Automatic Volumetry for Surgical Reconstruction of the Orbit

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Relevance

- Fracture of orbital floor is frequent in cranio-maxillofacial surgery
- Double vision or diplopia results from
  - 58% – 86% of all blow-out fractures
  - 13% – 20% of all midface fractures
- Surgical treatment [1]
  - Preformed titanium mesh
  - Exact reconstruction of orbital volume (same volume on each side)

Goal

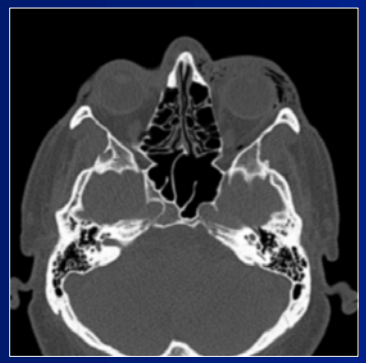
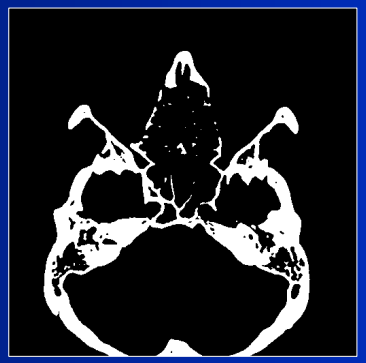
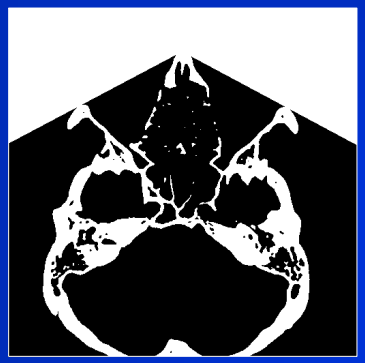
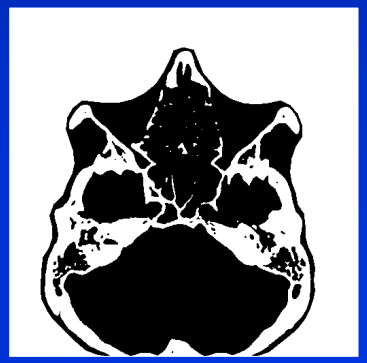
- Support of treatment planning
  - Automatic orbit segmentation in CT volumes
  - Orbital volume measurement
- Robust and reliable image processing scheme
  - Find suitable algorithm
  - Find robust parameterization
  - Evaluate on real data

Materials & Methods

- Selected subjects
  - A: 2 normal cases
  - B: 3 with fracture before treatment
  - C: 6 after mesh-based reconstruction
- Siemens Sensation 64 CT scanner
  - 120 kV at 82 mA
  - 512 x 512, 1mm slice thickness
- General discrete contour model [2]
  - Constant pressure moves towards edges
  - Biological membrane behavior avoids sharp bends
  - External influences regionally based on HU

