Learning to Compute the Symmetry Plane for Human Faces

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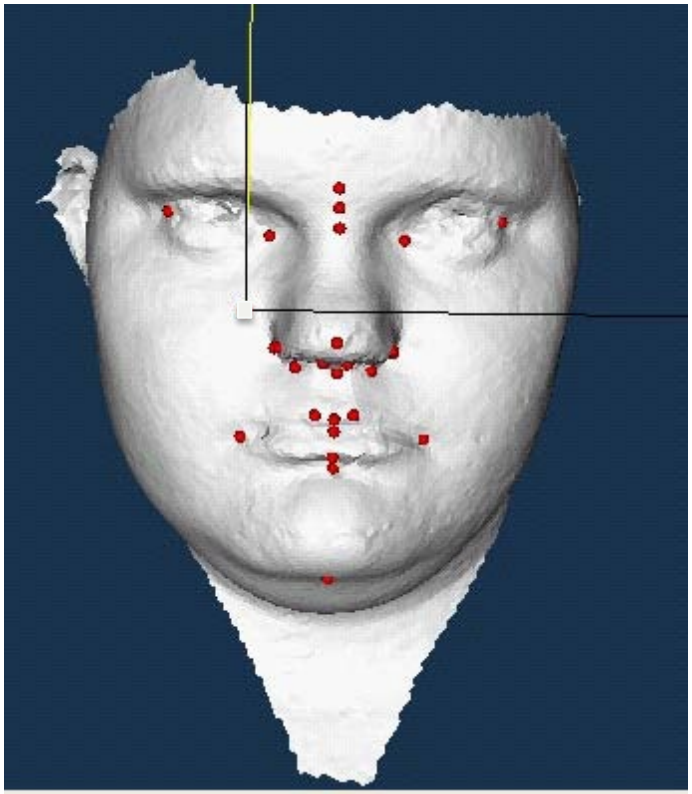
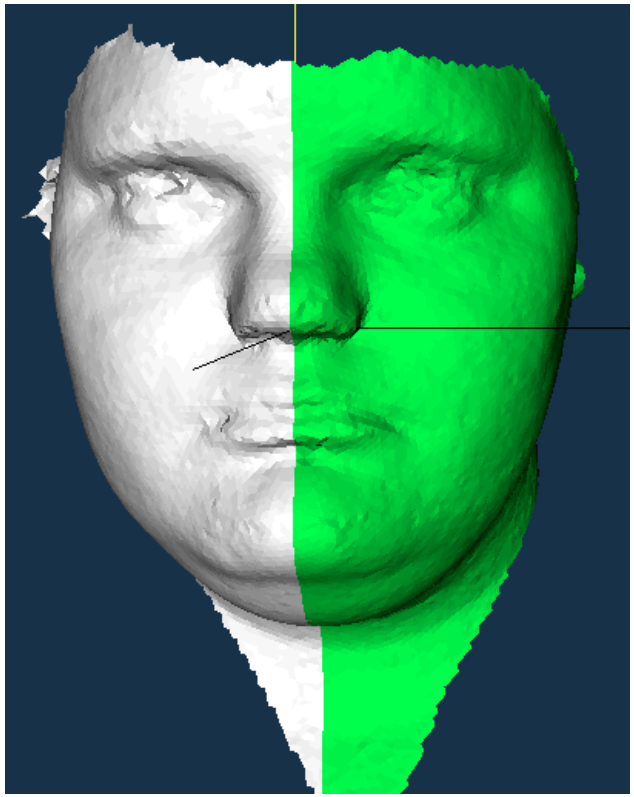
ACM-BCB '11, August 2011

Landmark by medical experts

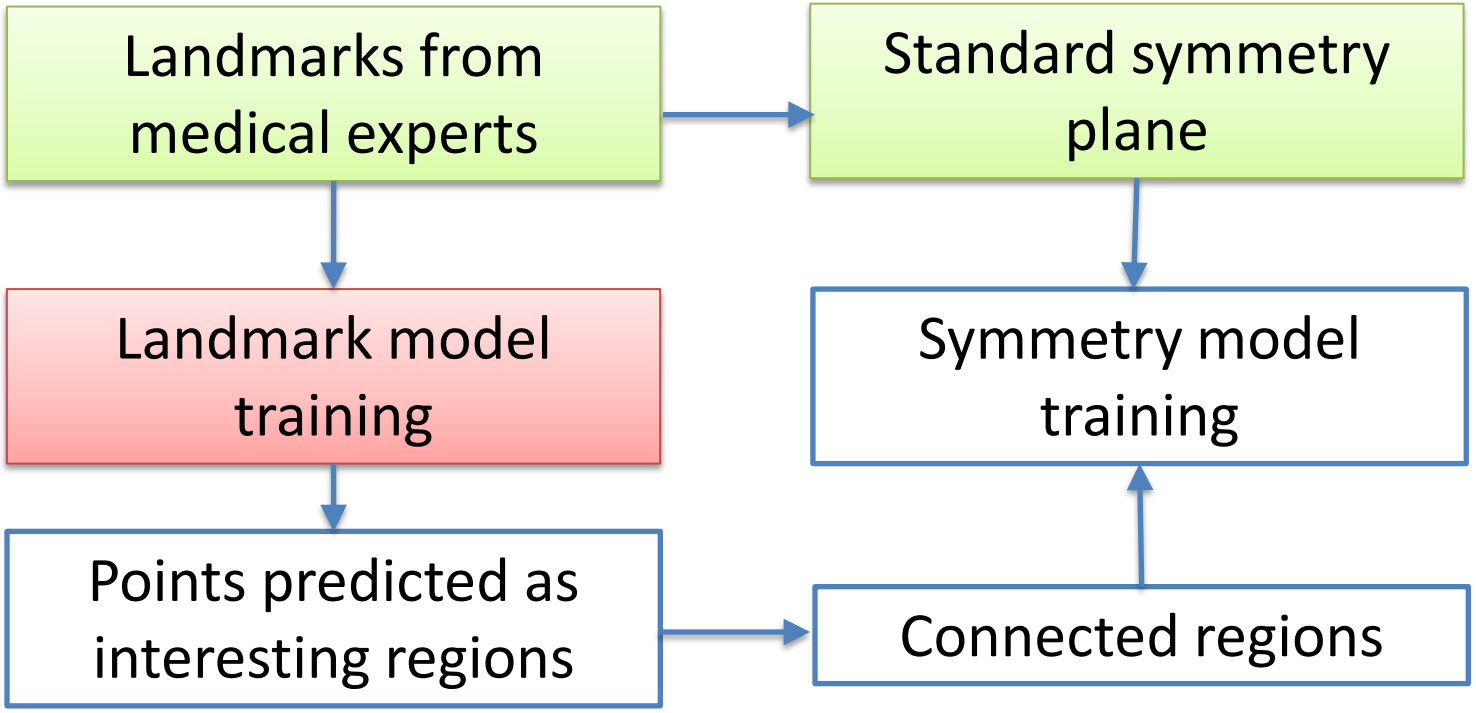


Landmarks labeled by experts



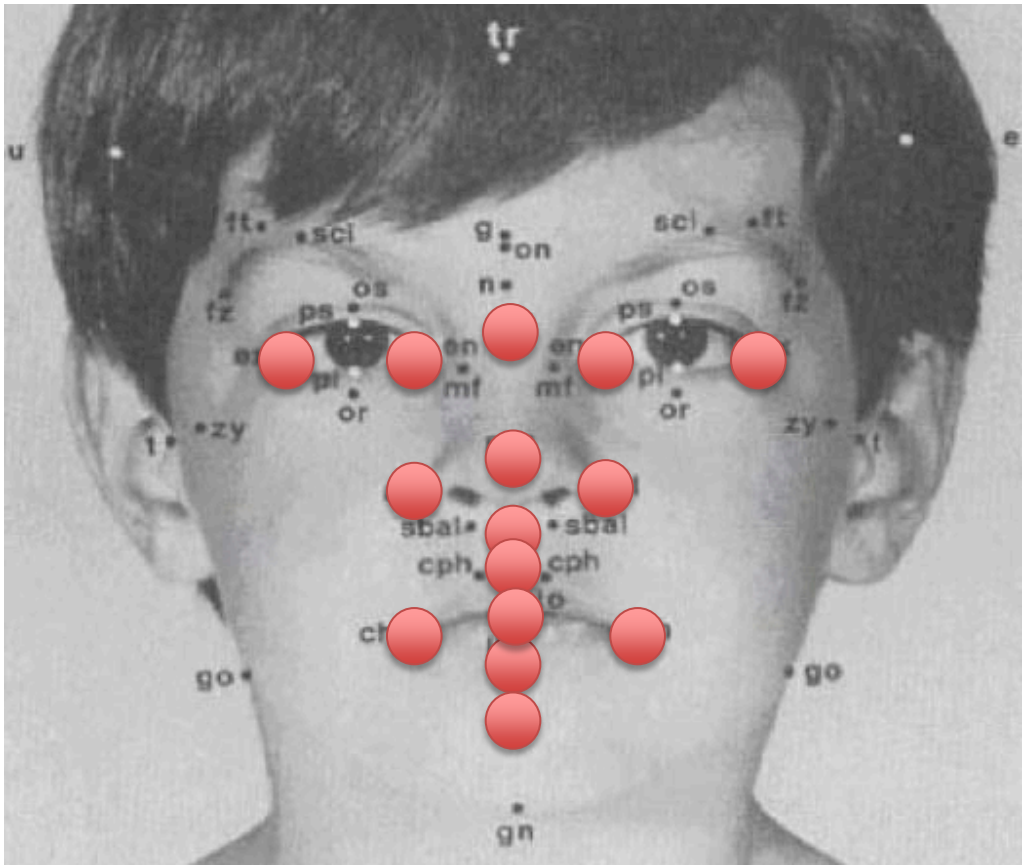
Standard symmetry plane

Flow chart for training

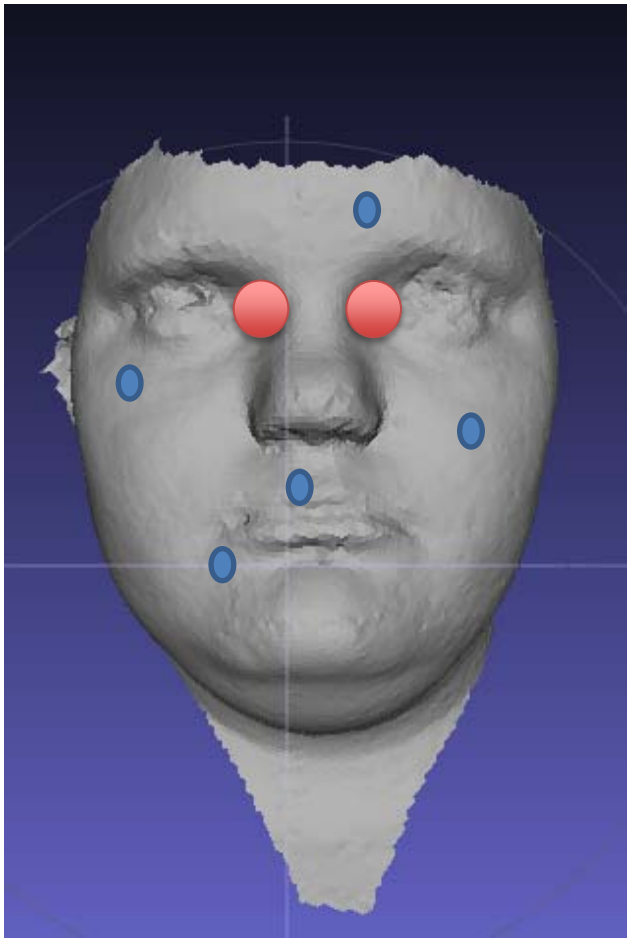


10 kinds of landmarks.

