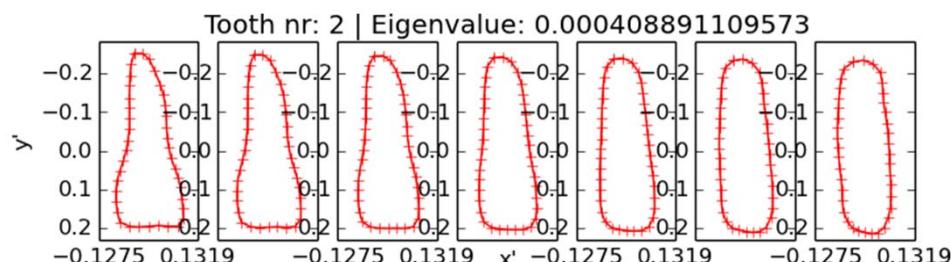
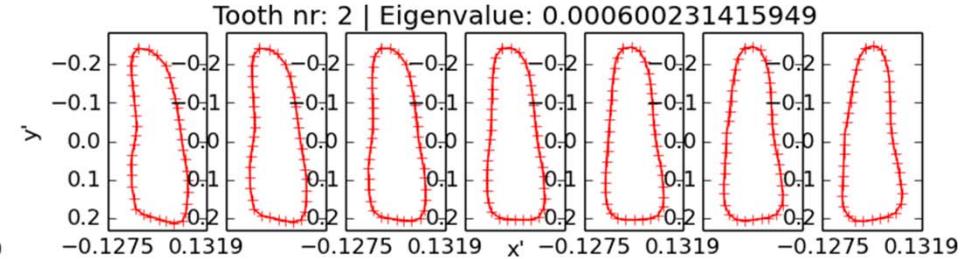
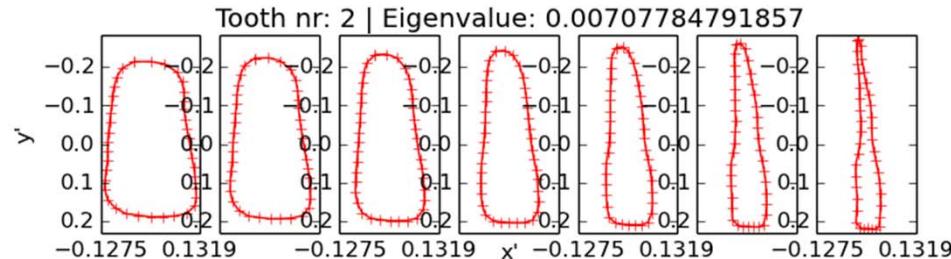
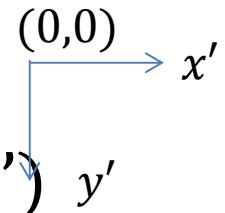
$(0,0)$   $x'$   
 $y'$



Het effect van  $-3\sqrt{\lambda}, -2\sqrt{\lambda}, -\sqrt{\lambda}, 0, \sqrt{\lambda}, 2\sqrt{\lambda}, 3\sqrt{\lambda}$  ( $\pm 3$  standaard deviaties) afwijkingen ten opzichte van het gemiddelde model voor de 1<sup>ste</sup> tand in de model-coördinatenruimte  $(x', y')$ . Hierbij zijn deze vormfactoren in beschouwing genomen die minstens 98% van de variantie van de landmarkposities van de 14 trainingsamples t.o.v. het gemiddelde model verklaren.

## Principal Component Analysis: Variaties op

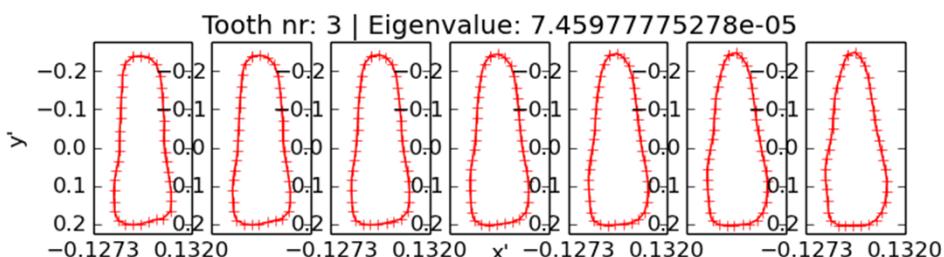
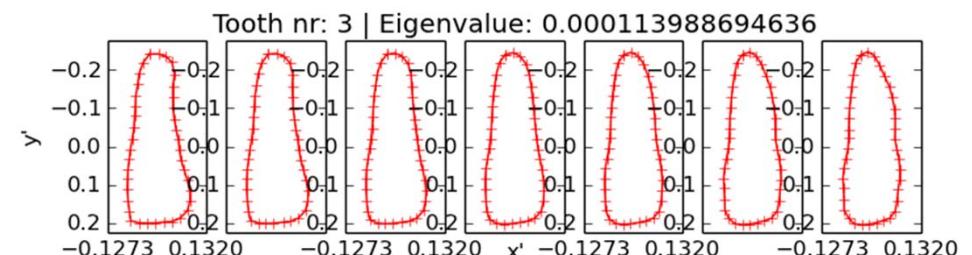
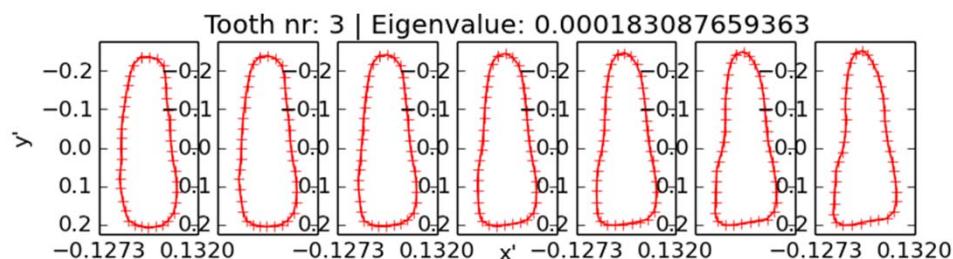
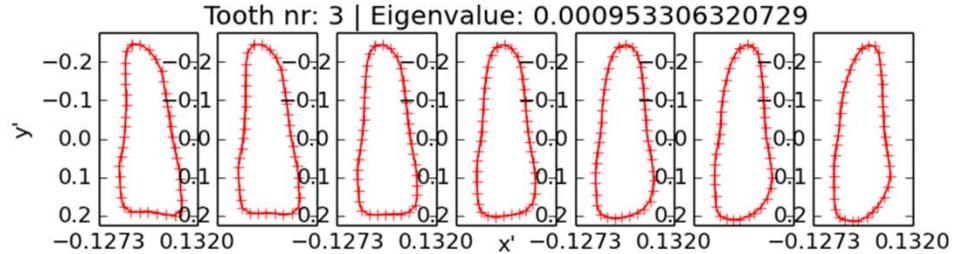
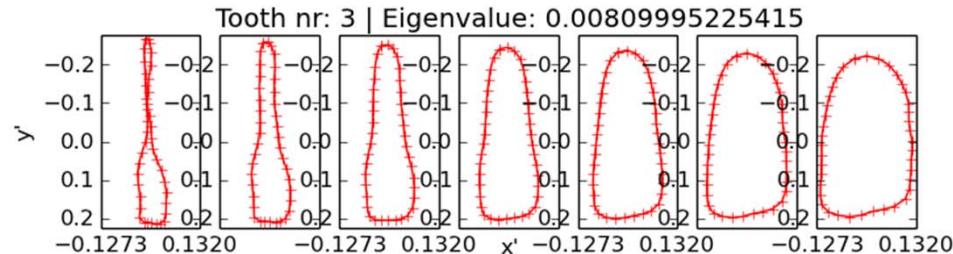
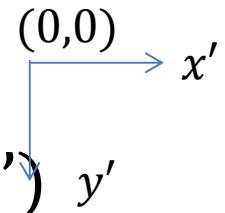
modeltand 2 in de model-coördinatenruimte  $(x', y')$



Het effect van  $-3\sqrt{\lambda}, -2\sqrt{\lambda}, -\sqrt{\lambda}, 0, \sqrt{\lambda}, 2\sqrt{\lambda}, 3\sqrt{\lambda}$  ( $\pm 3$  standaard deviaties) afwijkingen ten opzichte van het gemiddelde model voor de 2<sup>e</sup> tand in de model-coördinatenruimte  $(x', y')$ . Hierbij zijn deze vormfactoren in beschouwing genomen die minstens 98% van de variantie van de landmarkposities van de 14 trainingsamples t.o.v. het gemiddelde model verklaren.

## Principal Component Analysis: Variaties op

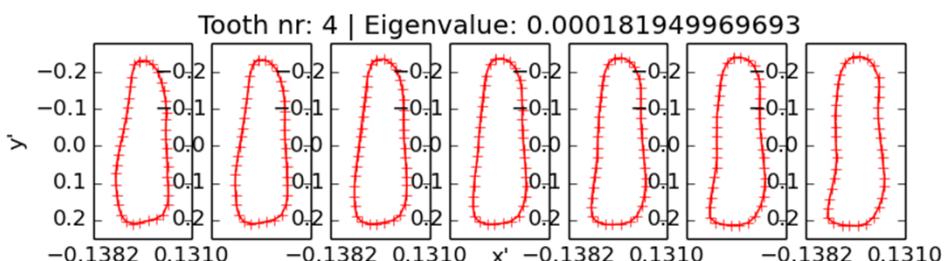
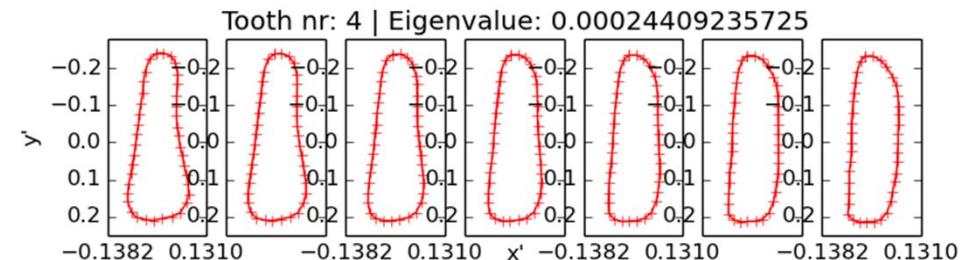
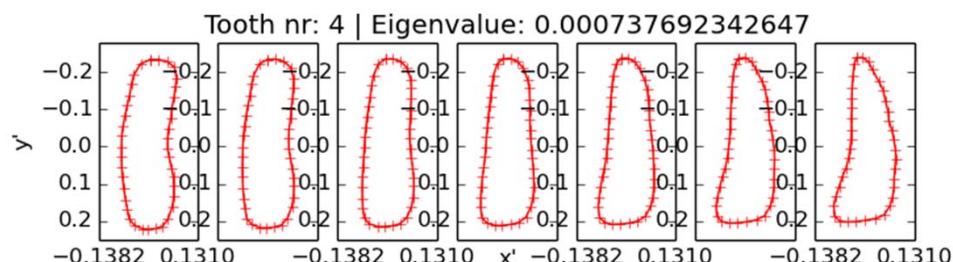
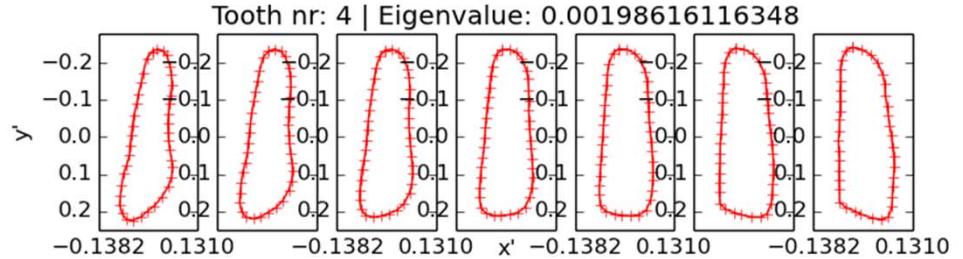
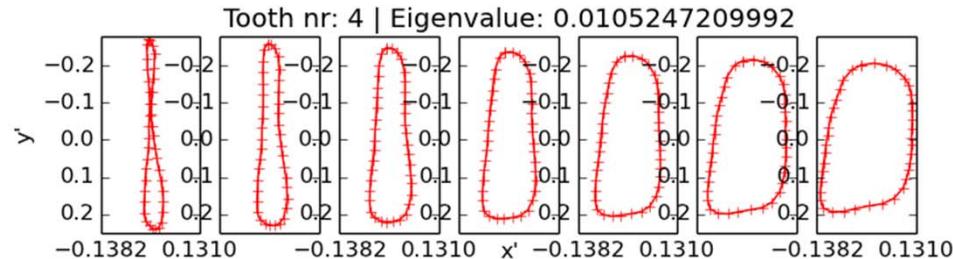
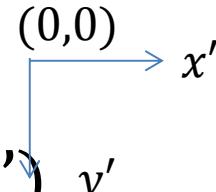
modeltand 3 in de model-coördinatenruimte  $(x', y')$



Het effect van  $-3\sqrt{\lambda}, -2\sqrt{\lambda}, -\sqrt{\lambda}, 0, \sqrt{\lambda}, 2\sqrt{\lambda}, 3\sqrt{\lambda}$  ( $\pm 3$  standaard deviaties) afwijkingen ten opzichte van het gemiddelde model voor de 3<sup>e</sup> tand in de model-coördinatenruimte  $(x', y')$ . Hierbij zijn deze vormfactoren in beschouwing genomen die minstens 98% van de variantie van de landmarkposities van de 14 trainingsamples t.o.v. het gemiddelde model verklaren.