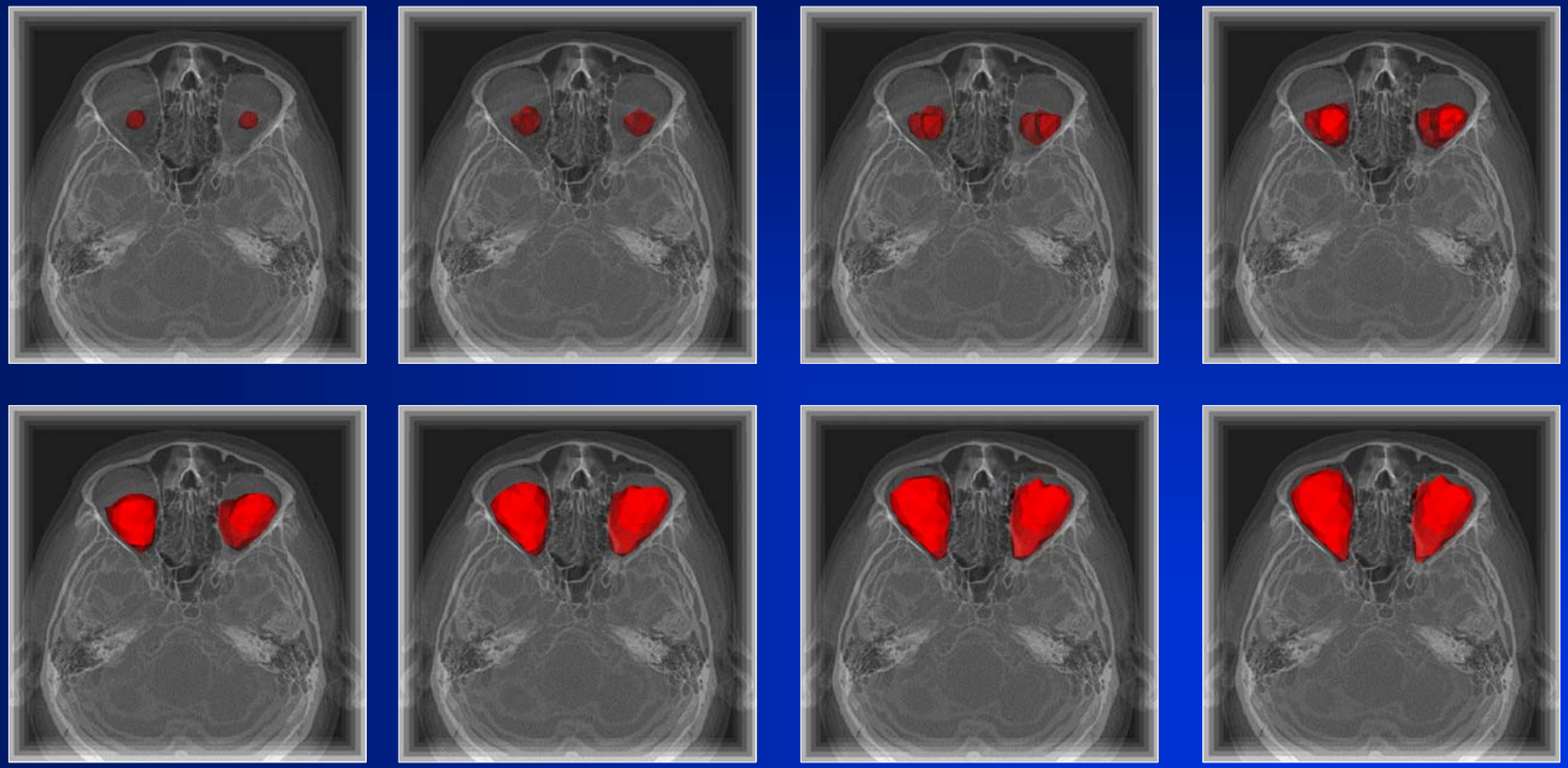
Preprocessing

- Problem: open orbit
- Solution
  - Noise reduction
  - Binarization
  - Linear boundary
  - Contour-based boundary using same balloon model