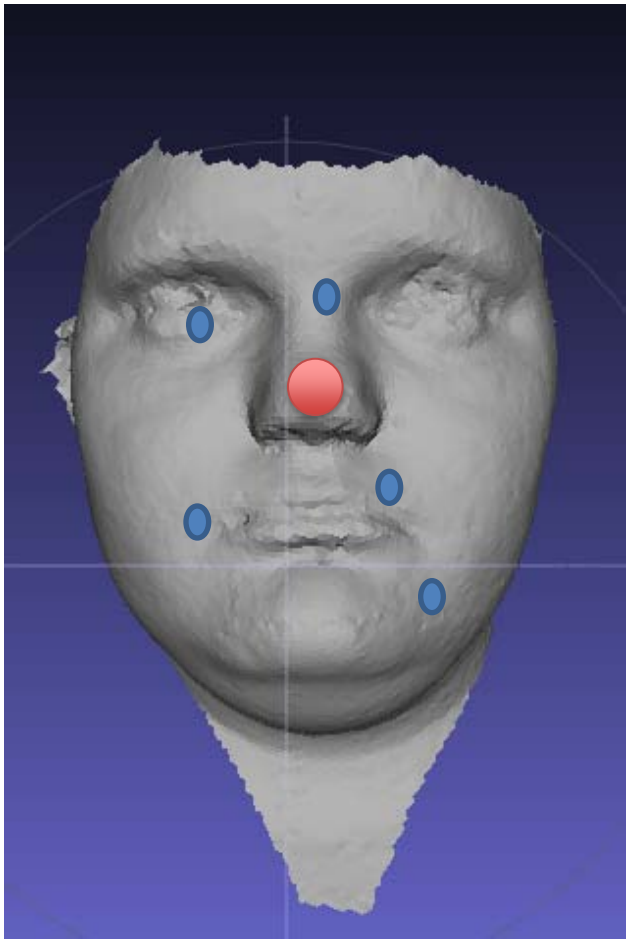
- Nose: ac (nose side), prn, sn,se
- Eyes: en, ex
- Mouth: (li,ls), ch, sto
- Chin: slab