## Principal Component Analysis: Variaties op

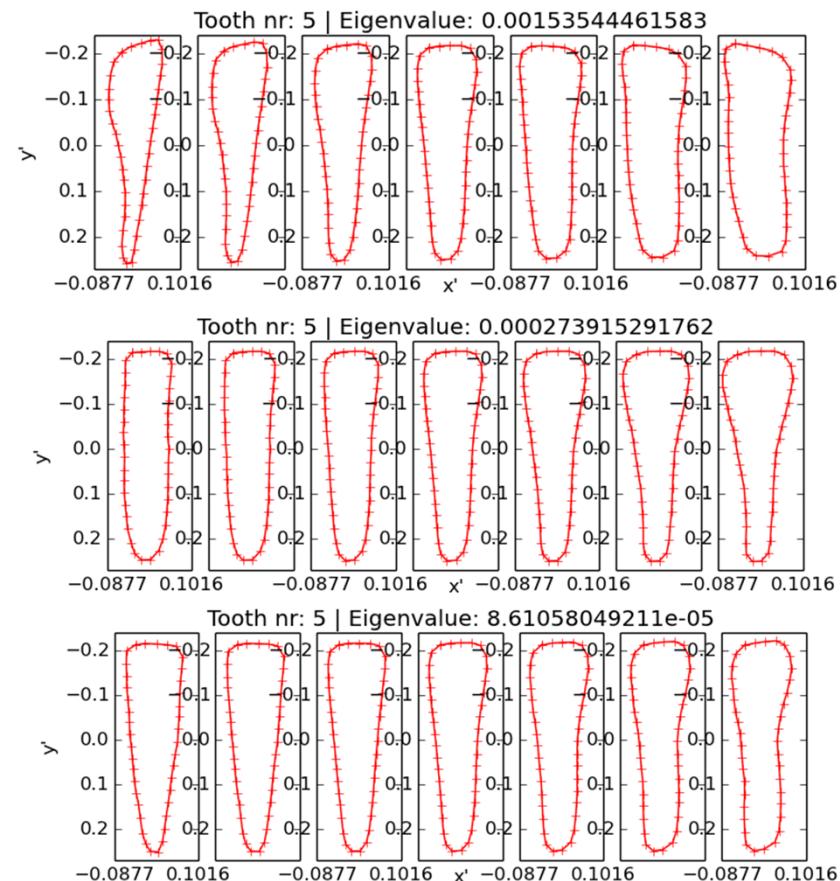
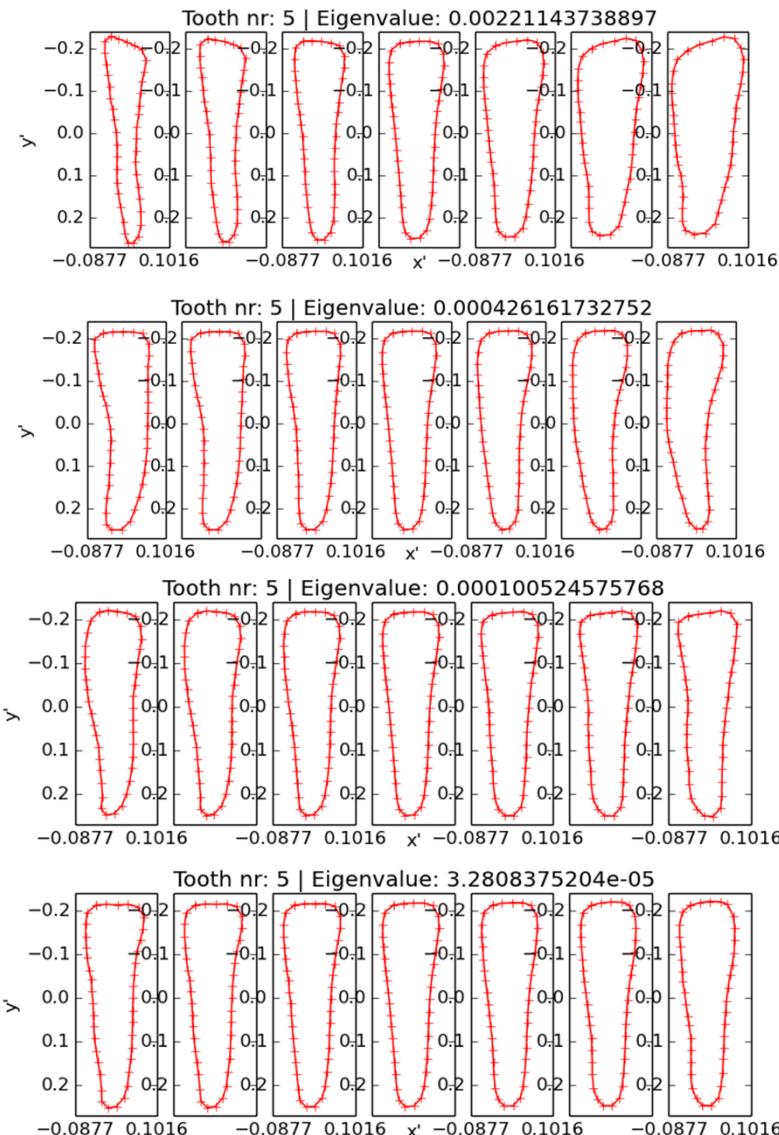
modeltand 4 in de model-coördinatenruimte  $(x', y')$



Het effect van  $-3\sqrt{\lambda}, -2\sqrt{\lambda}, -\sqrt{\lambda}, 0, \sqrt{\lambda}, 2\sqrt{\lambda}, 3\sqrt{\lambda}$  ( $\pm 3$  standaard deviaties) afwijkingen ten opzichte van het gemiddelde model voor de 4<sup>e</sup> tand in de model-coördinatenruimte  $(x', y')$ . Hierbij zijn deze vormfactoren in beschouwing genomen die minstens 98% van de variantie van de landmarkposities van de 14 trainingsamples t.o.v. het gemiddelde model verklaren.

# Principal Component Analysis: Variaties op modeltand 5 in de model-coördinatenruimte $(x', y')$

$(0,0)$   $x'$   
y'

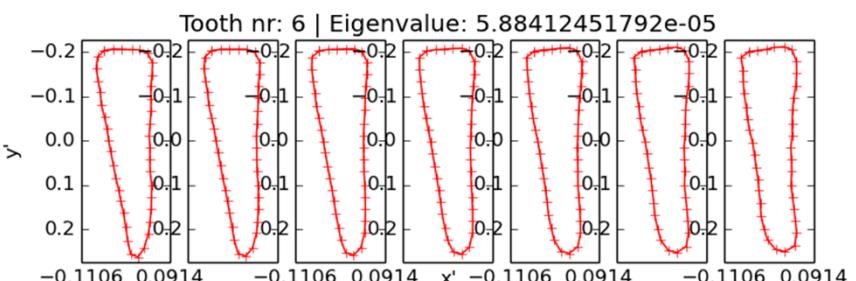
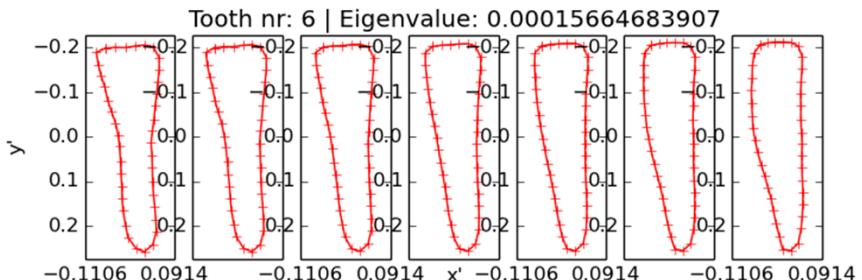
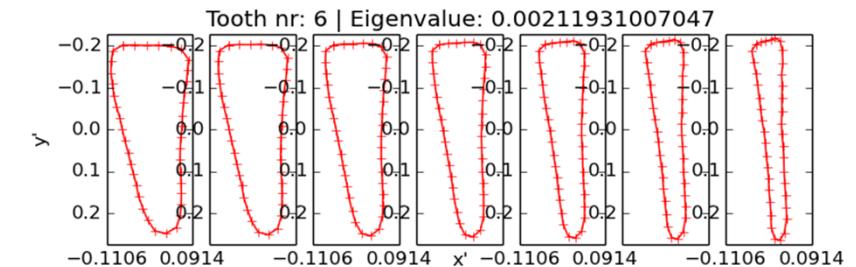
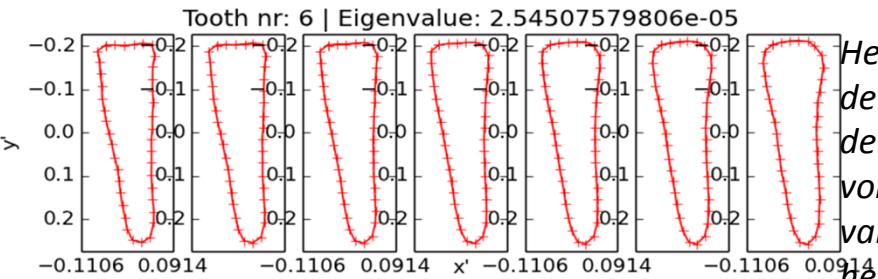
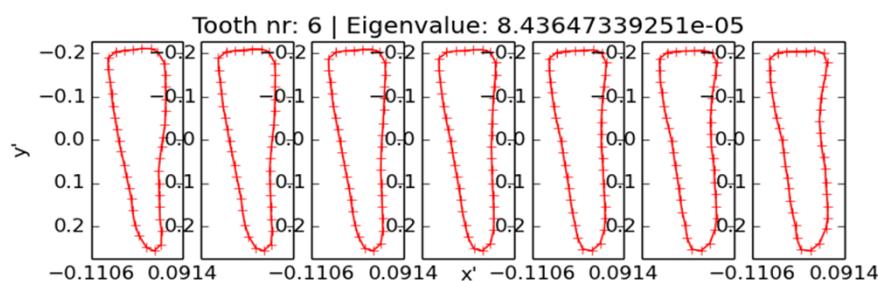
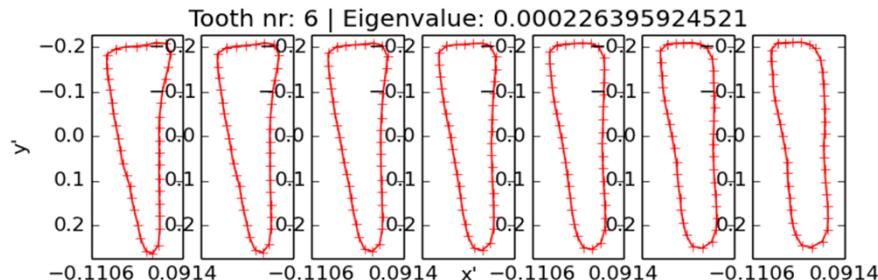
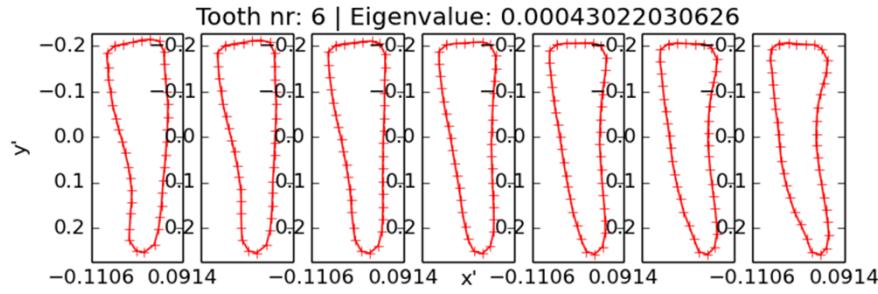


Het effect van  $-3\sqrt{\lambda}, -2\sqrt{\lambda}, -\sqrt{\lambda}, 0, \sqrt{\lambda}, 2\sqrt{\lambda}, 3\sqrt{\lambda}$  ( $\pm 3$  standaard deviaties) afwijkingen ten opzichte van het gemiddelde model voor de 5<sup>e</sup> tand in de model-coördinatenruimte  $(x', y')$ . Hierbij zijn deze vormfactoren in beschouwing genomen die minstens 98% van de variantie van de landmarkposities van de 14 trainingsamples t.o.v. het gemiddelde model verklaren.

## Principal Component Analysis: Variaties op

modeltand 6 in de model-coördinatenruimte  $(x', y')$

$(0,0)$   $x'$   
y'

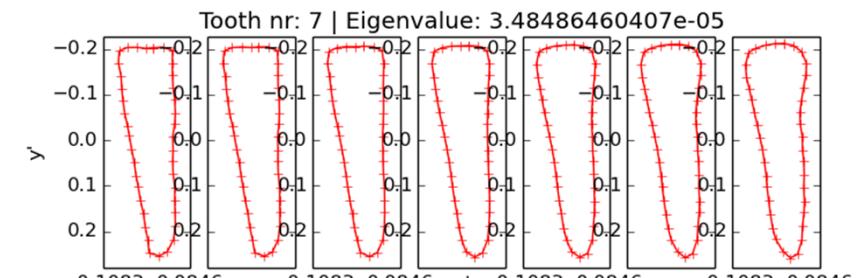
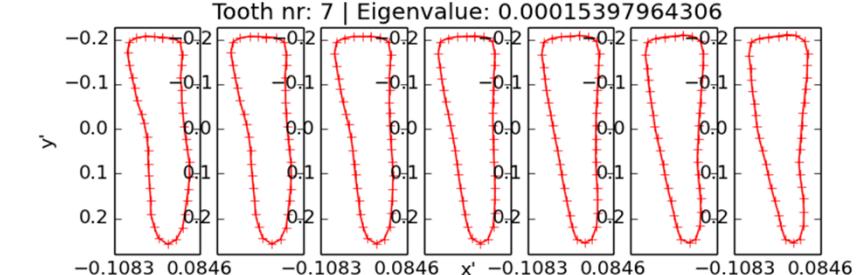
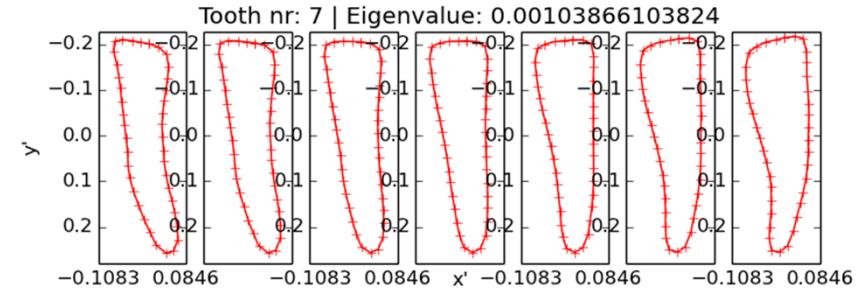
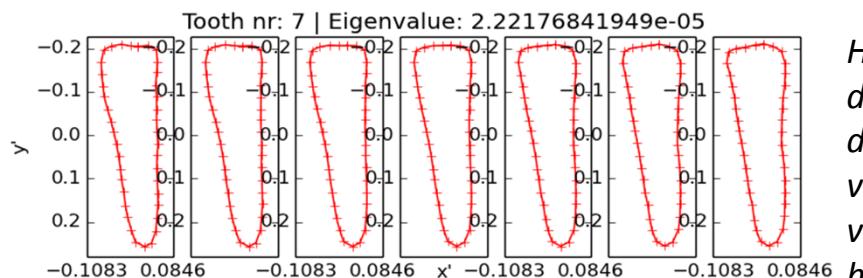
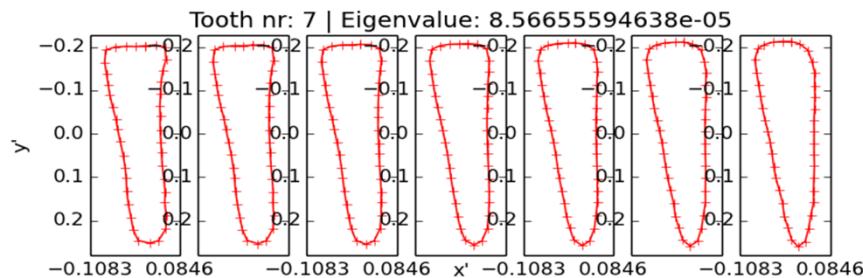
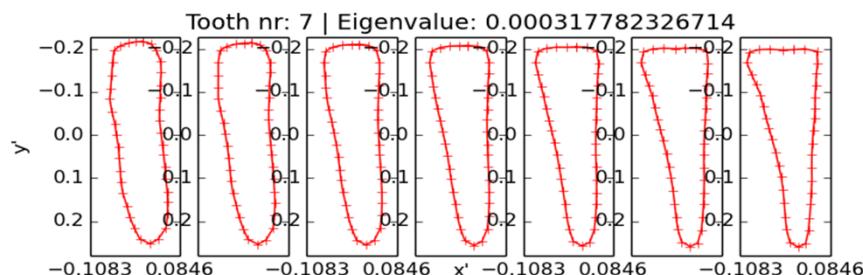
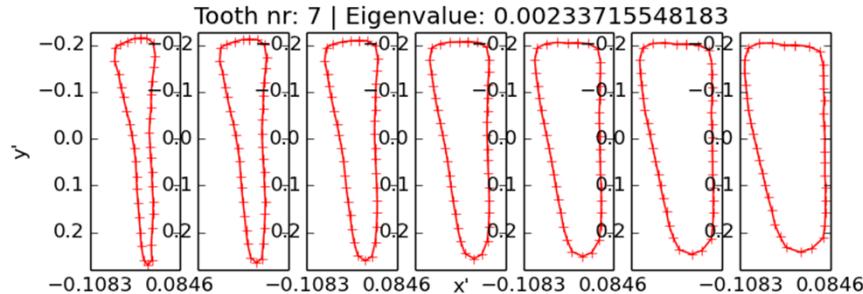


Het effect van  $-3\sqrt{\lambda}, -2\sqrt{\lambda}, -\sqrt{\lambda}, 0, \sqrt{\lambda}, 2\sqrt{\lambda}, 3\sqrt{\lambda}$  ( $\pm 3$  standaard afwijkingen) ten opzichte van het gemiddelde model voor de 6<sup>e</sup> tand in de model-coördinatenruimte  $(x', y')$ . Hierbij zijn deze vormfactoren in beschouwing genomen die minstens 98% van de variantie van de landmarkposities van de 14 trainingsamples t.o.v. het gemiddelde model verklaren.