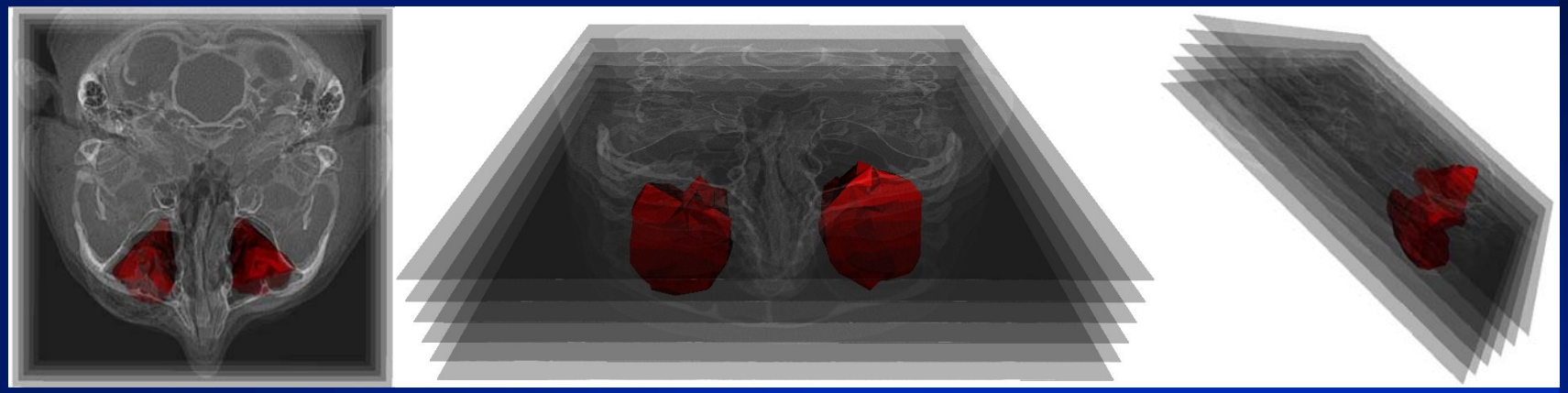
Example

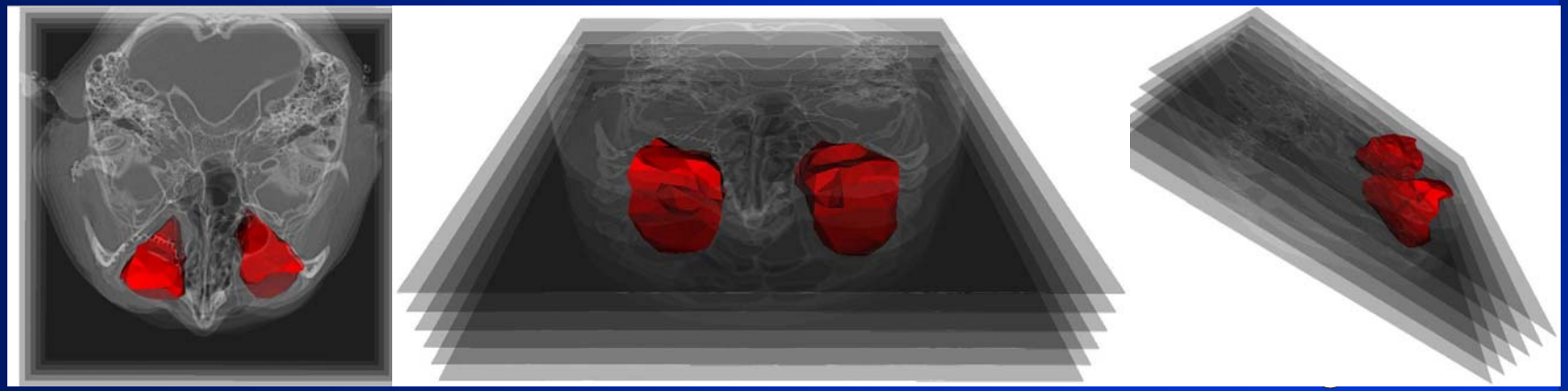
- Iteration



Example

- Orbit segmentation





Evaluation

- Healthy patients
  - Left side equals right side
- Measurements
  - Volume of left orbit: l
  - Volume of right orbit: r
- Relative difference: d
  - Assumed to be zero

$$d = 100 \frac{|l - r|}{l + r}$$

Results

Group	ID	No of slices	V_l	V_r	d
A	3a	136	541376	521174	1,90%
A	6	226	89395	87841	0,88%
					1.39%
B	1	139	339819	350085	1,49%
B	4	261	207250	221110	3,24%
B	10	191	506487	544712	3,65%
					2.79%
C	2	181	396430	390265	0,78%
C	3b	204	358029	365773	1,07%
C	5	244	469642	527664	5,82%
C	8	188	260264	255632	0,90%
C	9	216	151774	153774	0,65%
C	14	192	381866	320753	8,70%
					3.58%

Discussion & Conclusion

- New method for CT orbita segmentation
  - Membrane-like balloon structure
  - Shrunk from image border to close orbit
  - Blown from the orbit center for volume measurements
- Robustness
  - Mean variation below 5% for
    (A) healthy, (B) fractured, (C) reconstructed subjects
- Applications
  - Surgery planning
  - Follow-up studies

References & Contact

- References

1 Metzger MC, Schön R, Zizelmann C, et al.
Semi-automatic procedure for individual preforming of titanium meshes for orbital fractures
Plast Reconstr Surg 2007; submitted

2 Bredno J, Lehmann TM, Spitzer K.
A general discrete contour model in 2, 3, and 4 dimensions for topology-adaptive multi-channel segmentation.
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- Contact information

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