Positive/negative samples

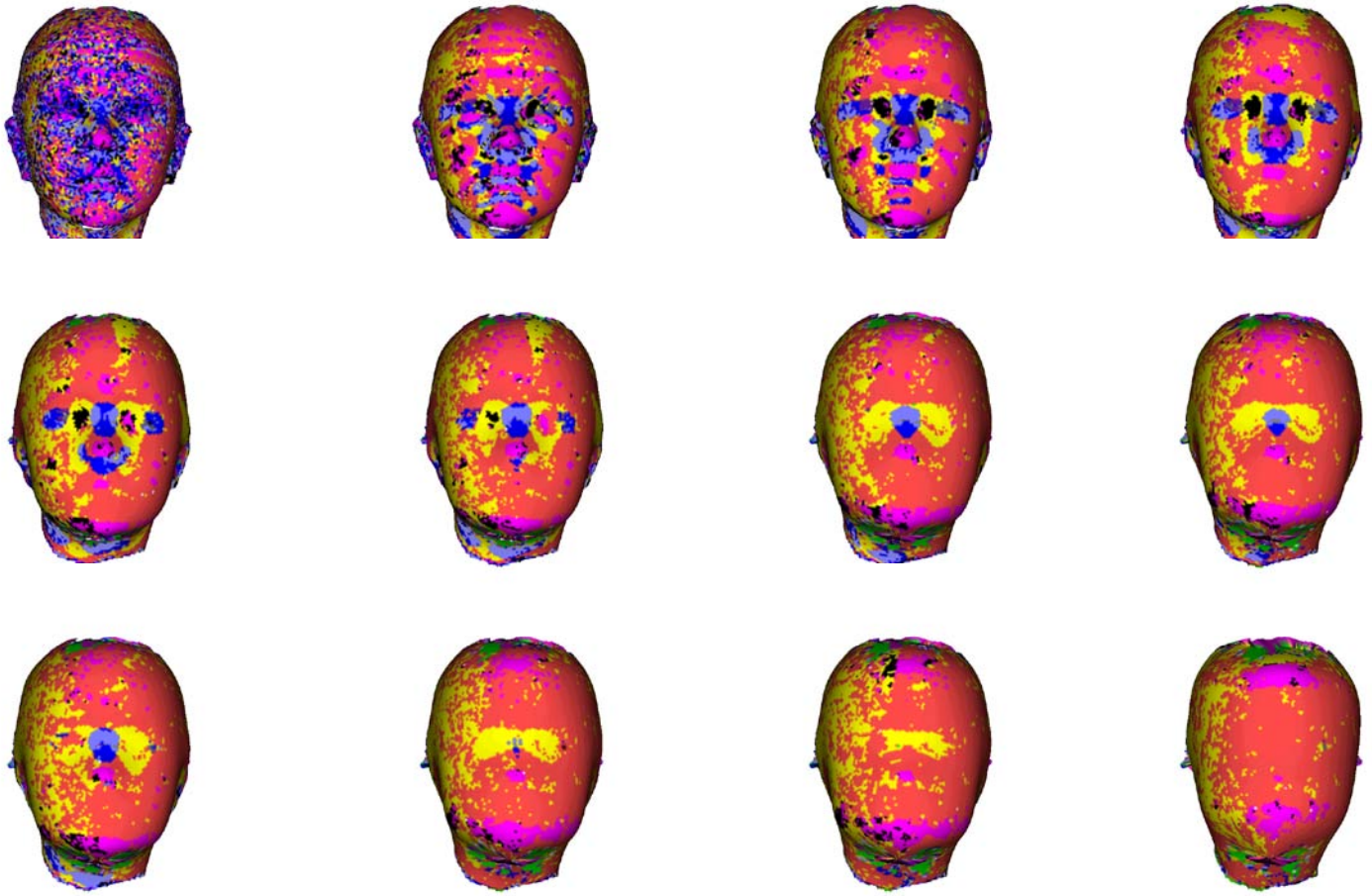


Training for en: the inner corners of the eyes

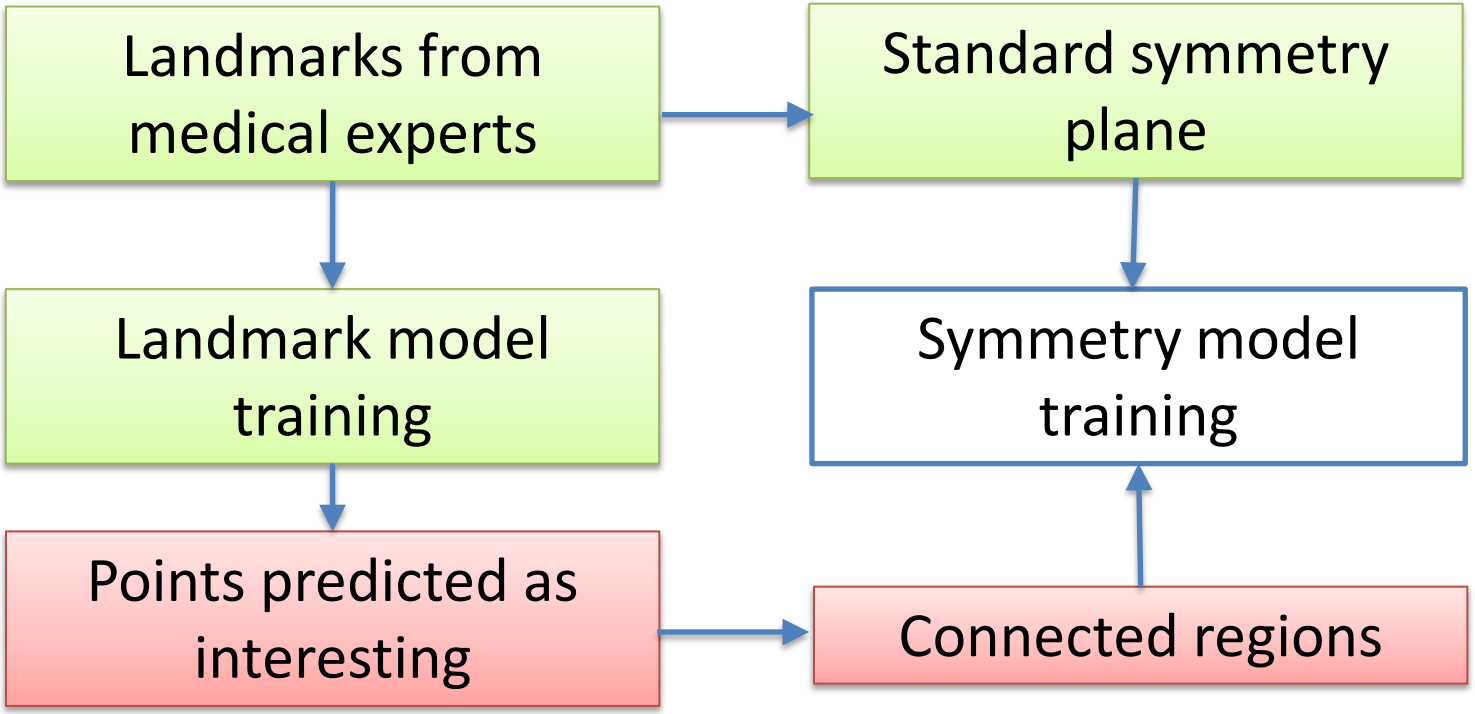


Training for prn: most protruded point of nasal tip

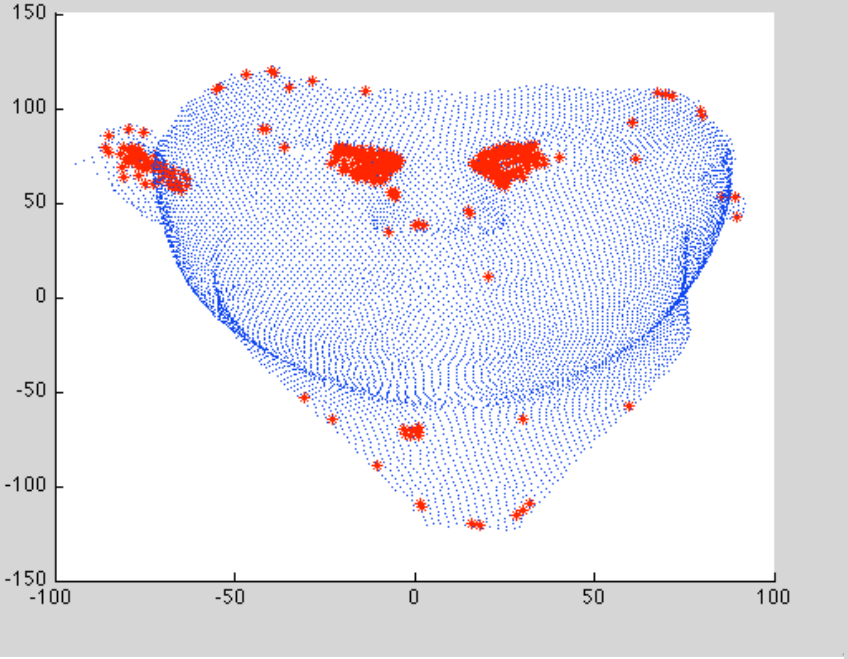
Features: mean and Gaussian curvatures for original head and smoothed head



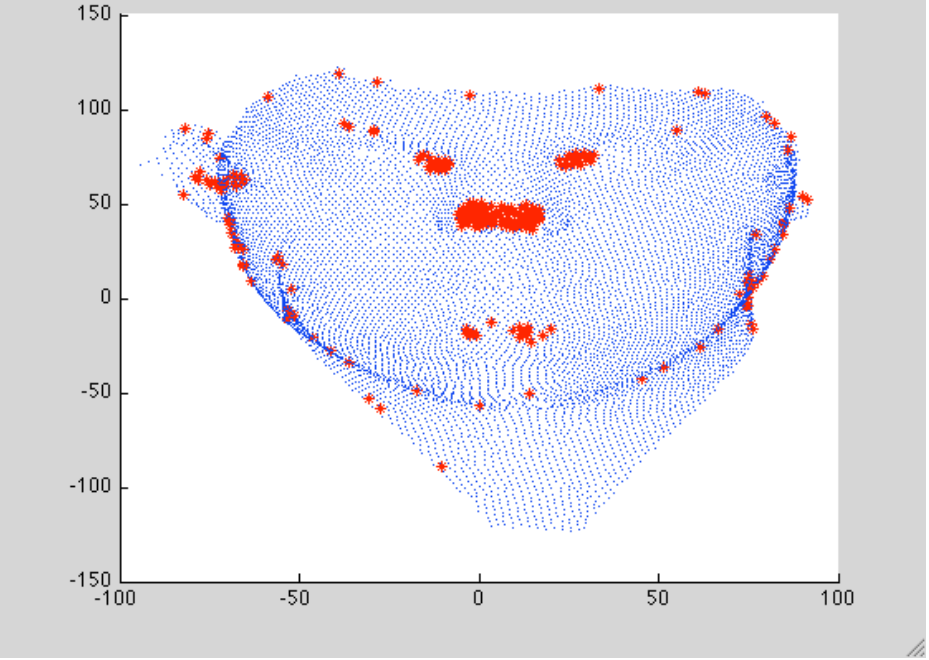
Flow chart


Landmarks from medical experts
Standard symmetry plane
Landmark model training
Symmetry model training
Points predicted as interesting
Connected regions

