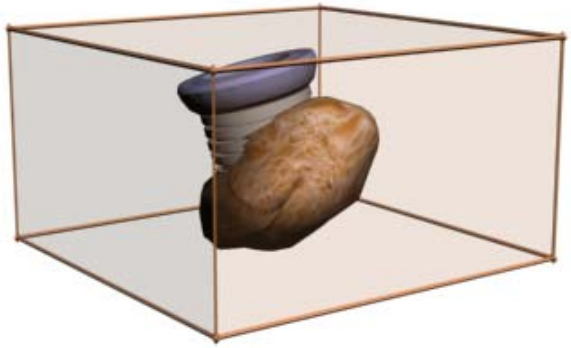
REGISTRATION OF 2D HISTOLOGICAL IMAGES WITH 3D SRμCT VOLUMES OF BONE IMPLANTS



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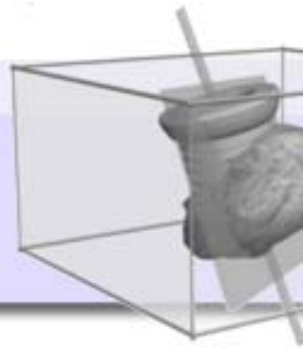
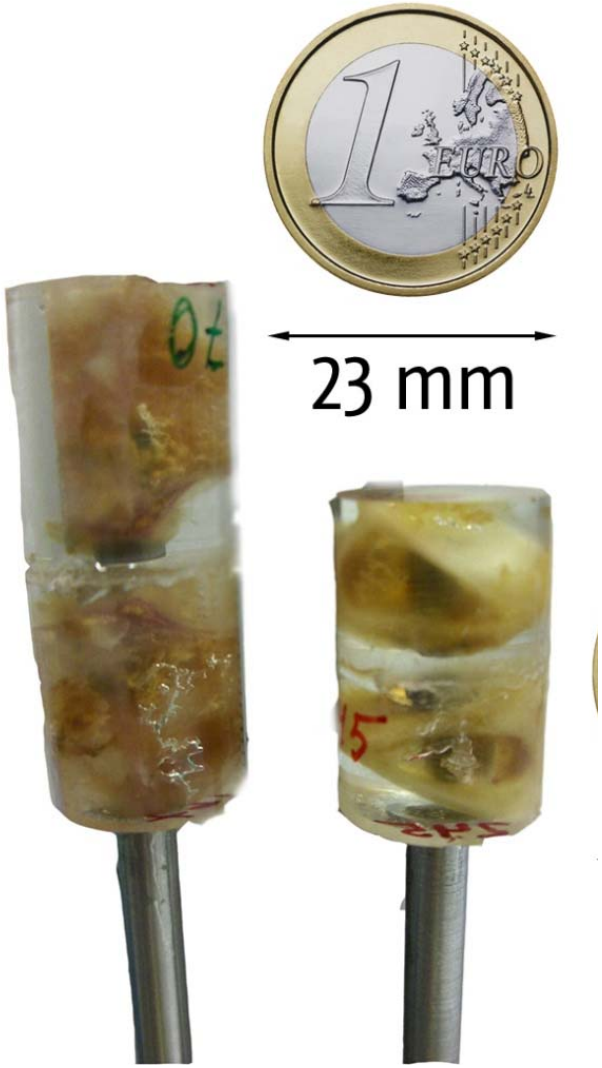
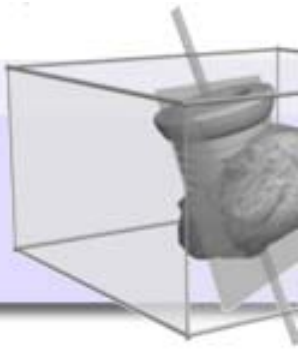


Screw Shaped Bone Implants

- Pure titanium
- In focus: **regeneration of bone**
- Different imaging techniques used for quantitative analysis