## Principal Component Analysis: Variaties op

modeltand 7 in de model-coördinatenruimte  $(x', y')$

$(0,0)$   $x'$   
y'

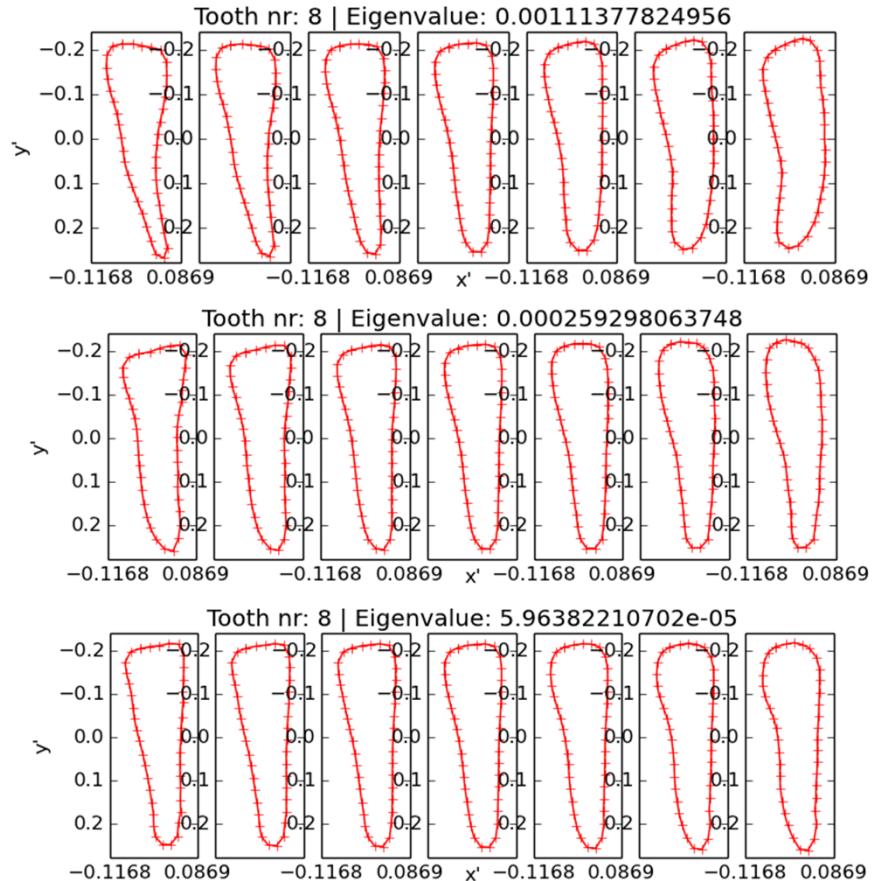
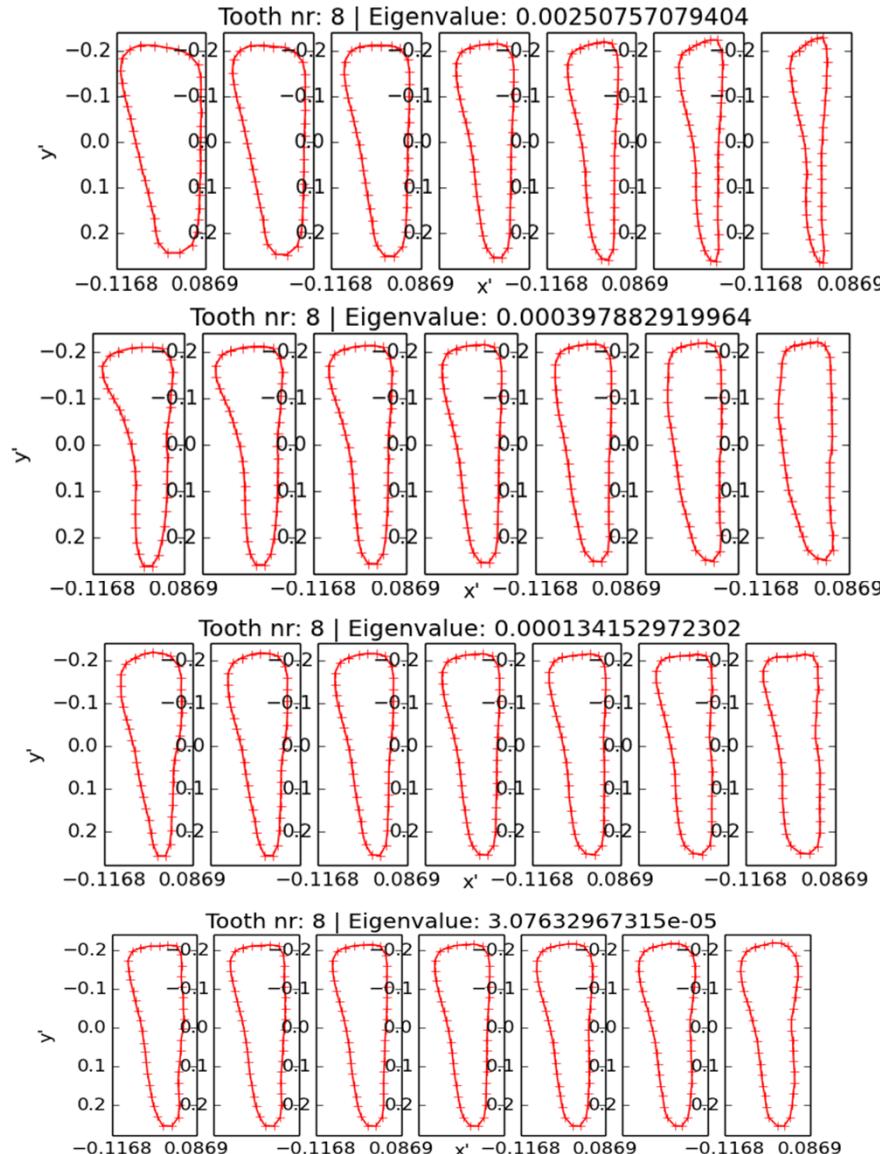


Het effect van  $-3\sqrt{\lambda}, -2\sqrt{\lambda}, -\sqrt{\lambda}, 0, \sqrt{\lambda}, 2\sqrt{\lambda}, 3\sqrt{\lambda}$  ( $\pm 3$  standaard deviaties) afwijkingen ten opzichte van het gemiddelde model voor de 7<sup>e</sup> tand in de model-coördinatenruimte  $(x', y')$ . Hierbij zijn deze vormfactoren in beschouwing genomen die minstens 98% van de variantie van de landmarkposities van de 14 trainingsamples t.o.v. het gemiddelde model verklaren.

## Principal Component Analysis: Variaties op

modeltand 8 in de model-coördinatenruimte  $(x', y')$

$(0,0)$   $x'$   
y'



Het effect van  $-3\sqrt{\lambda}, -2\sqrt{\lambda}, -\sqrt{\lambda}, 0, \sqrt{\lambda}, 2\sqrt{\lambda}, 3\sqrt{\lambda}$  ( $\pm 3$  standaard deviaties) afwijkingen ten opzichte van het gemiddelde model voor de 8<sup>e</sup> tand in de model-coördinatenruimte  $(x', y')$ . Hierbij zijn deze vormfactoren in beschouwing genomen die minstens 98% van de variantie van de landmarkposities van de 14 trainingsamples t.o.v. het gemiddelde model verklaren.

**Preprocessen**: Croppen -> Denoisen



Origineel



Denoised

**Preprocessen**: Croppen -> Denoisen -> Histogram Equalization



Denoised

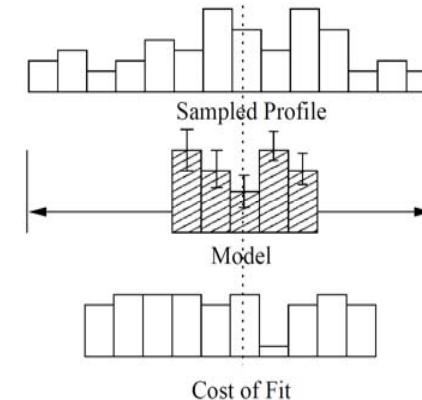
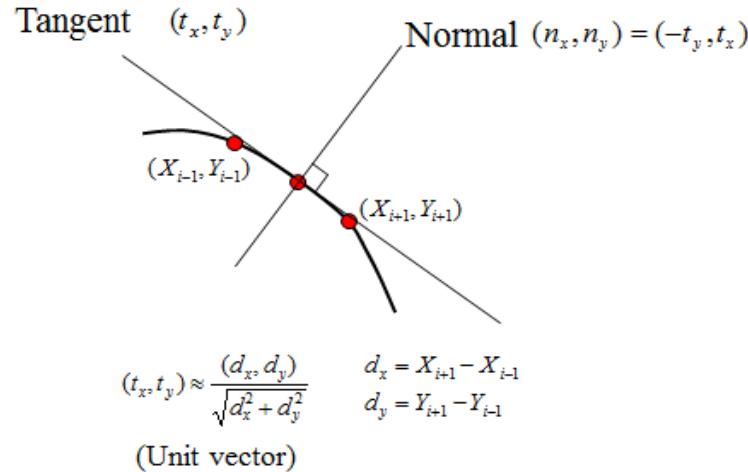


Denoised + Histogram Equalization

**Preprocessen:** Croppen -> Denoisen -> (Linear) Contrast Stretching



## Fitting: Constructie van de fitting functies



$$f(\mathbf{g}_s) = (\mathbf{g}_s - \bar{\mathbf{g}}) \mathbf{S}_g^+ (\mathbf{g}_s - \bar{\mathbf{g}}) \quad (\text{Mahalanobisafstand})$$

met

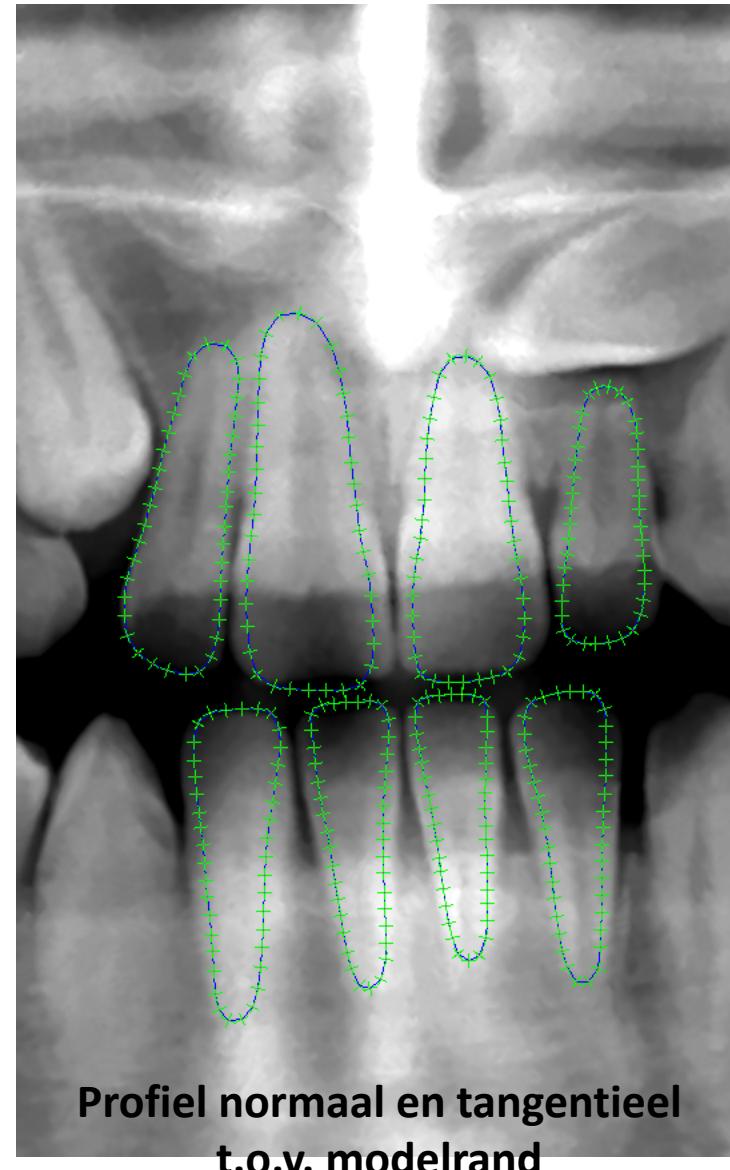
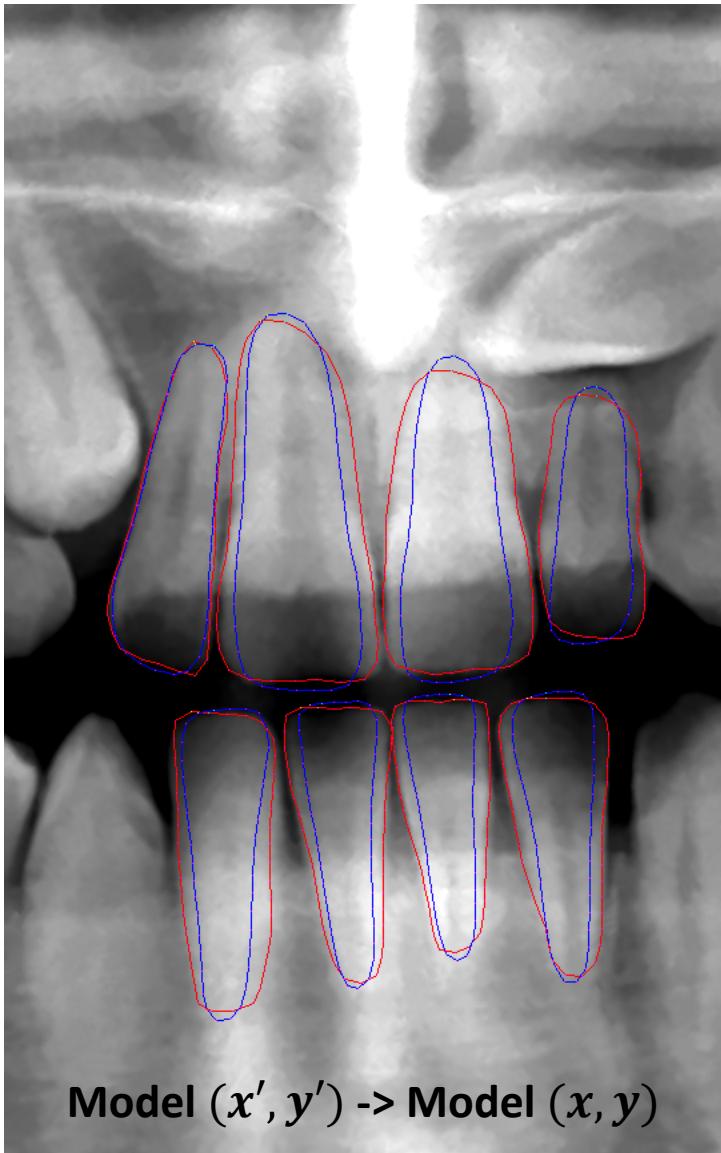
$$\bar{\mathbf{g}} = \frac{1}{n} \sum_{i=1}^n \mathbf{g}_i \quad (\text{Mean})$$

$$\mathbf{S}_g = \frac{1}{n} \sum_{i=1}^n (\mathbf{g}_s - \bar{\mathbf{g}})^T (\mathbf{g}_s - \bar{\mathbf{g}}) \quad (\text{Covariantiematrix})$$