Interesting points prediction

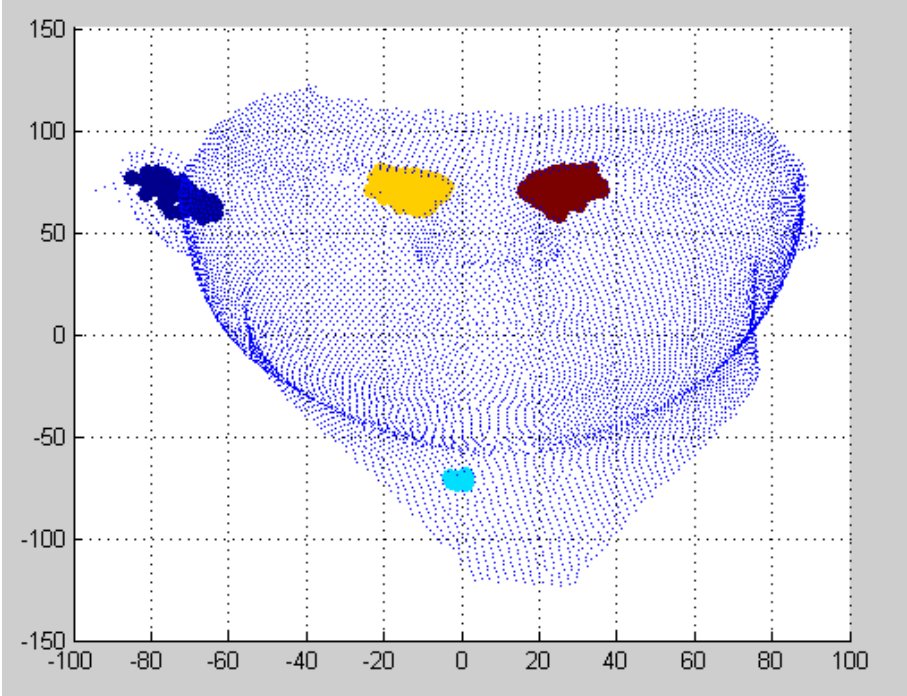


Prediction of en:
the inner corners
of the eyes

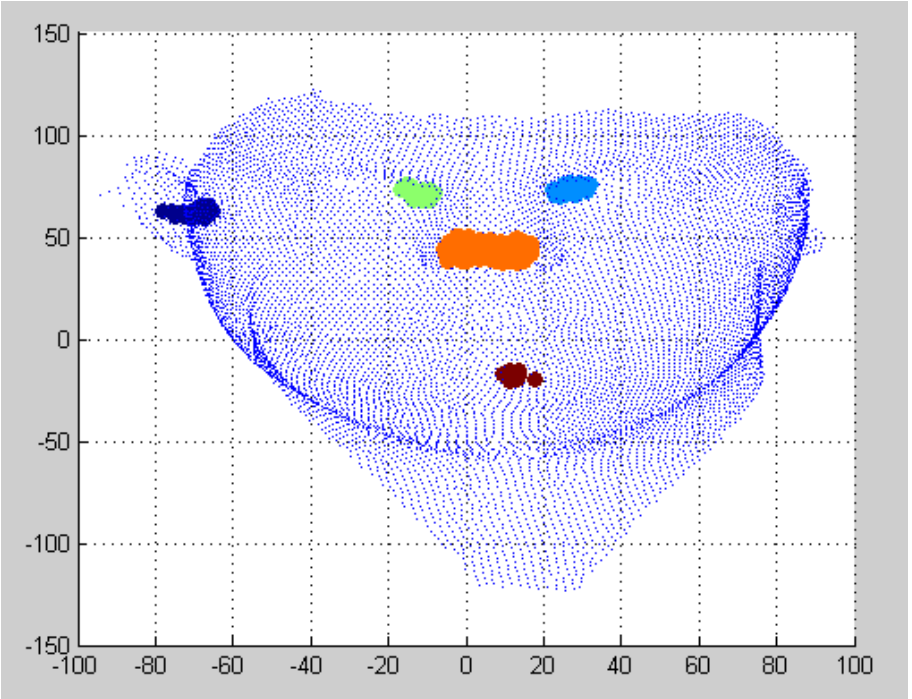


Prediction of prn: most
protruded point of nasal tip

Connected regions

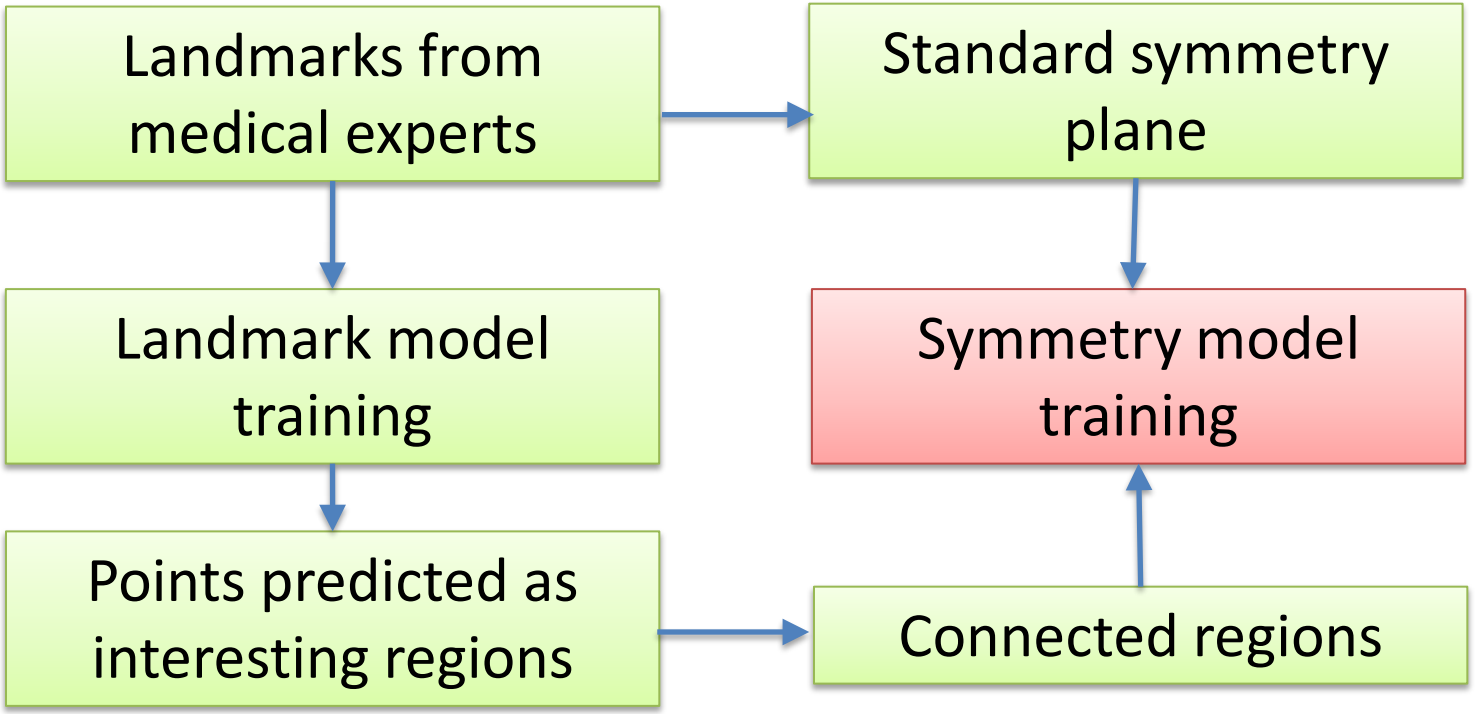


Connected regions for en: each color means one region



Connected regions for prn: each color means one region

Flow chart


Landmarks from medical experts
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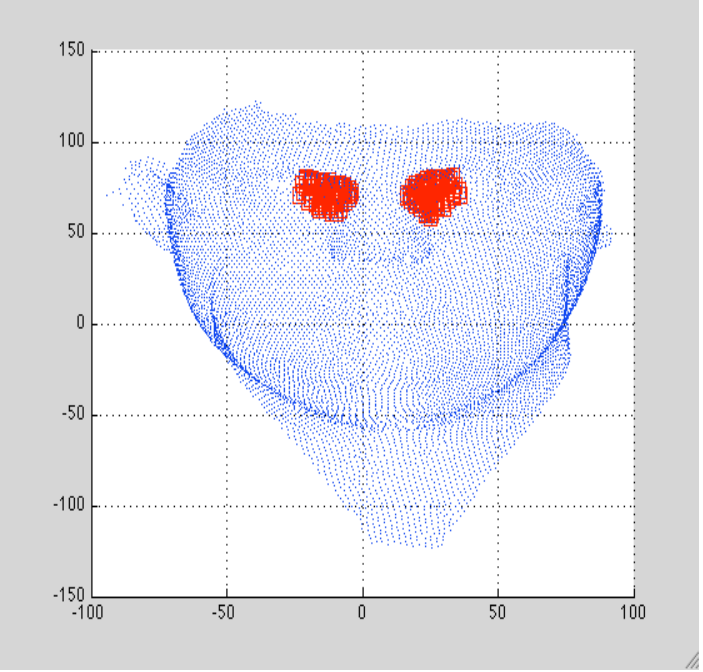
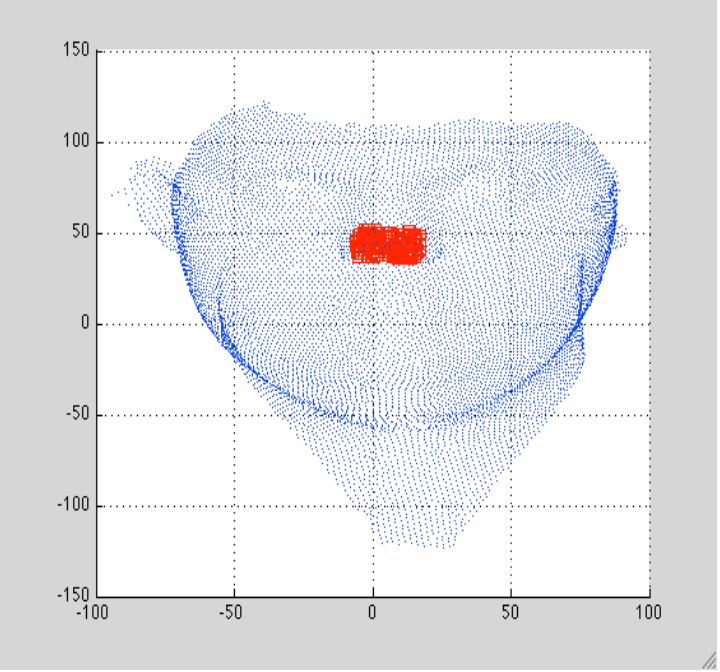
Points predicted as interesting regions
Connected regions

How to define “good” symmetric regions

- A “good” pair of regions should be symmetric to the standard symmetry plane
- A “good” single region should have the center on the standard symmetry plane



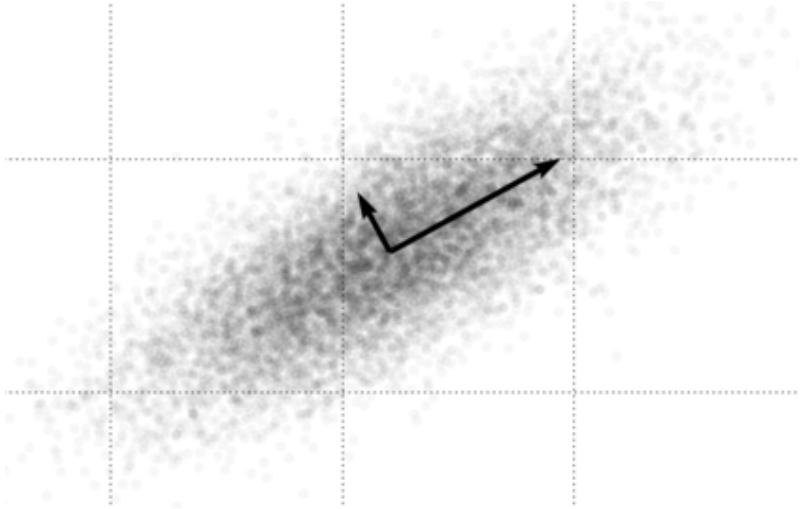
“good” regions for en



“good” regions for prn

Feature for regions

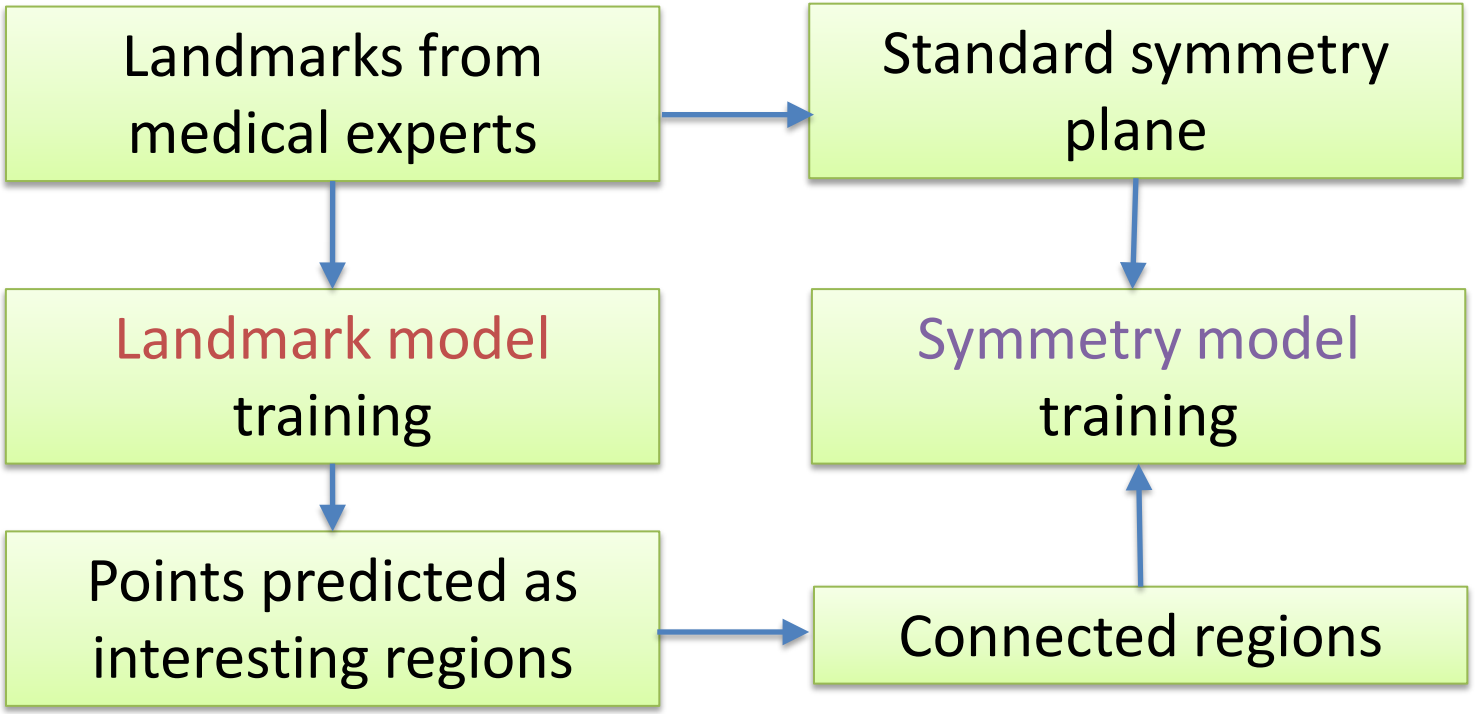
$$Csingle_m = [Num_m, \lambda_{m1}, \lambda_{m2}, \lambda_{m3}]$$



Principal component analysis and eigenvalues

$$Cpair_{m,n} = [|Num_m - Num_n|, |\lambda_{m1} - \lambda_{n1}|, |\lambda_{m2} - \lambda_{n2}|, |\lambda_{m3} - \lambda_{n3}|, D(C_m, C_n)]$$

Flow chart for training



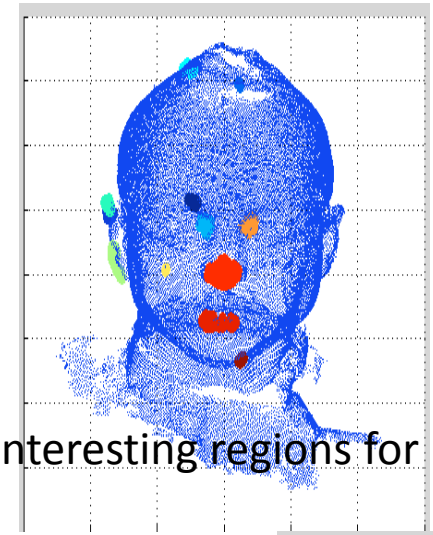
Procedure for New data

Select possible landmark areas(from Landmark model)