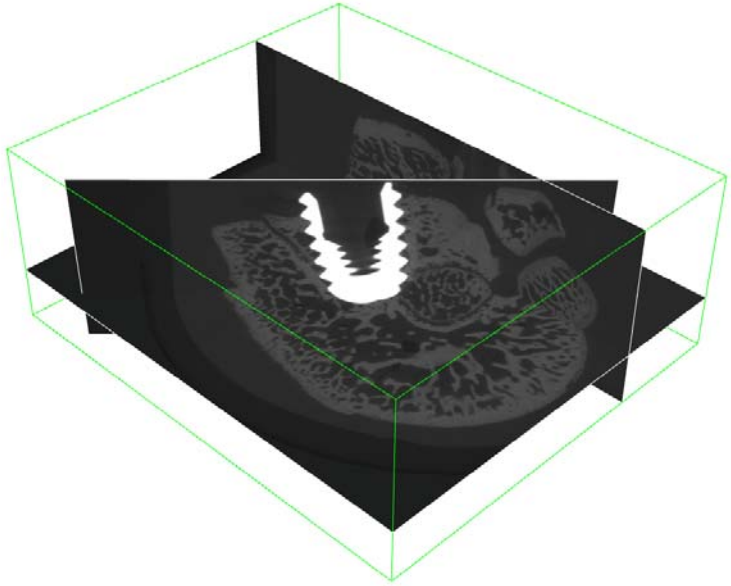




Imaging

SRμCT

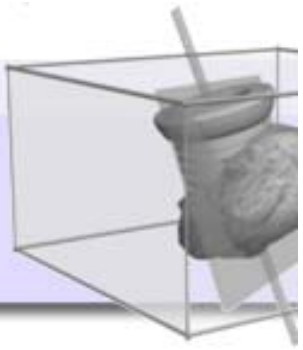
(Synchotron Radiation Based μCT)



3D

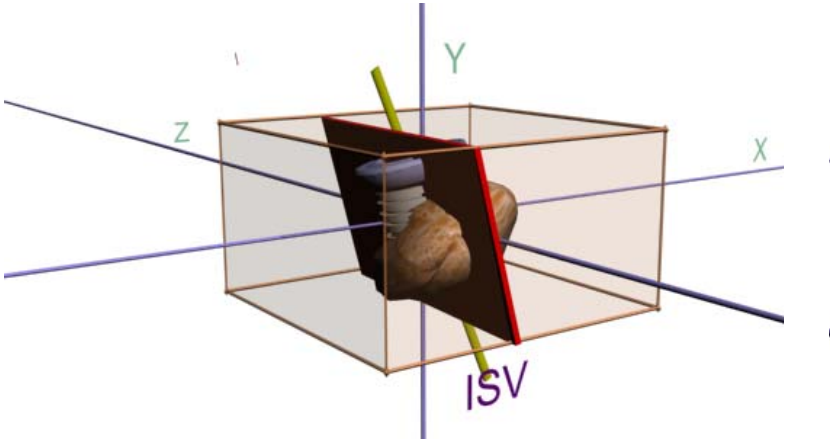
Microscopy

2D



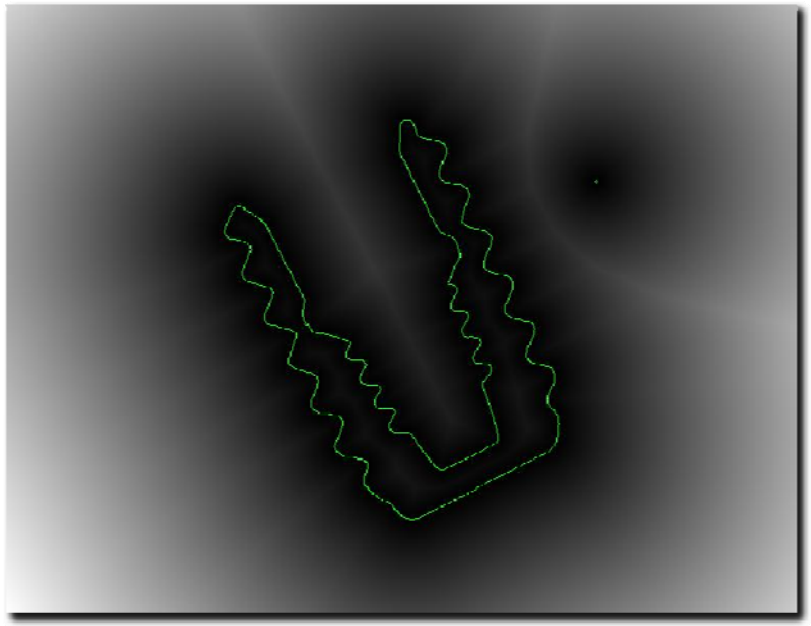
Intermodal Registration

- Large volumes
  - (about 500x500x250)
- 6 degrees of freedom
- Fast method required:
  - **Chamfer Mathcing** for matching the bone region
  - Rotation about the implant symmetry axis (ISV) for a complete registration