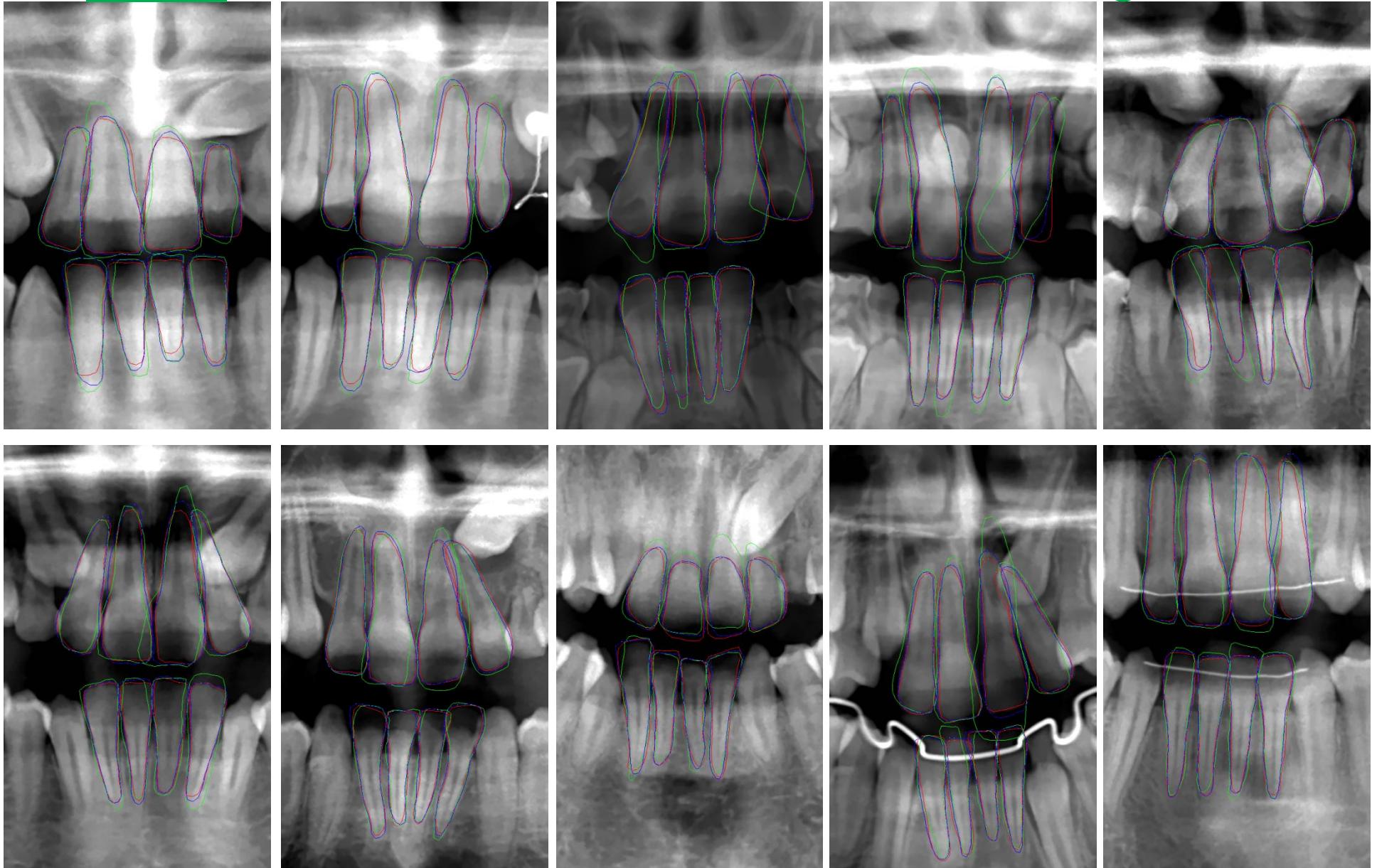
#Fitting functies 1D Profile ASM = 160 (= 8 tandmodellen \* 20 landmarks/tandmodel)

#Fitting functies 2D Profile ASM = 320 (= 2 \* 8 tandmodellen \* 20 landmarks/tandmodel)

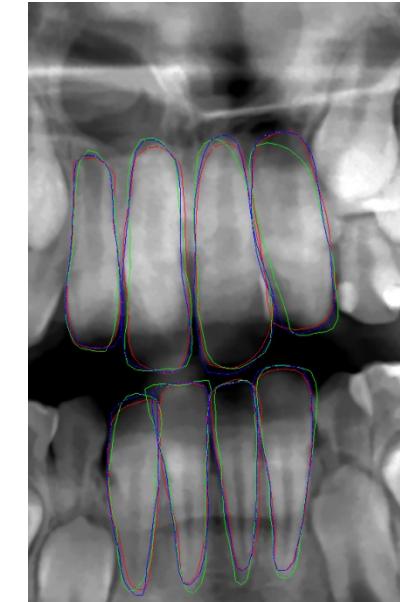
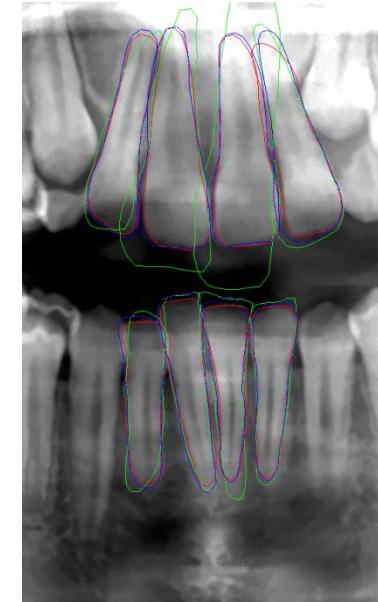
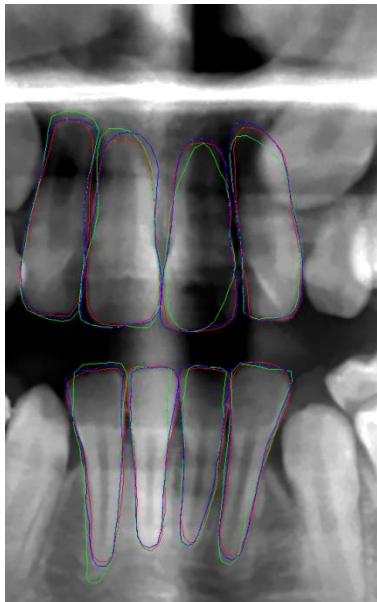
## Fitting: Constructie van de fitting functies



## Fitting: Referentie vs Normaal vs Normaal + Tangent



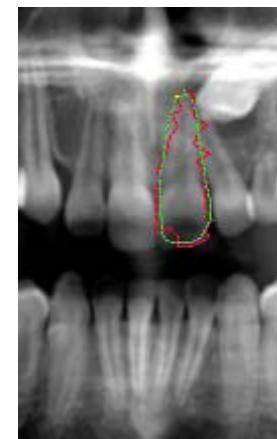
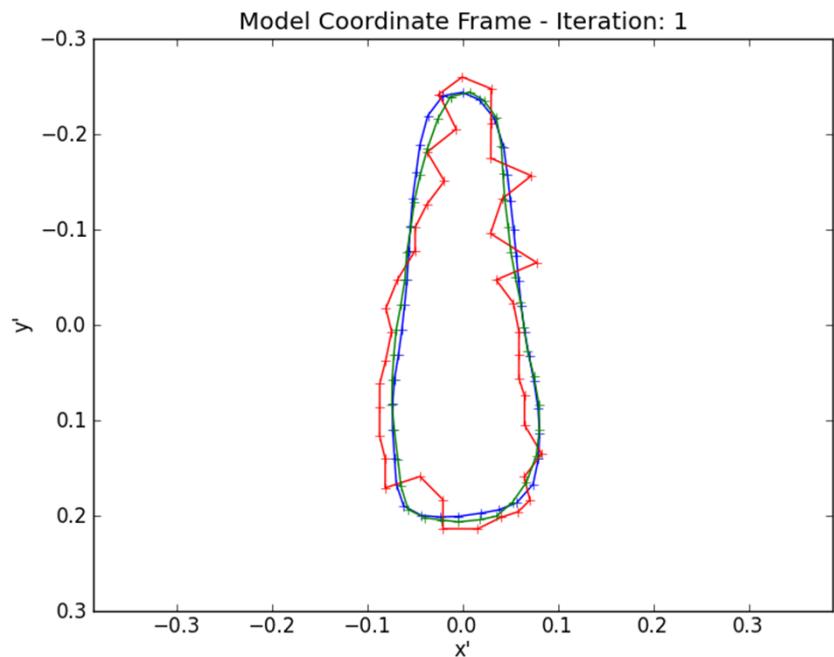
## Fitting: Referentie vs Normaal vs Normaal + Tangent



De targetlandmarks en contouren als initiële startoplossing weergegeven in het **rood** samen met de bekomen resultaatlandmarks na toepassen van een multi-resolutie ASM fittingprocedure op basis van 13 trainingsamples met fitting functies die enkel het profiel normaal t.o.v. de modelranden in beschouwing nemen, weergegeven in het **blauw**, en fitting functies die zowel het profiel normaal en tangentieel t.o.v. de modelranden in rekening nemen; weergegeven in het **groen**.

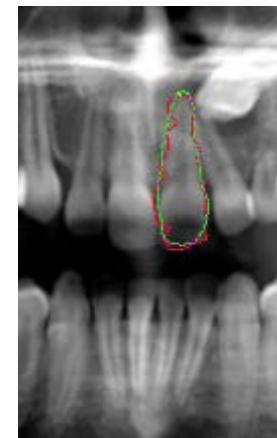
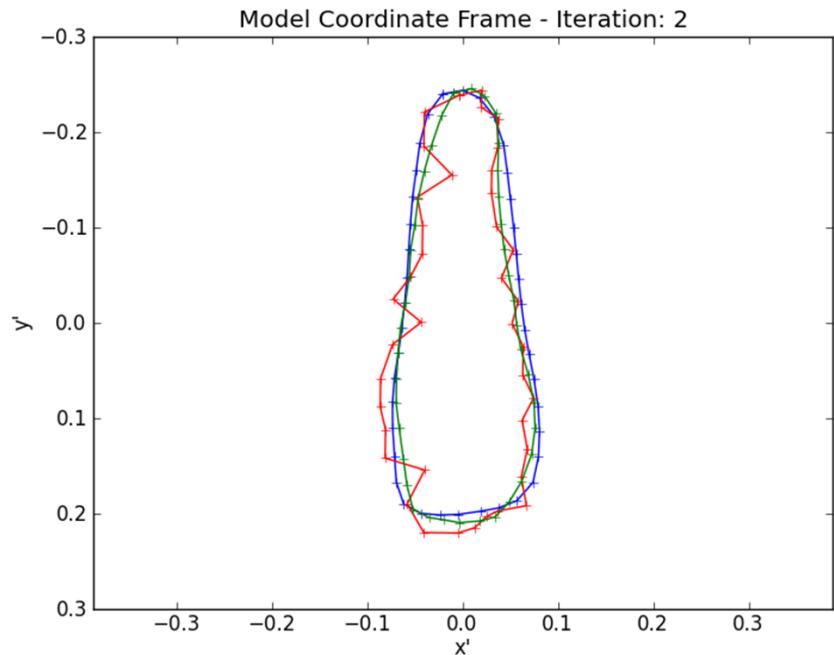
$$\#levels = 3, k = 4, m = 8$$

## Multi-Resolutie: Volledige run



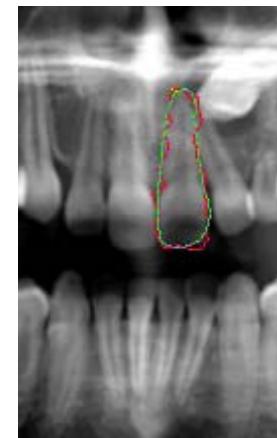
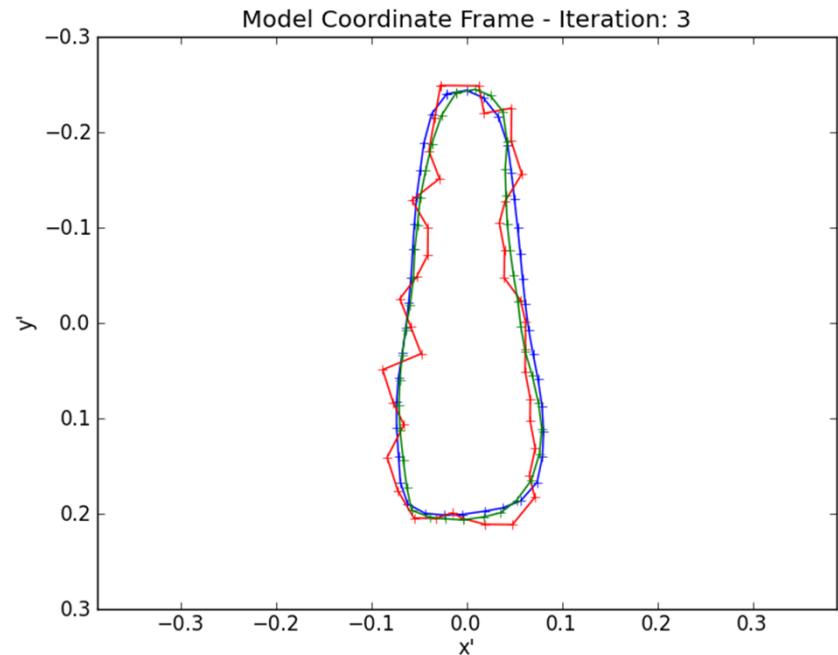
Level: 2, Iteration: 1, Ratio: 0.4

## Multi-Resolutie: Volledige run



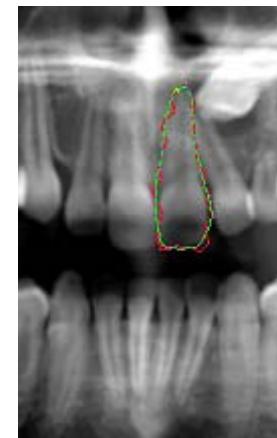
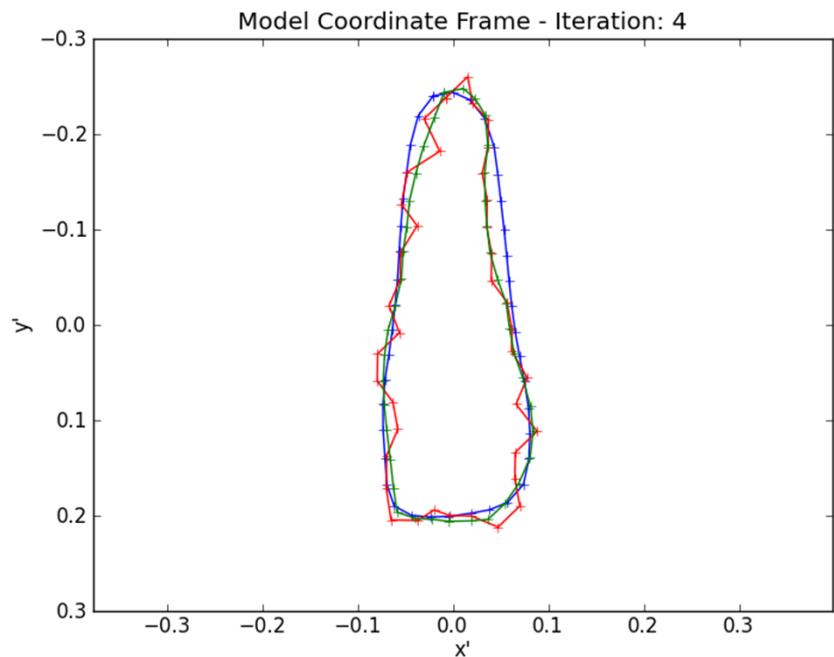
Level: 2, Iteration: 2, Ratio: 0.375