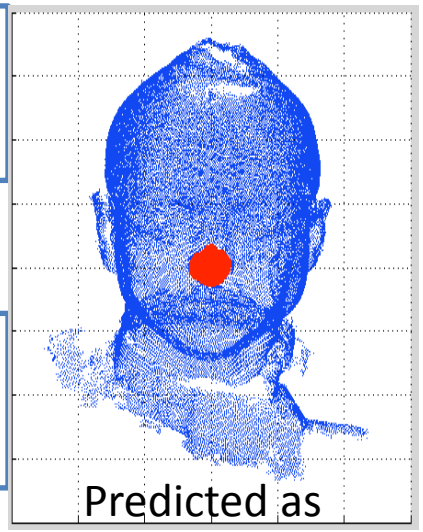
Find and pair connected regions

Determine good singles and good pairs (from Symmetry model)

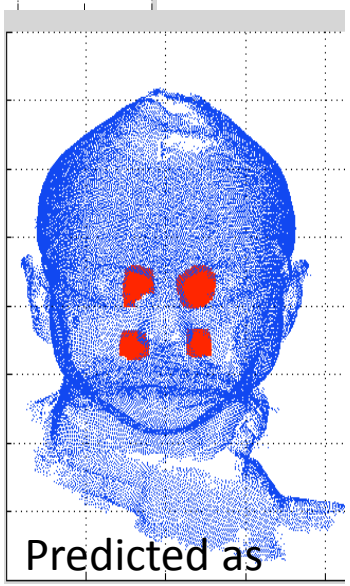
Get center and draw a plane using learned centers



interesting regions for prn

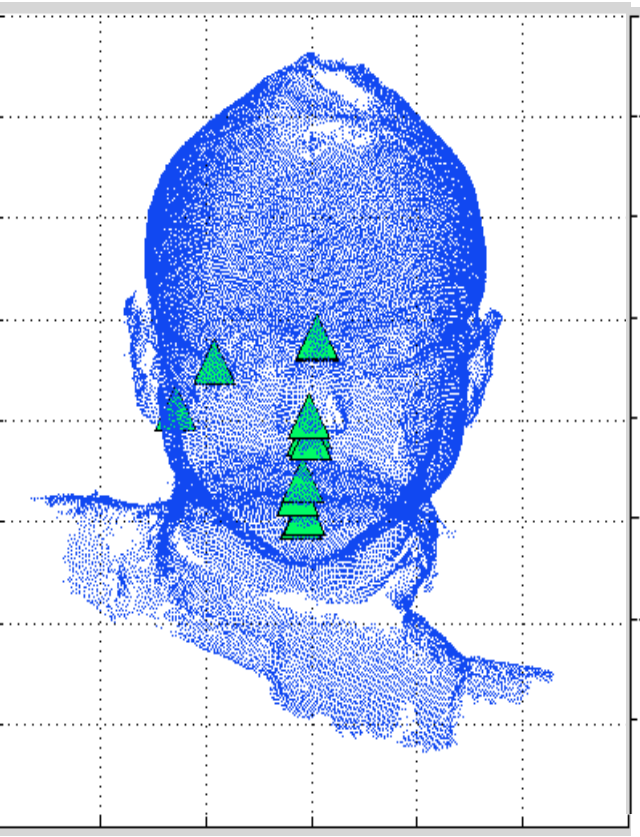


Predicted as good single

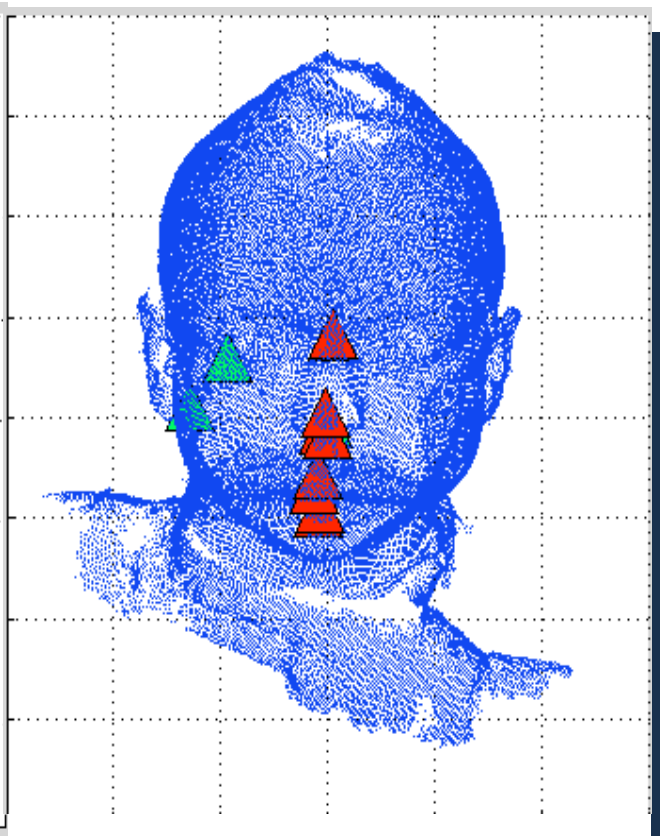


Predicted as good pair

Procedure for New Images



Centers of good regions



Centers for constructing plane of symmetry

Result: Plane of symmetry

Experiments

- Compare the plane of symmetry to
  - Ground truth (plane determined by expert labeled landmarks)
  - Mirror method in literature
- Ground truth dataset 1
- Ground truth dataset 2
- Cleft dataset

Mirror method in literature

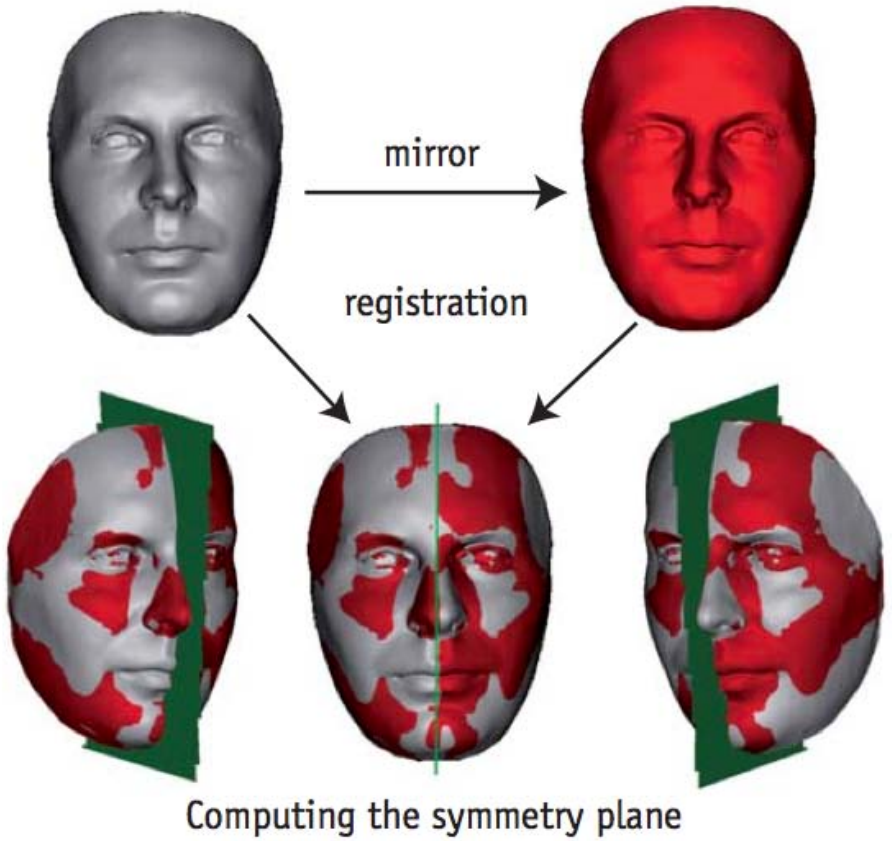
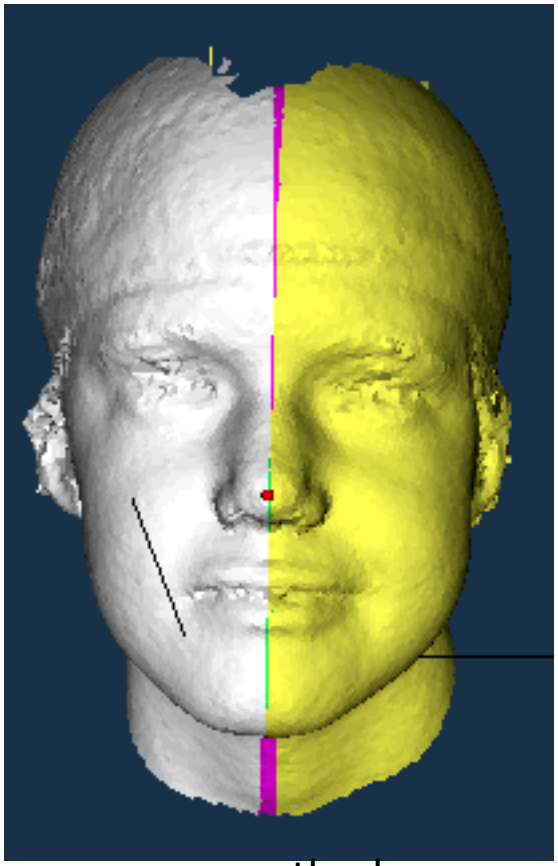
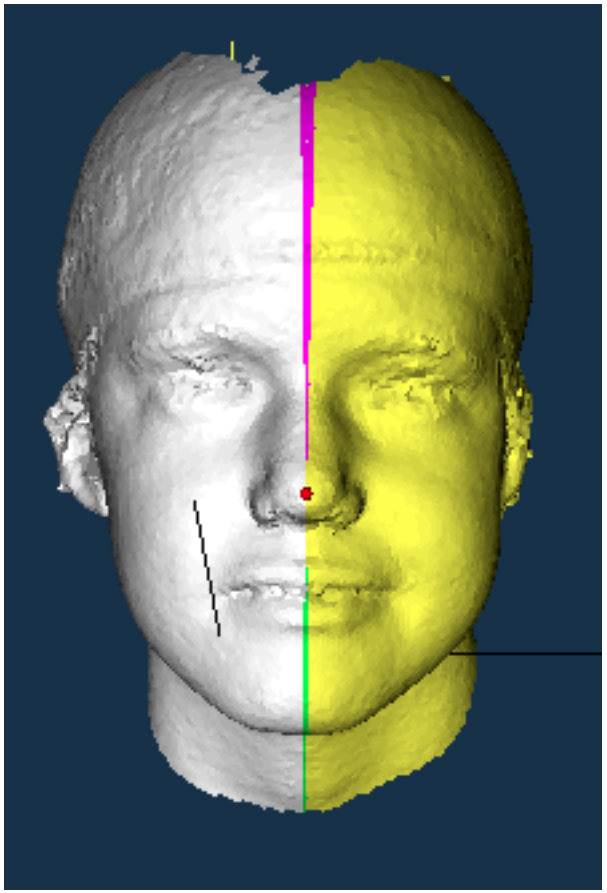


Figure 3. Registration of the original and mirrored data and computation of the symmetry plane by means of corresponding points.