## Multi-Resolutie: Volledige run



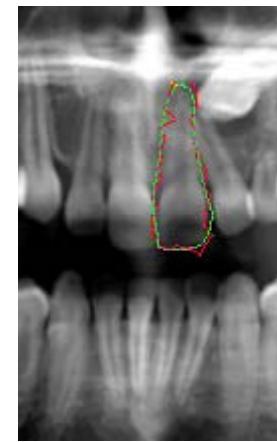
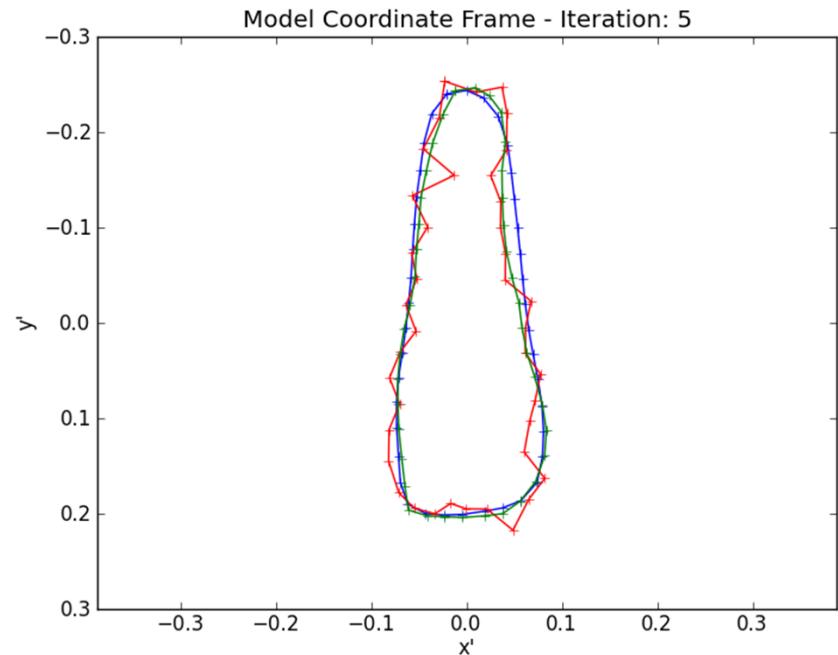
Level: 2, Iteration: 3, Ratio: 0.5

## Multi-Resolutie: Volledige run



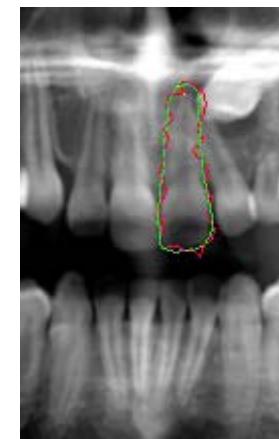
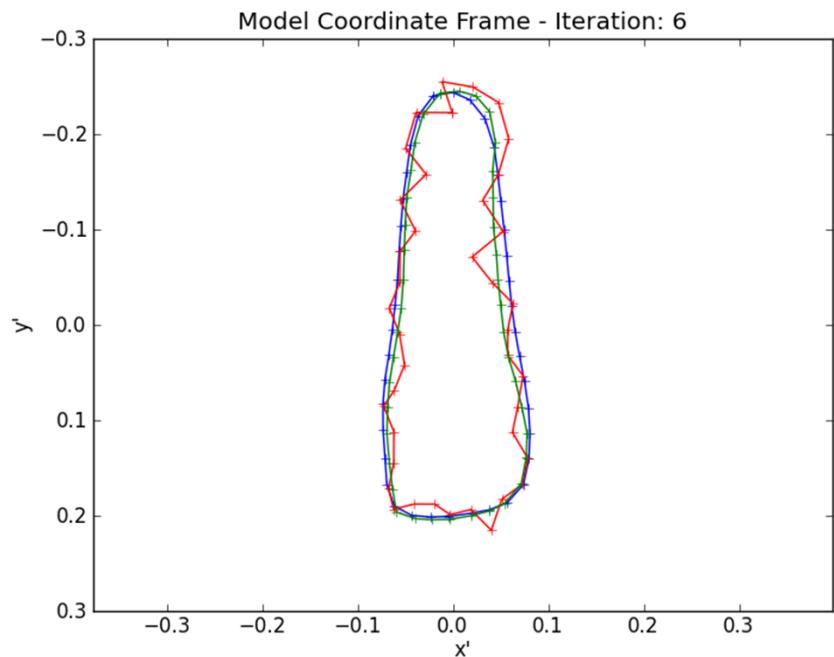
Level: 2, Iteration: 4, Ratio: 0.6

## Multi-Resolutie: Volledige run



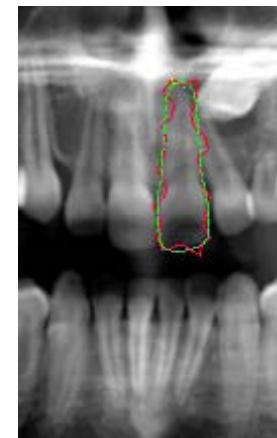
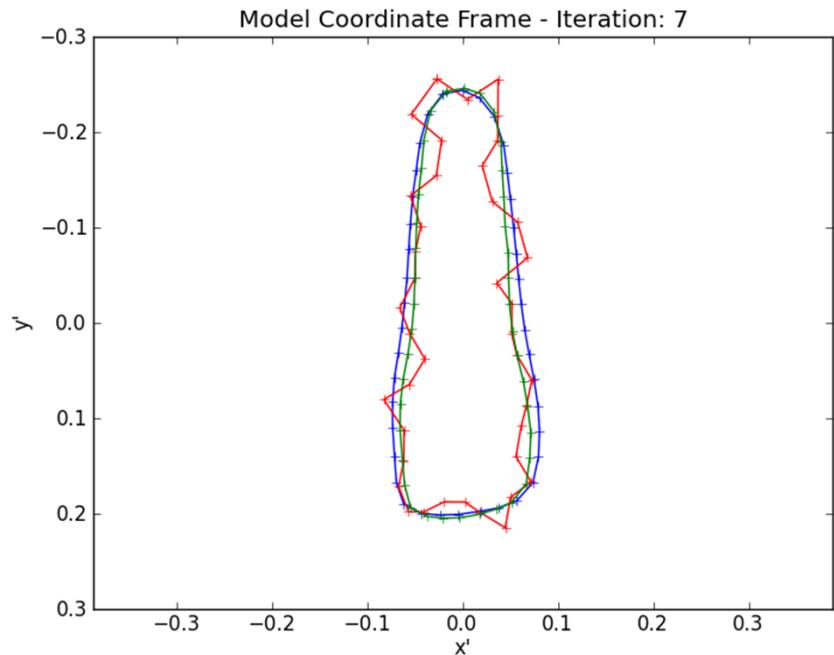
Level: 2, Iteration: 5, Ratio: 0.6

## Multi-Resolutie: Volledige run



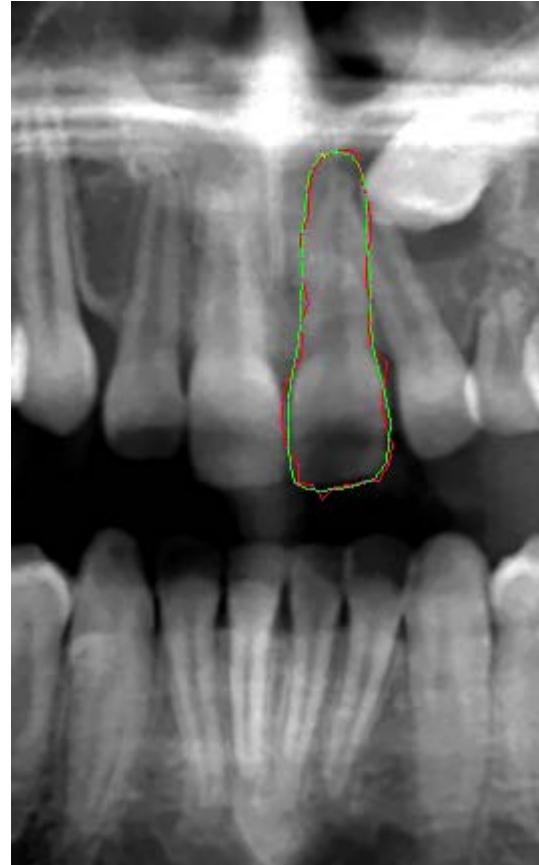
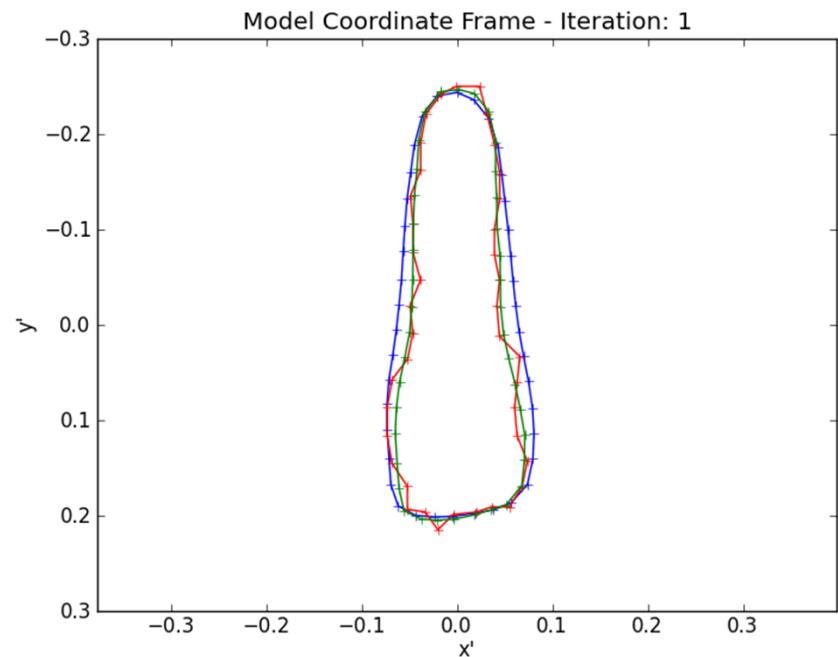
Level: 2, Iteration: 6, Ratio: 0.7

## Multi-Resolutie: Volledige run



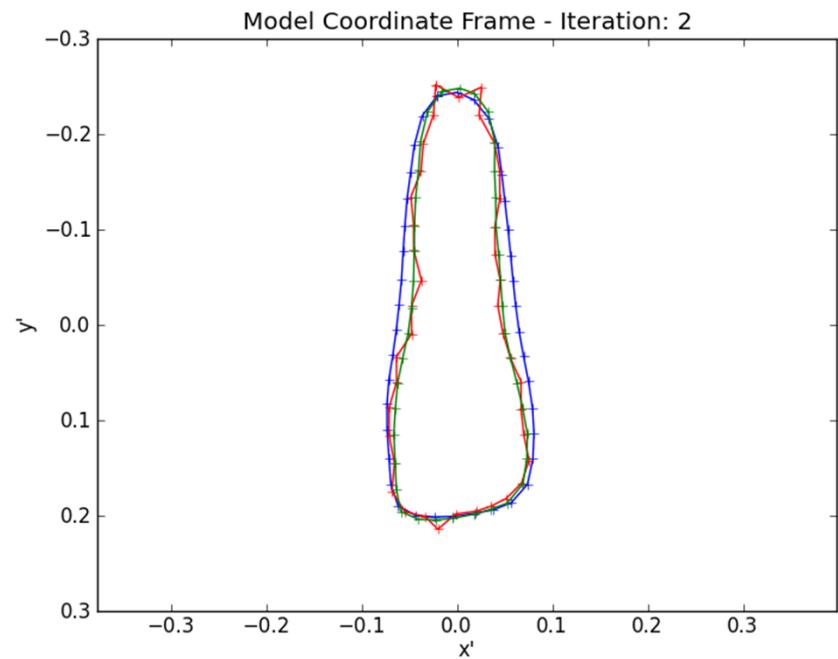
Level: 2, Iteration: 7, Ratio: 0.9

## Multi-Resolutie: Volledige run



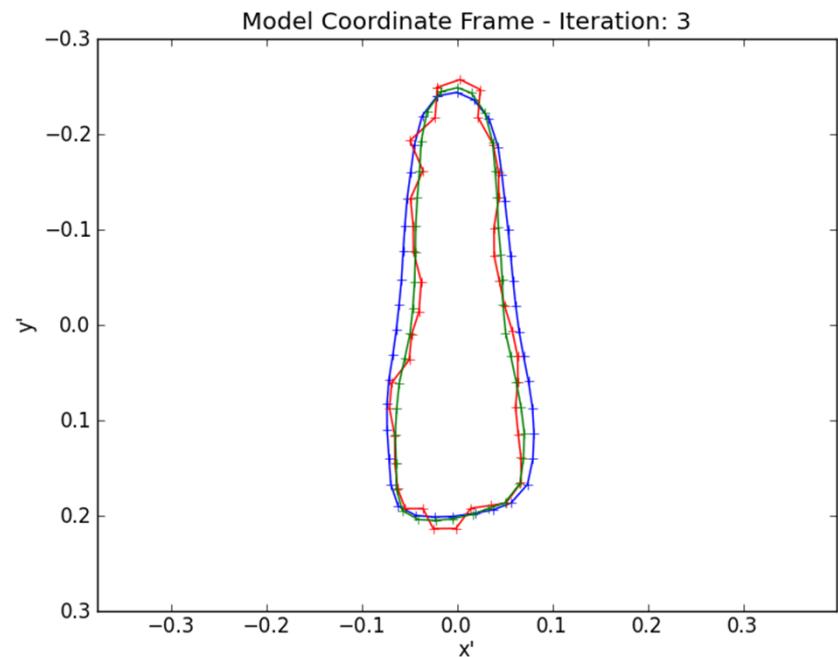
Level: 1, Iteration: 1, Ratio: 0.775

## Multi-Resolutie: Volledige run



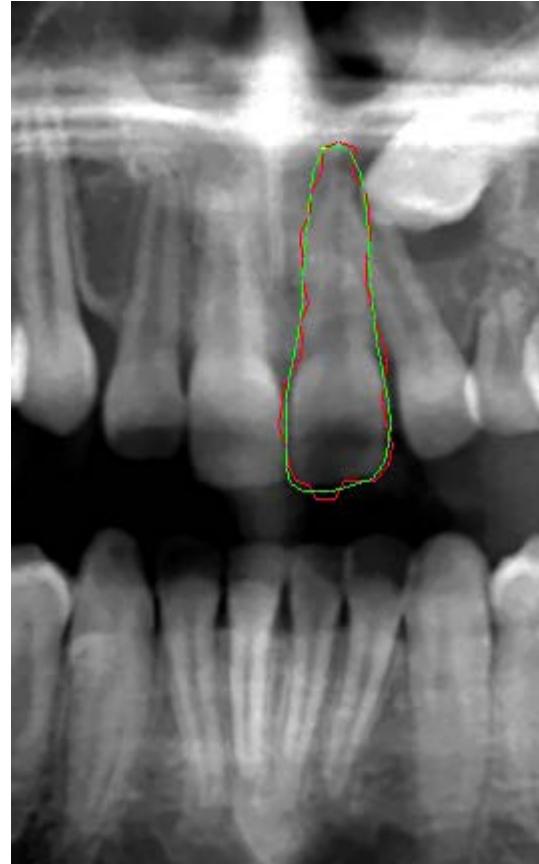
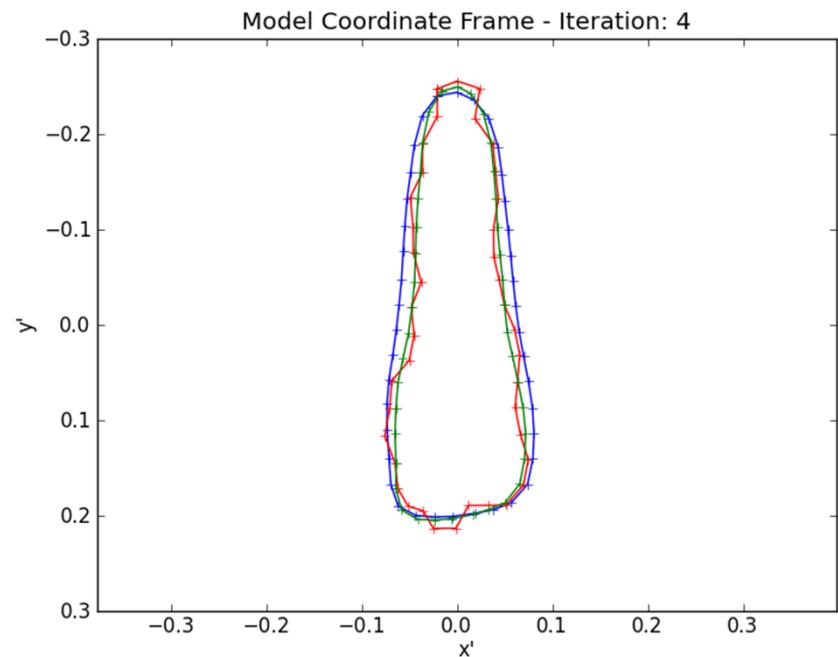
Level: 1, Iteration: 2, Ratio: 0.7