Results compare to ground truth



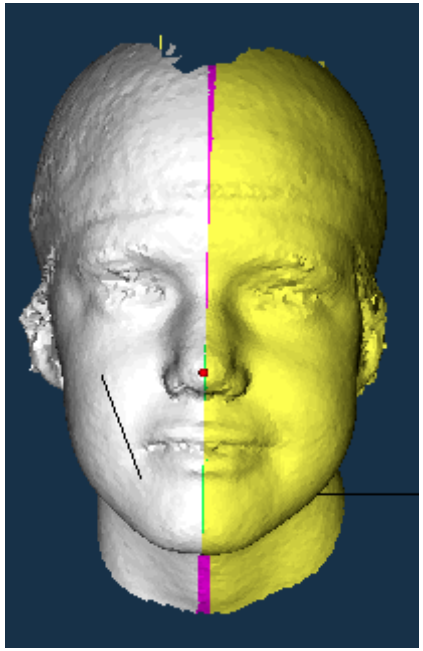
our method
Angle:4.03˚



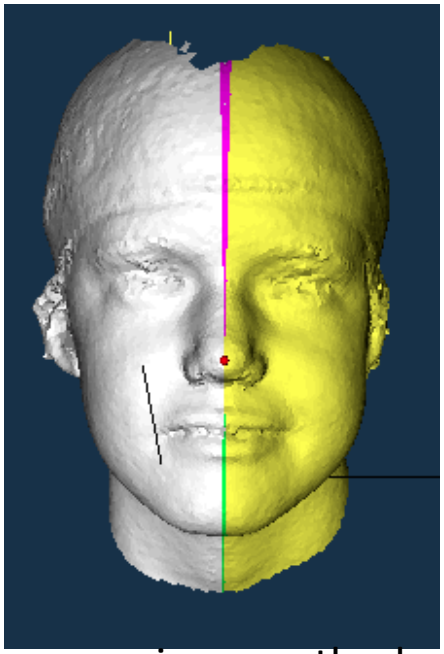
mirror method
Angle:2.15˚

- Yellow: overlapping with ground truth
- Green: ground truth
- Purple: extra from each method

Results compare to ground truth



our method



mirror method

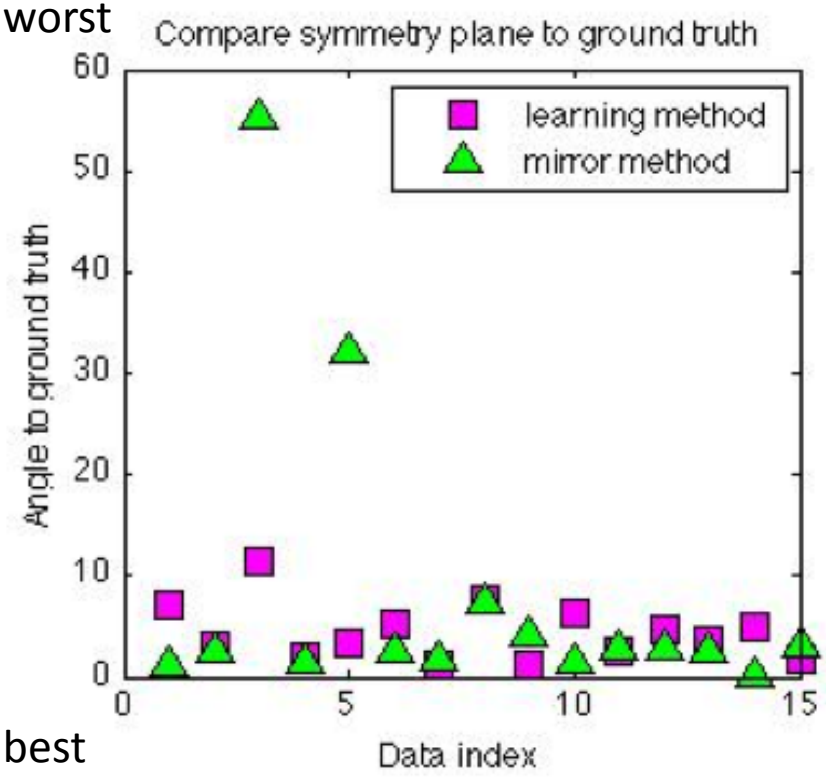
$$\text{Precision} = \frac{tp}{tp + fp}$$

$$\text{Recall} = \frac{tp}{tp + fn}$$

$$F = 2 \cdot \frac{\text{precision} \cdot \text{recall}}{\text{precision} + \text{recall}}$$

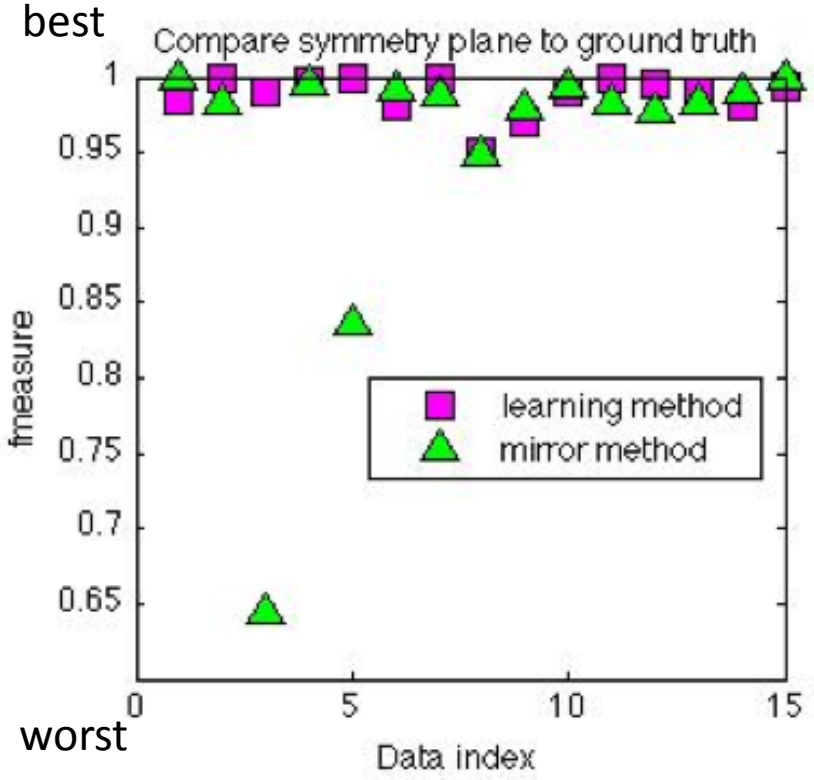
- Yellow: overlapping with ground truth -> true positive
- Green: ground truth -> false negative
- Purple: extra from each method -> false positive

worst



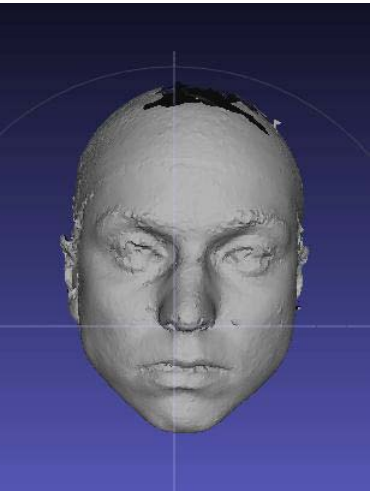
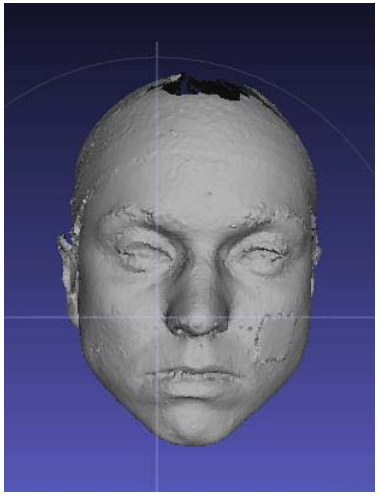
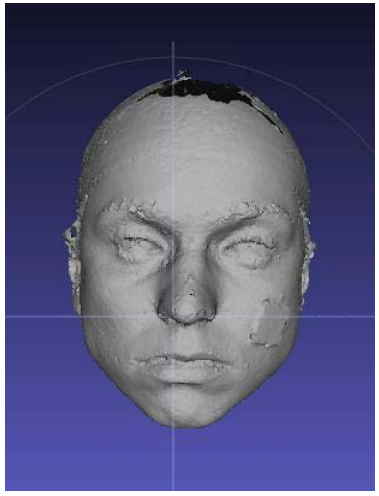
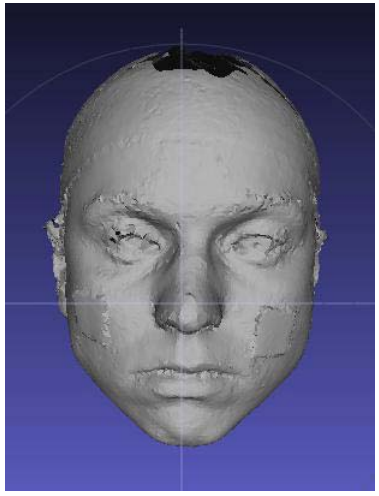
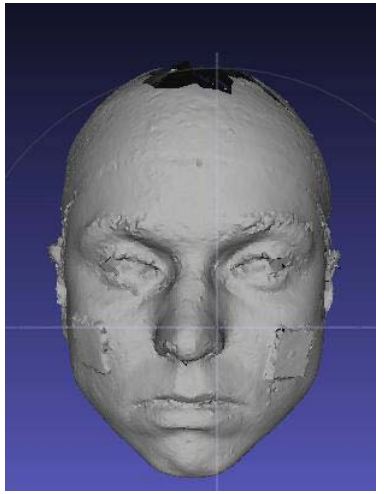
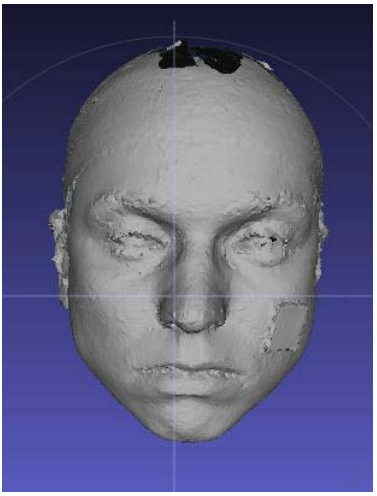
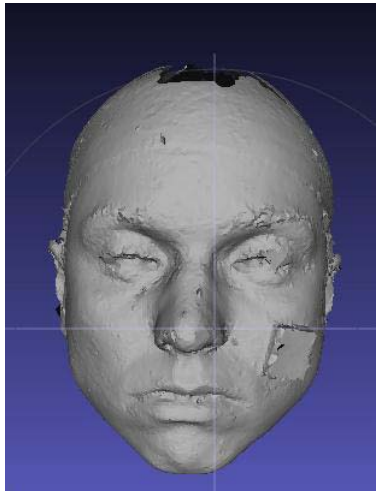
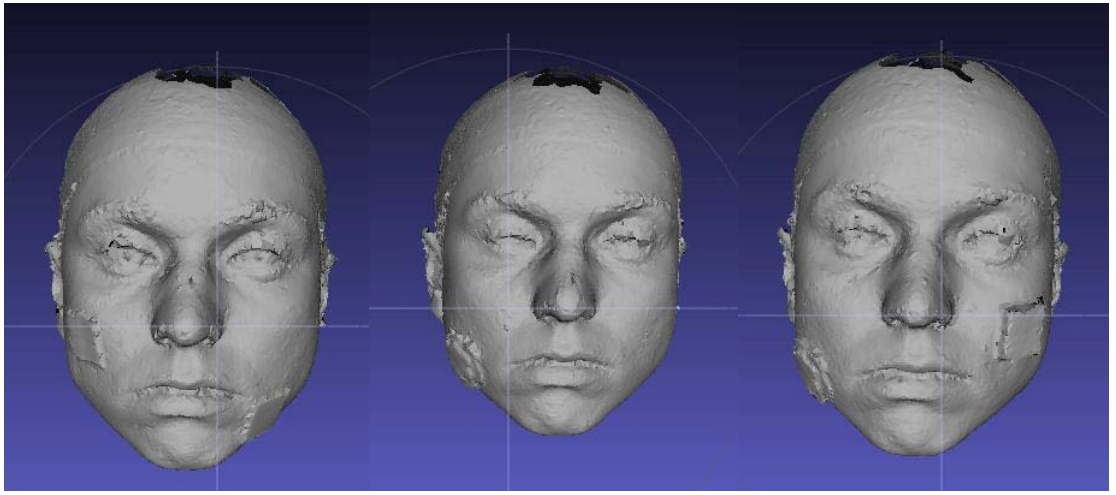
best