## Multi-Resolutie: Volledige run



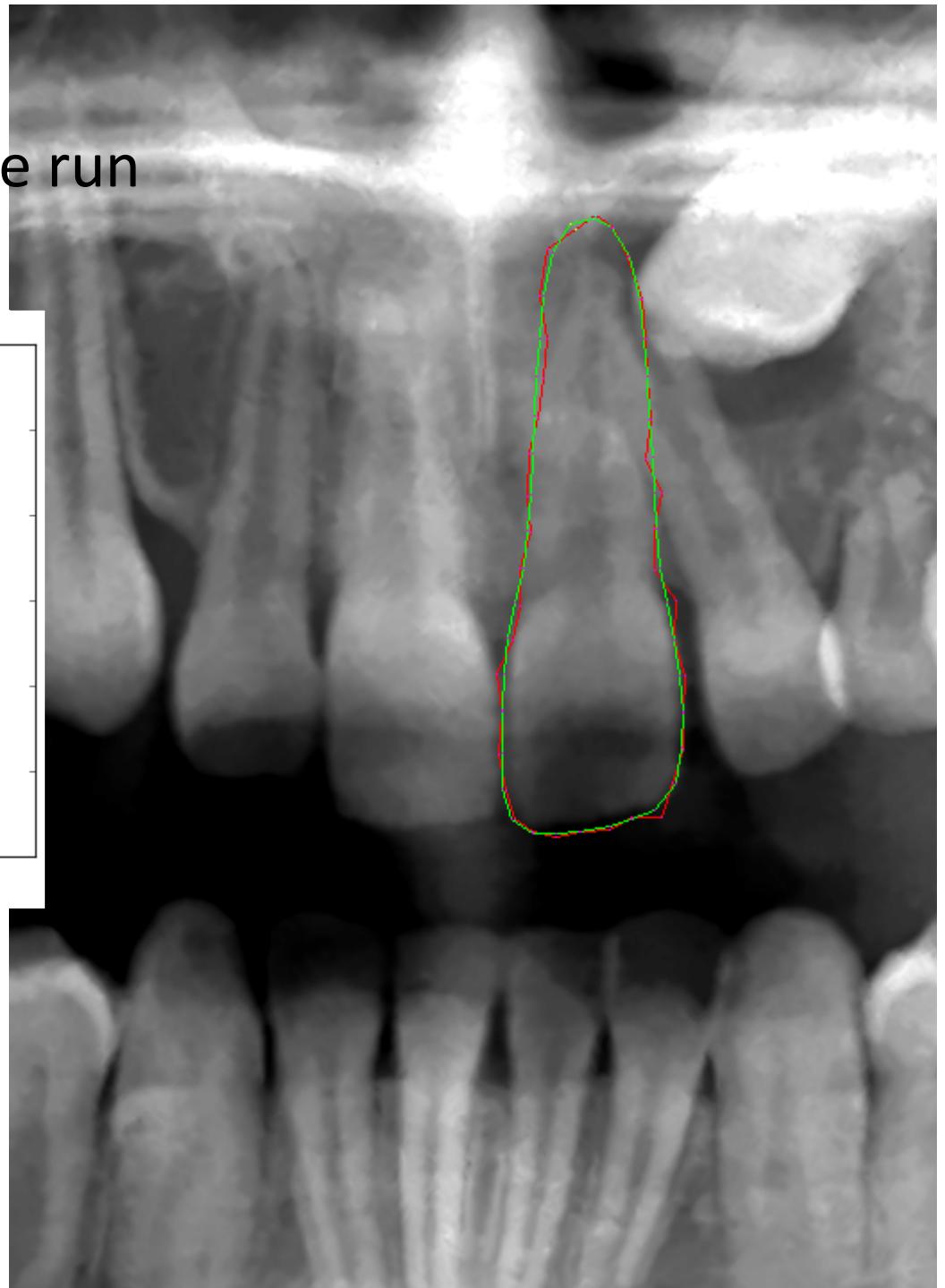
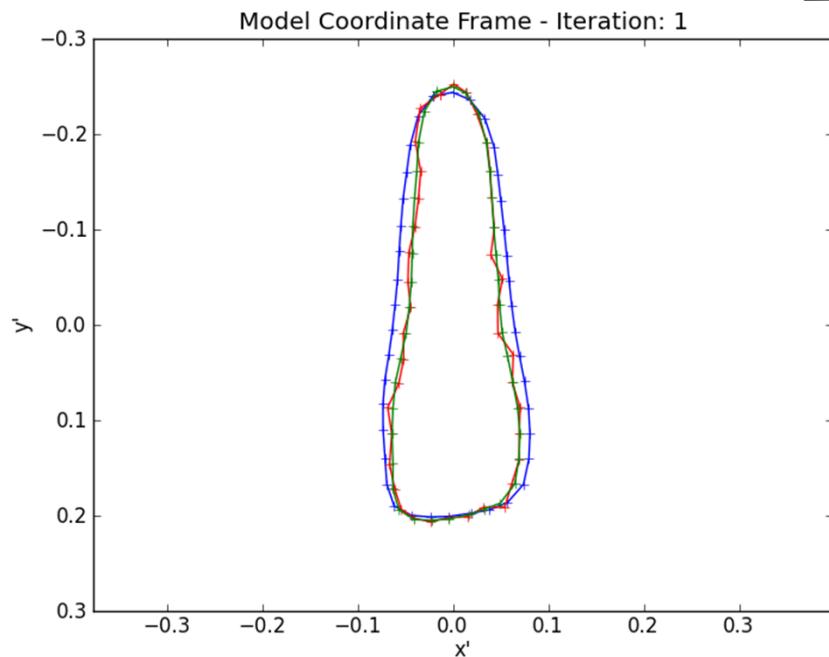
Level: 1, Iteration: 3, Ratio: 0.825

## Multi-Resolutie: Volledige run

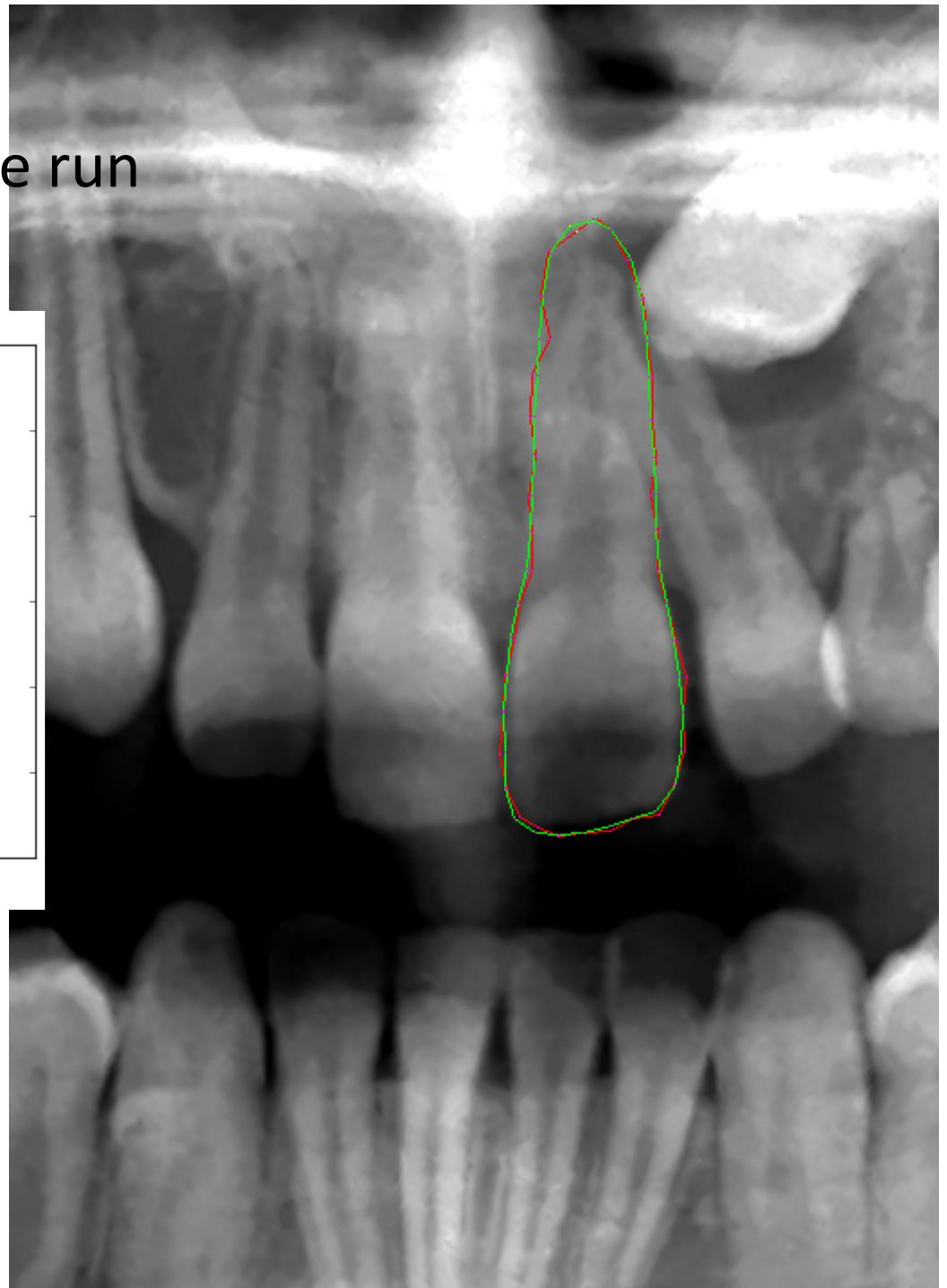
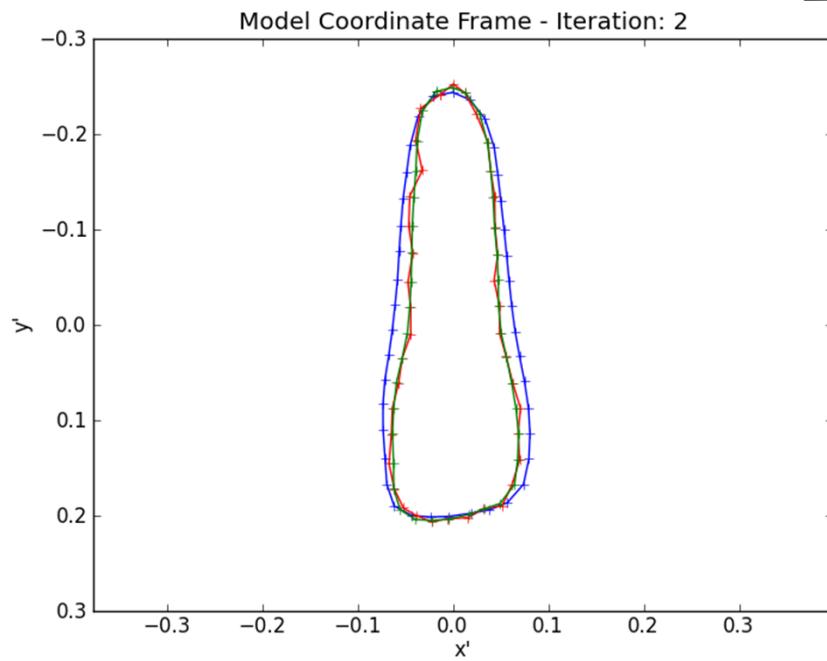


Level: 1, Iteration: 4, Ratio: 1.0

## Multi-Resolutie: Volledige run

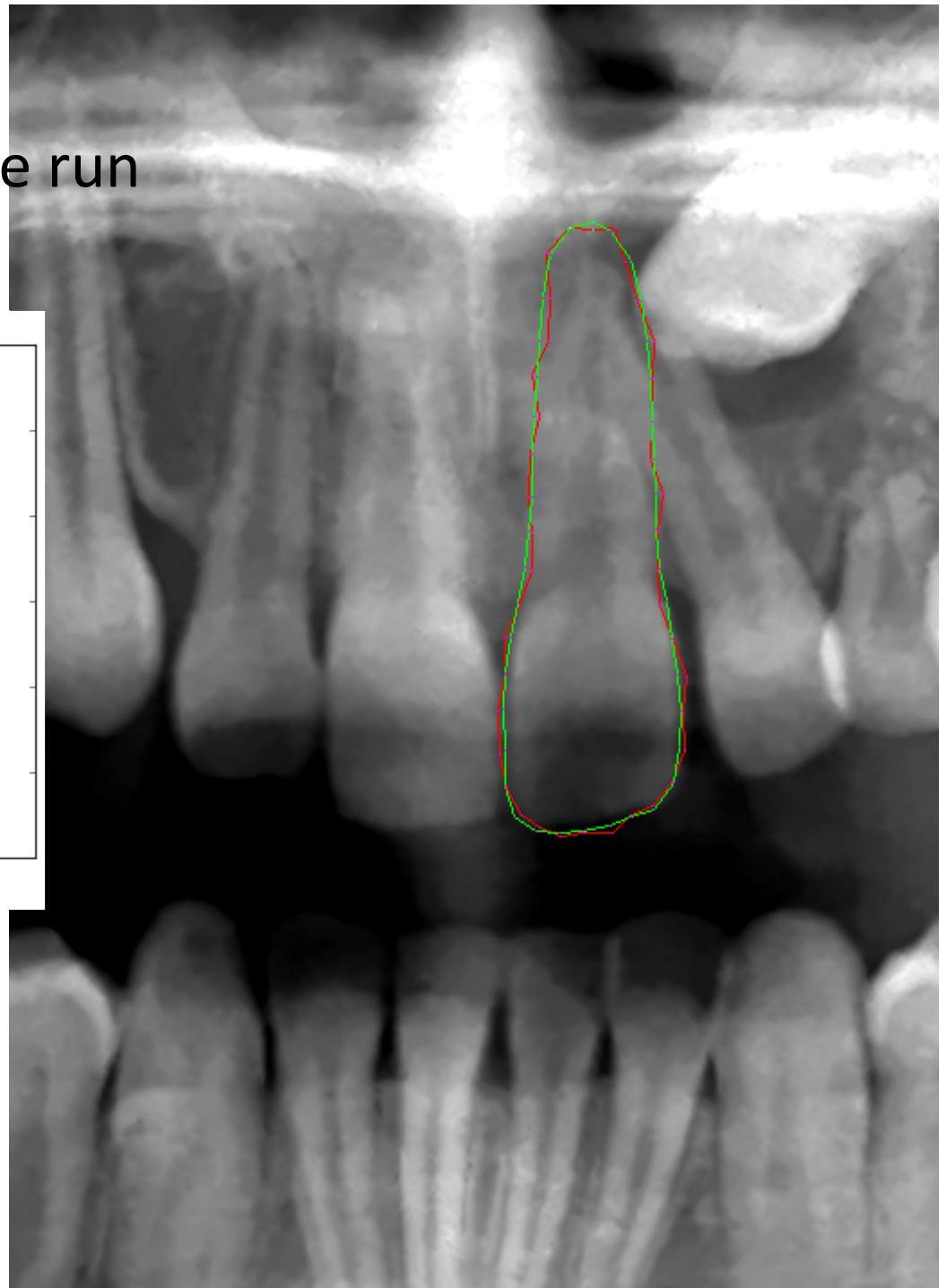
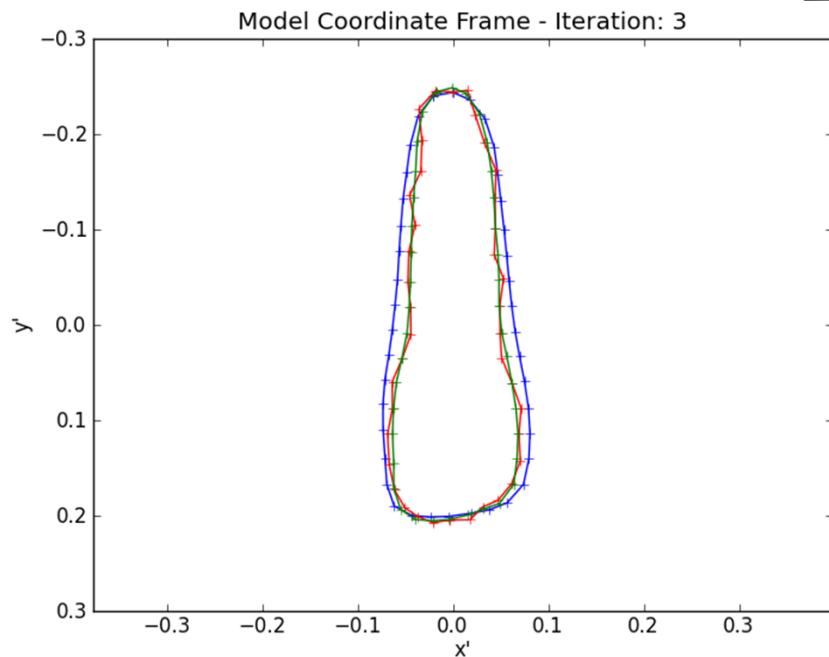