best

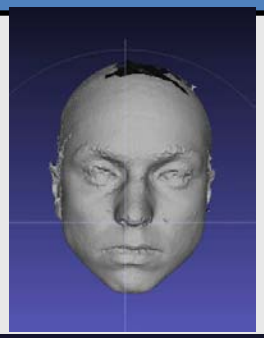


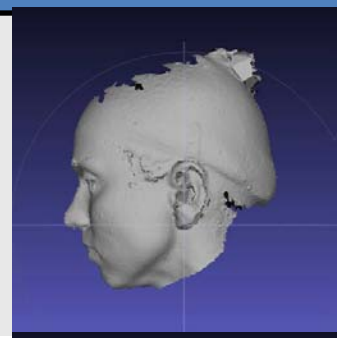
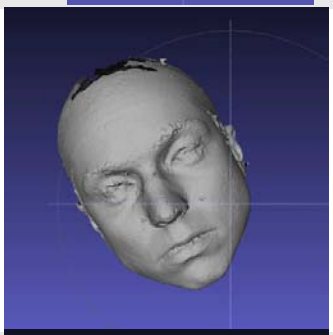
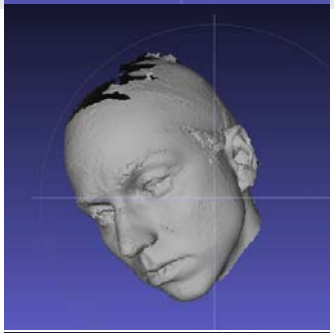
worst

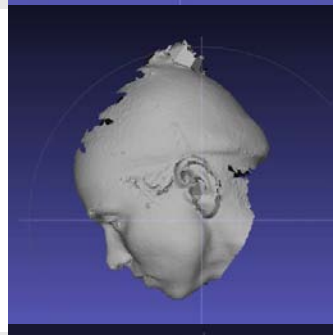
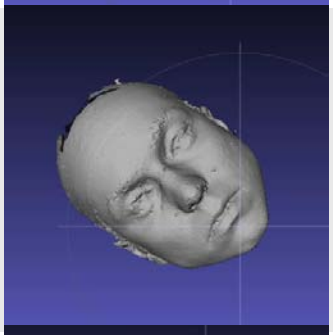
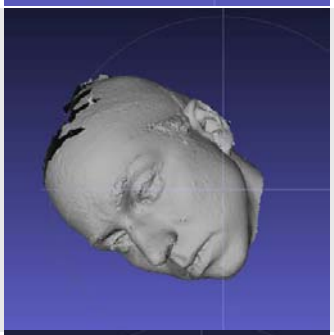
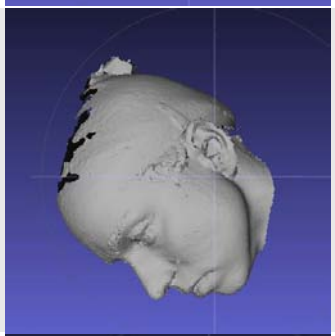
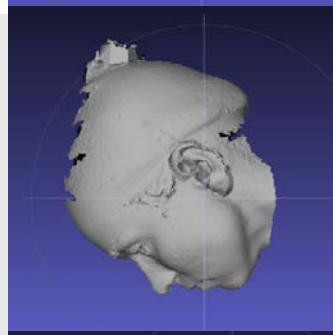
Ground truth dataset 2

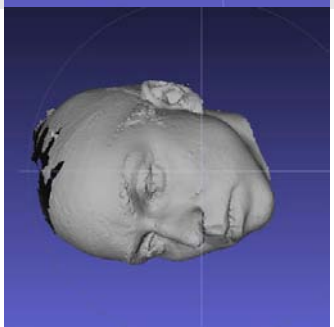
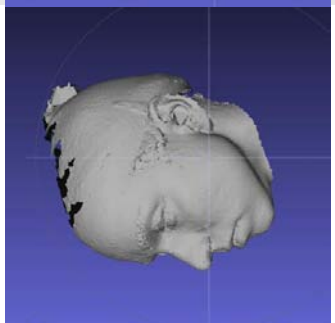
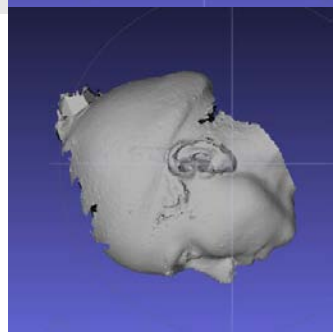
1	2	3	4	5
				