## Multi-Resolutie: Volledige run



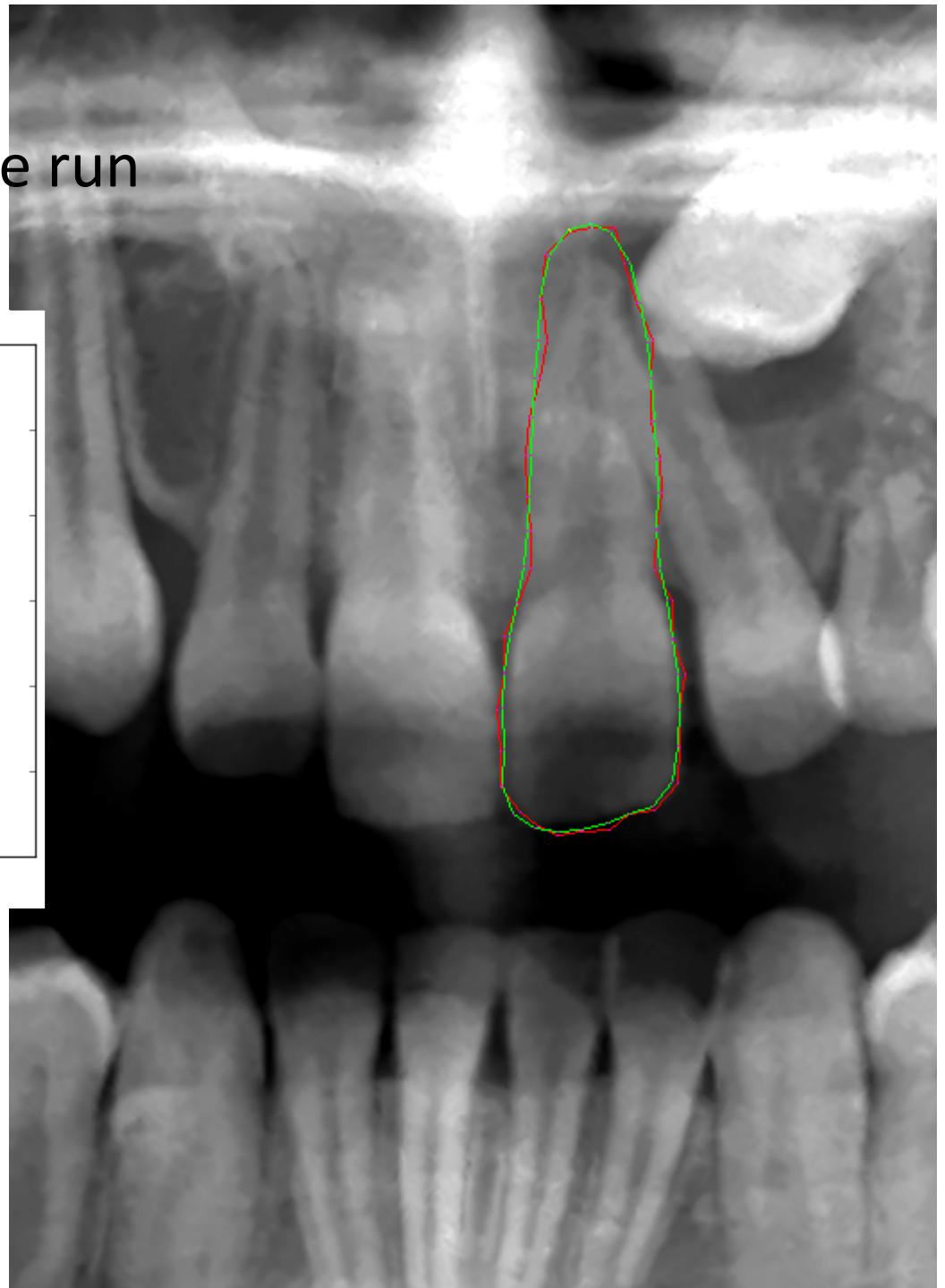
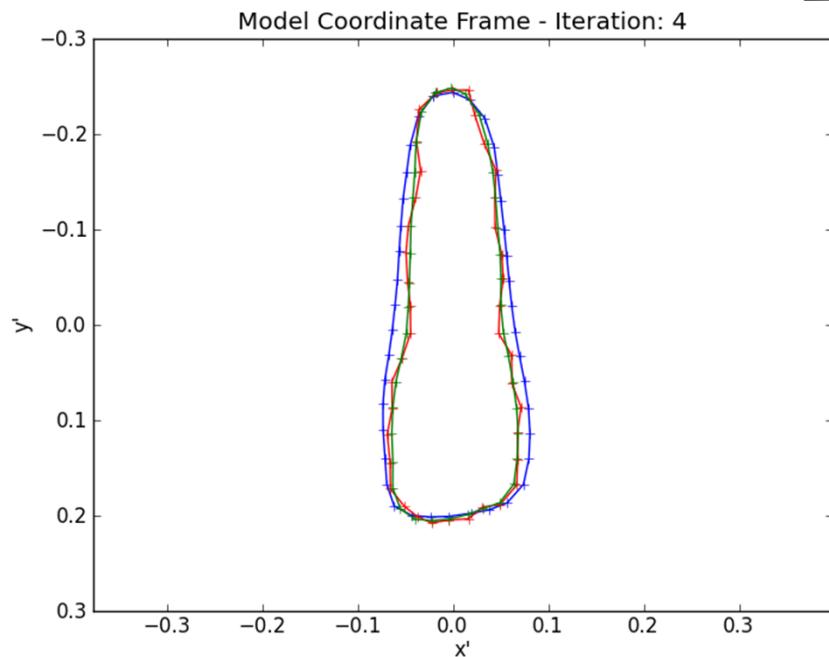
Level: 0, Iteration: 2, Ratio: 0.525

## Multi-Resolutie: Volledige run



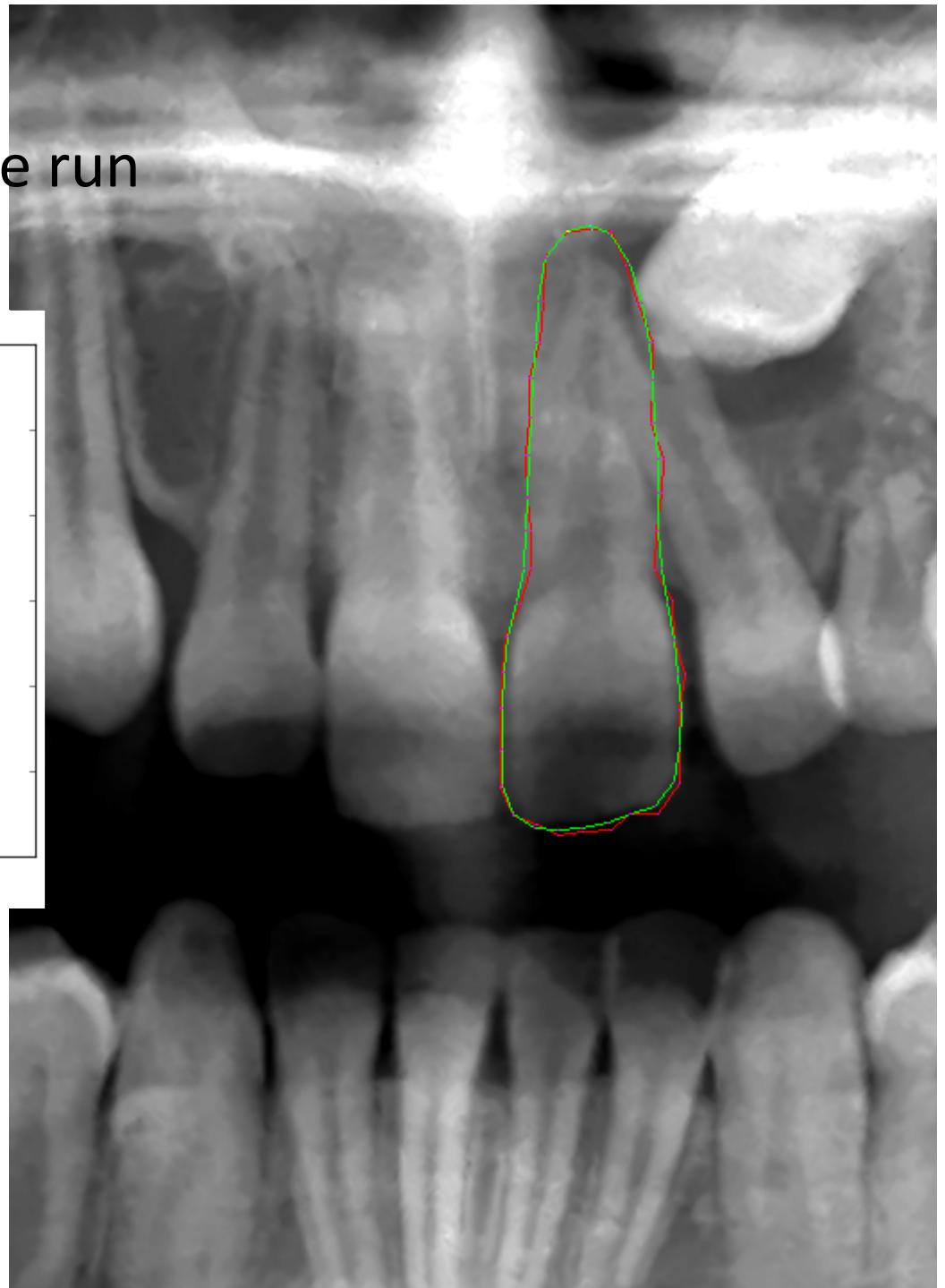
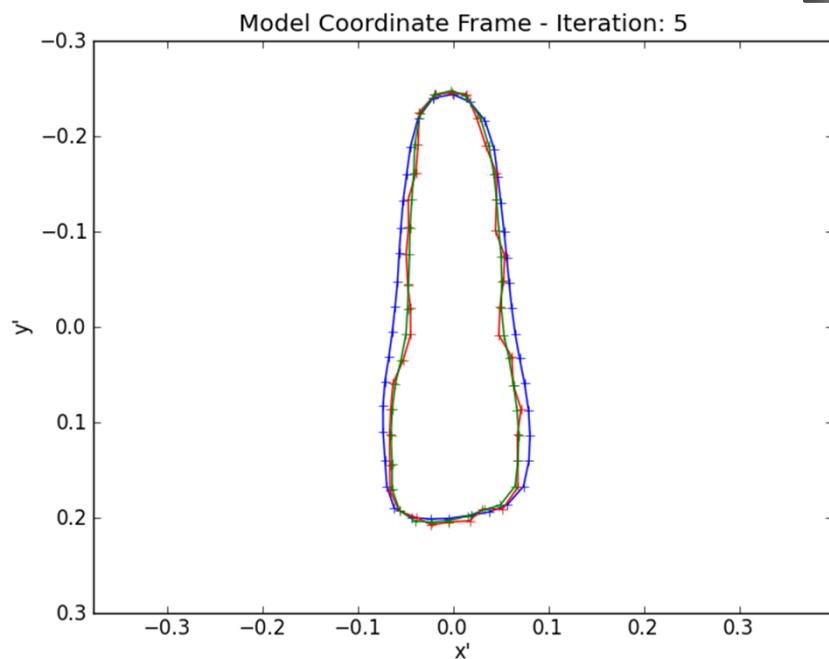
Level: 0, Iteration: 3, Ratio: 0.85

## Multi-Resolutie: Volledige run



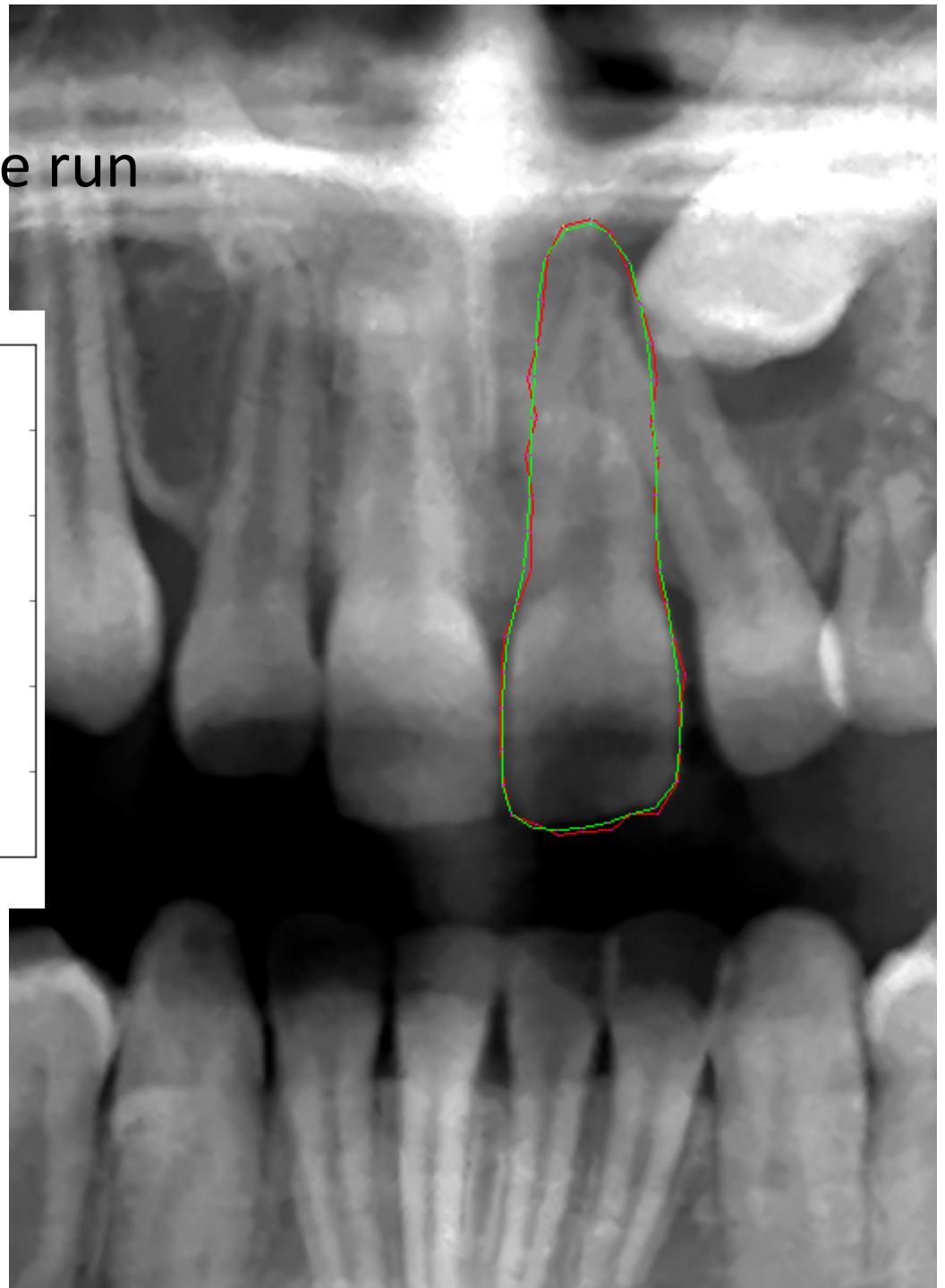
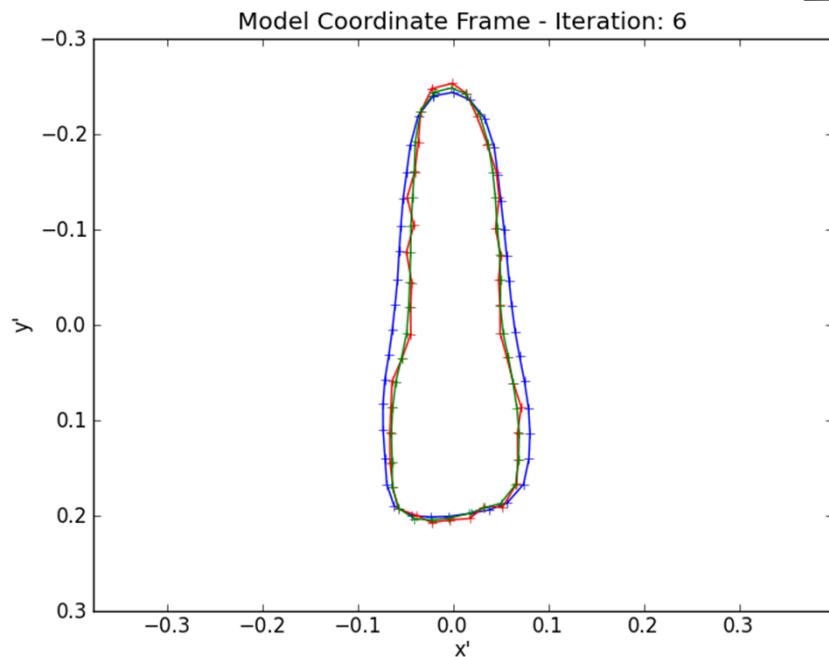
Level: 0, Iteration: 4, Ratio: 0.8

## Multi-Resolutie: Volledige run



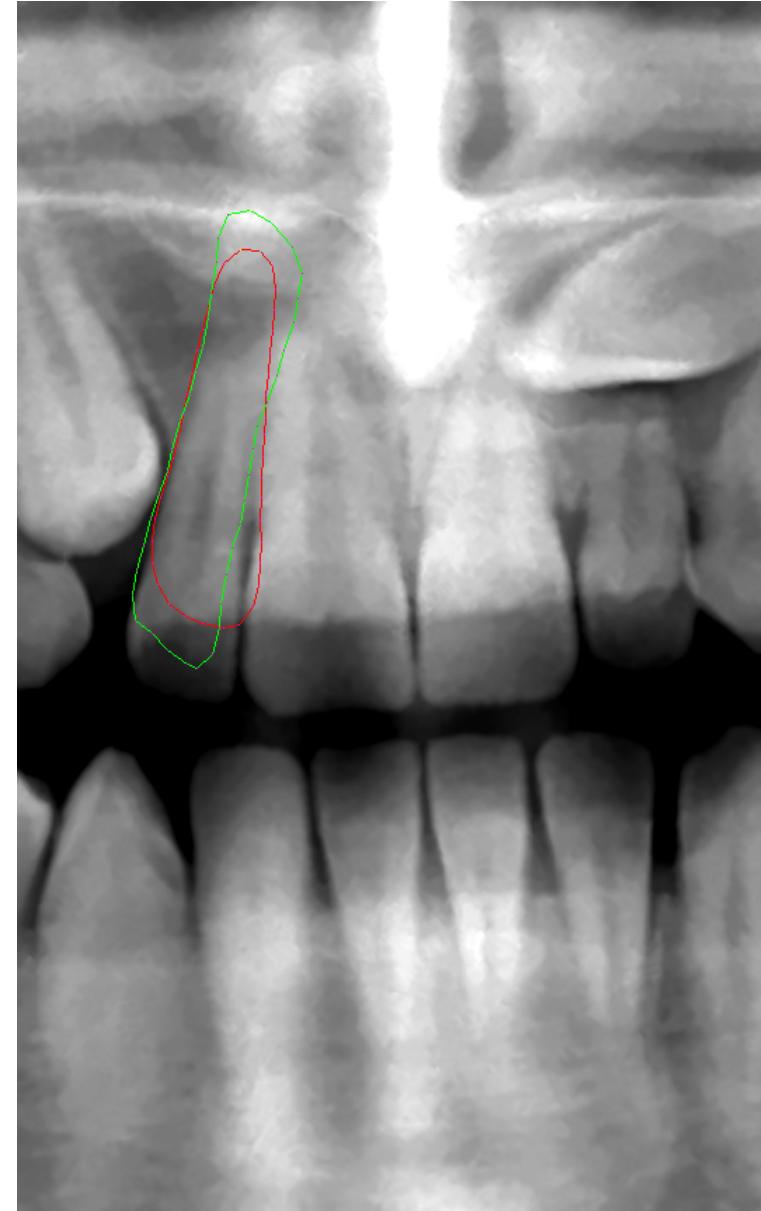
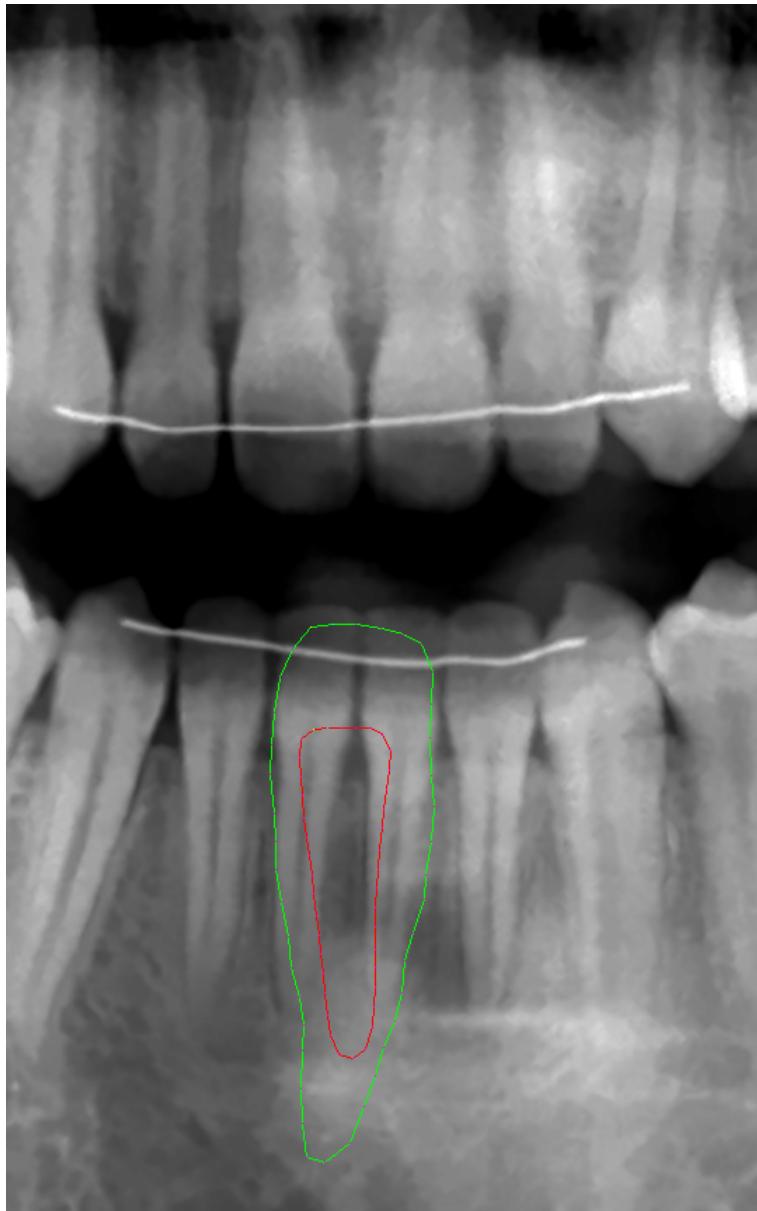
Level: 0, Iteration: 5, Ratio: 0.85

## Multi-Resolutie: Volledige run

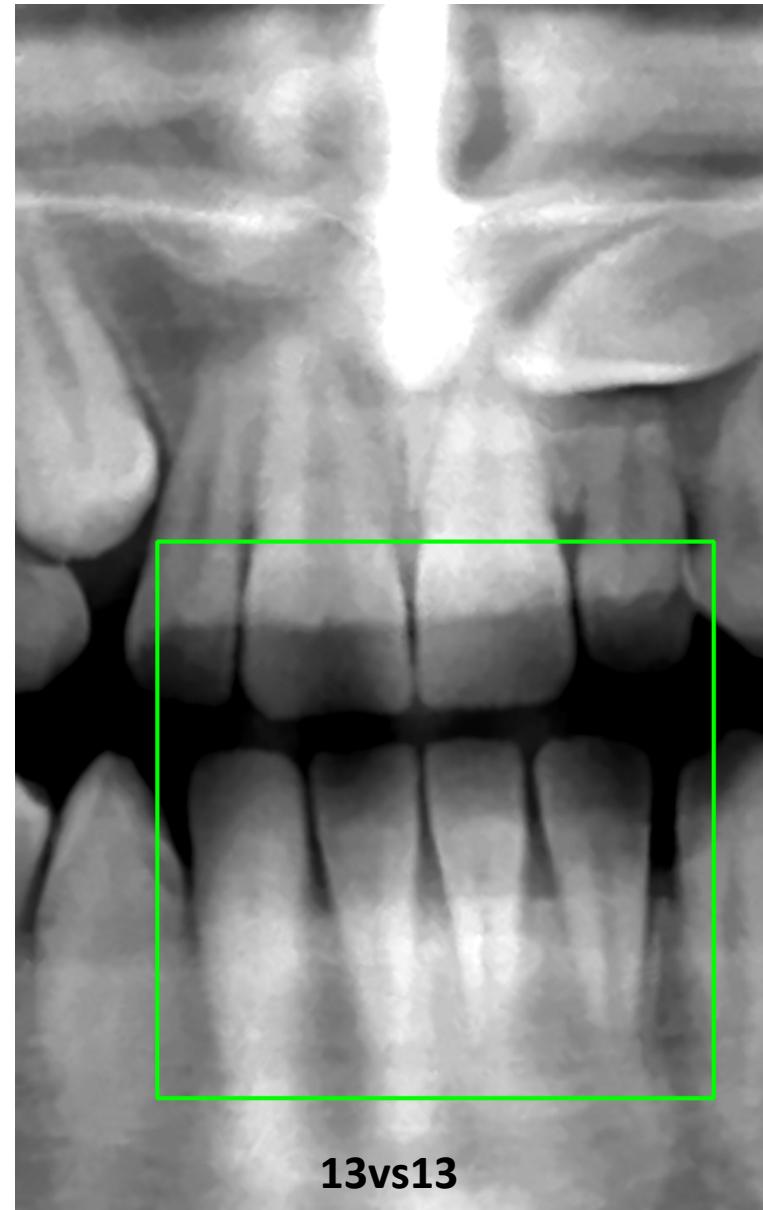
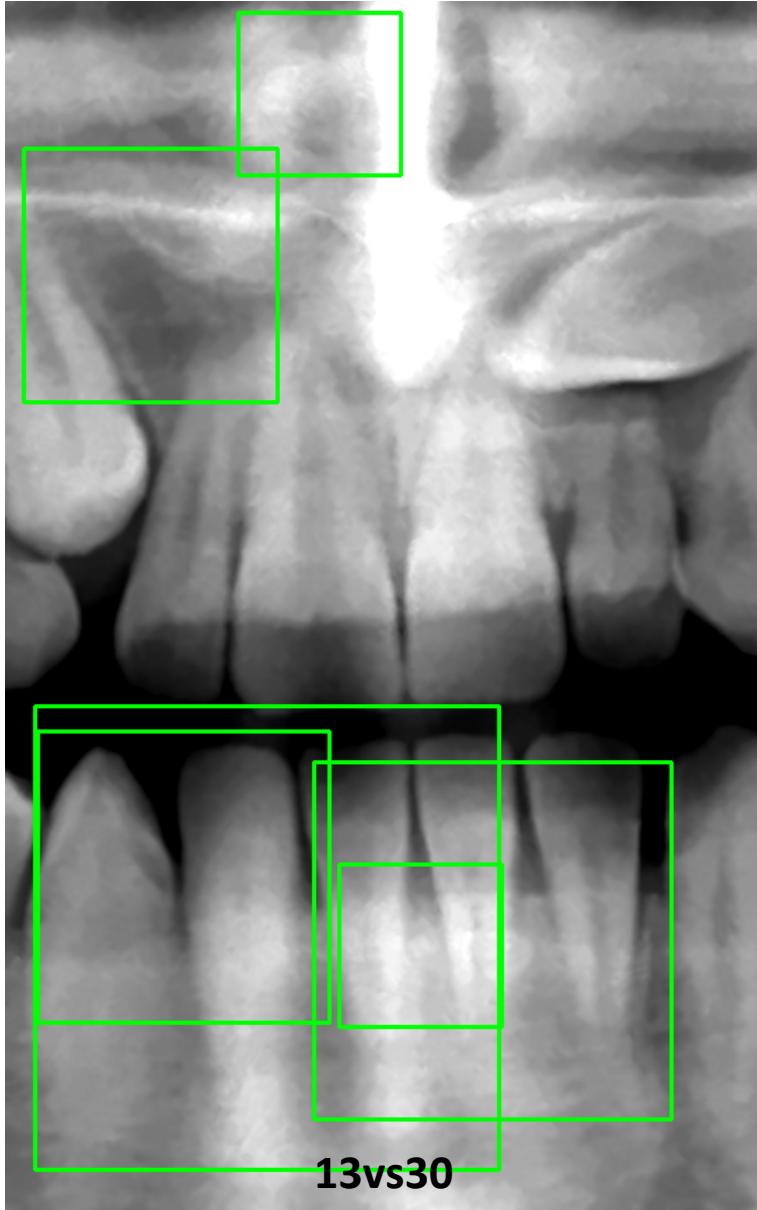


Level: 0, Iteration: 6, Ratio: 0.95

## Multi-Resolutie: Automatische initialisatie (Mean)



## Multi-Resolutie: Automatische initialisatie (Classifiers)



## Multi-Resolutie: Automatische initialisatie (@pre BBox)