6	7	8	9	10
				

	0	30	60	90
0	1	2	4	7
30	3	5	8	11
60	6	9	12	14
90	10	13	15	16

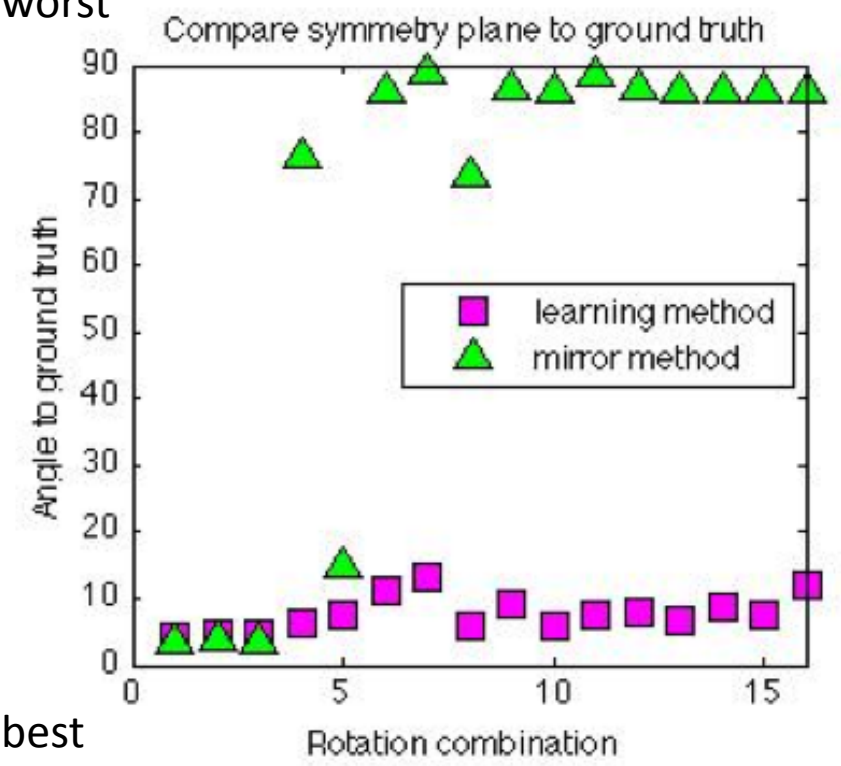


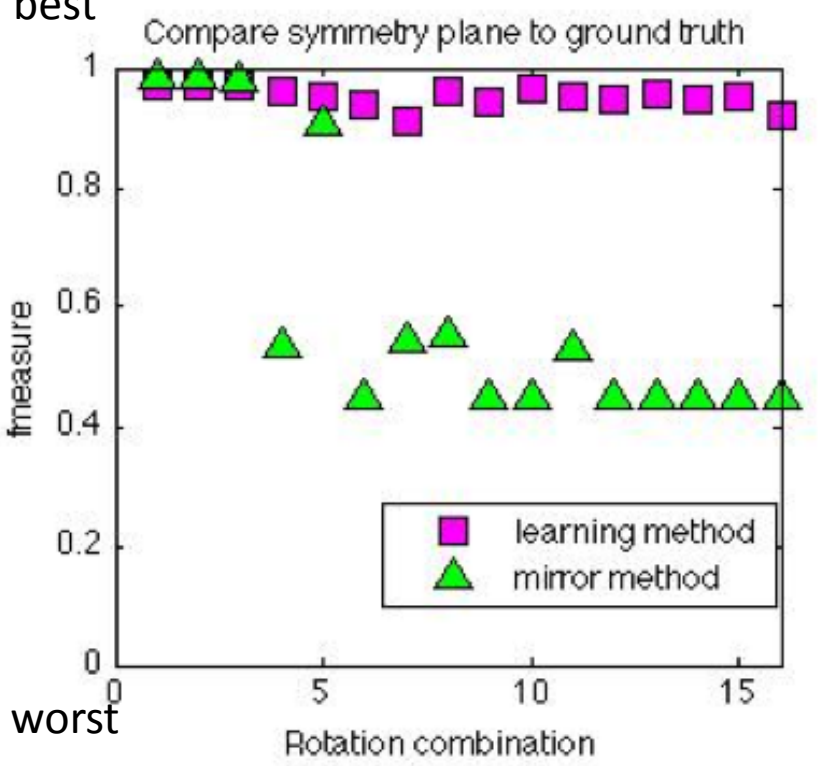




worst

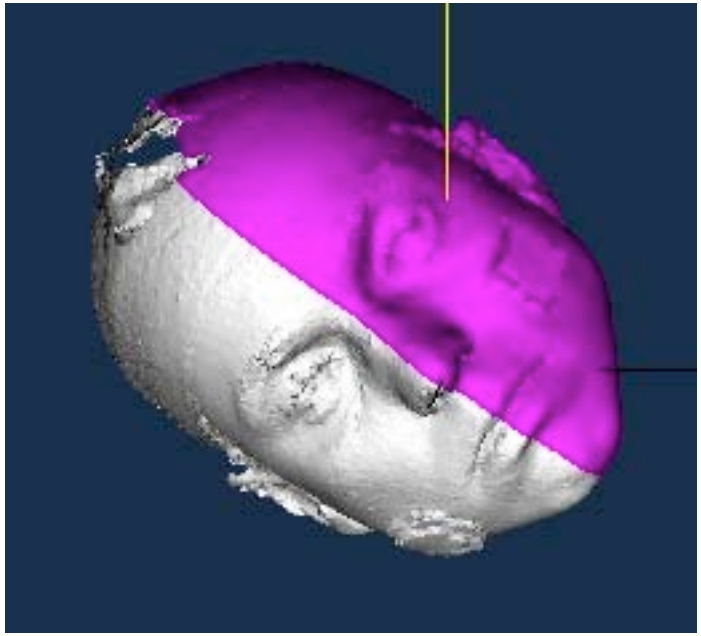


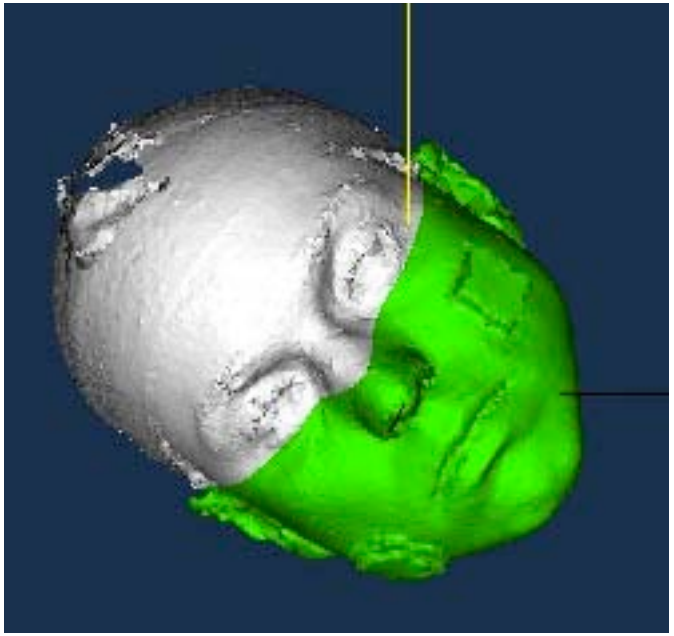
best

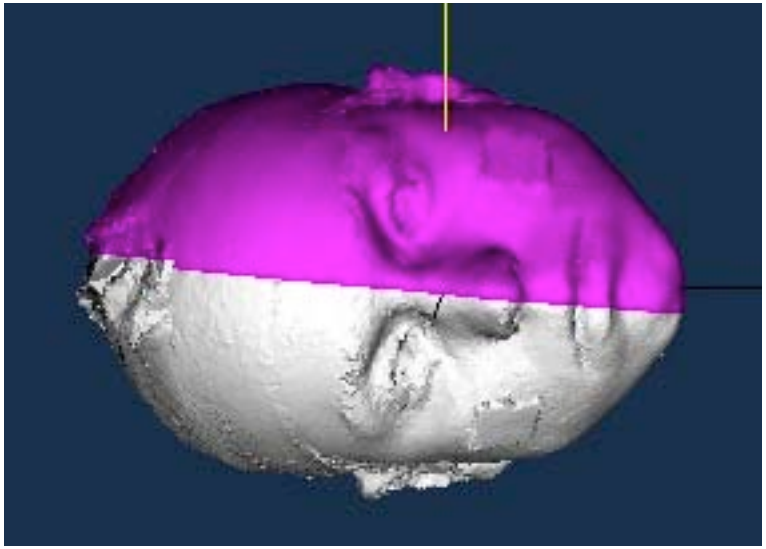
best

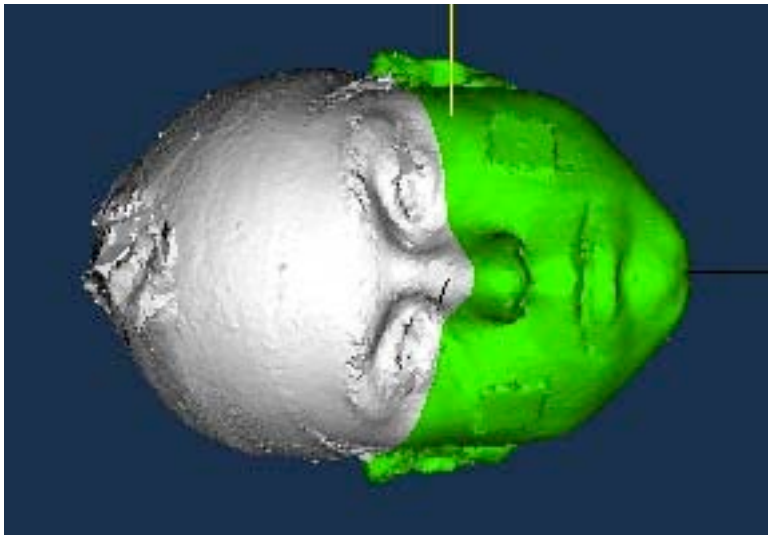


worst



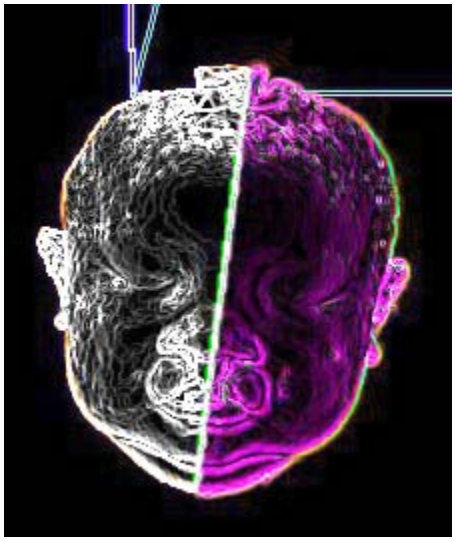


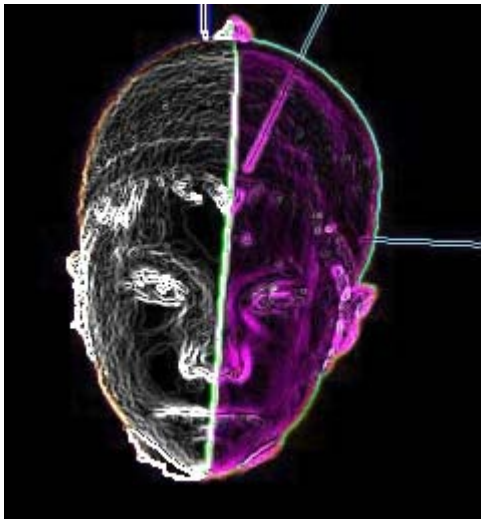




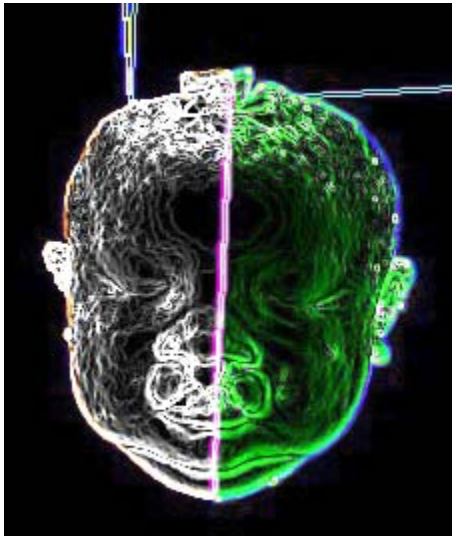
Cleft dataset

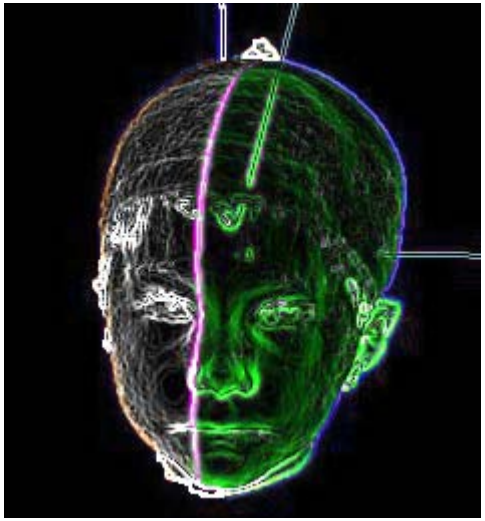
Learning method

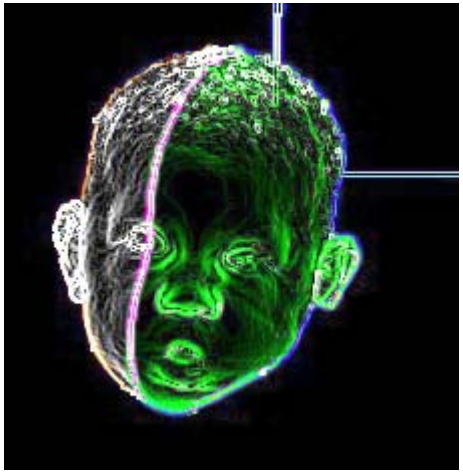




Mirror method







Questions?