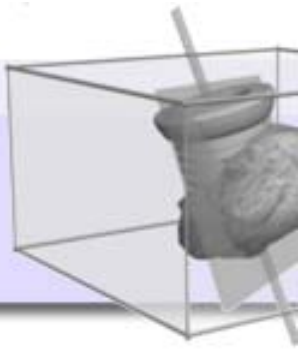


Chamfer Matching

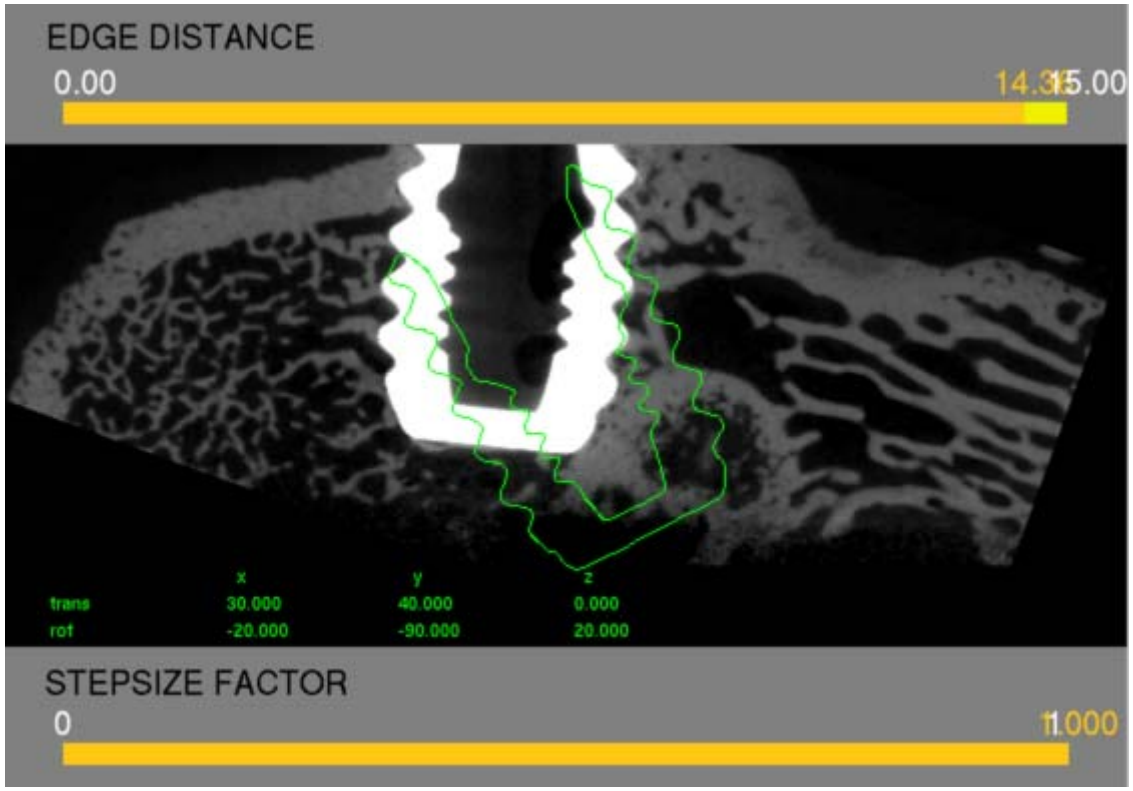
- 24 initial positions
- Converging to a matching slice by minimizing the edge distance
- Distance transform of the implant edge in the histological slice
- Hierarchical in the sense that the step size is decreasing for each level

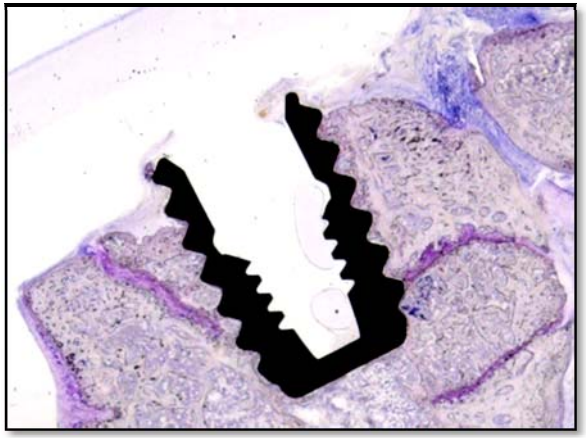


(Matching performed in 3D)



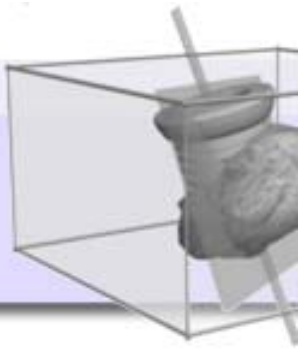
Visualizing CM





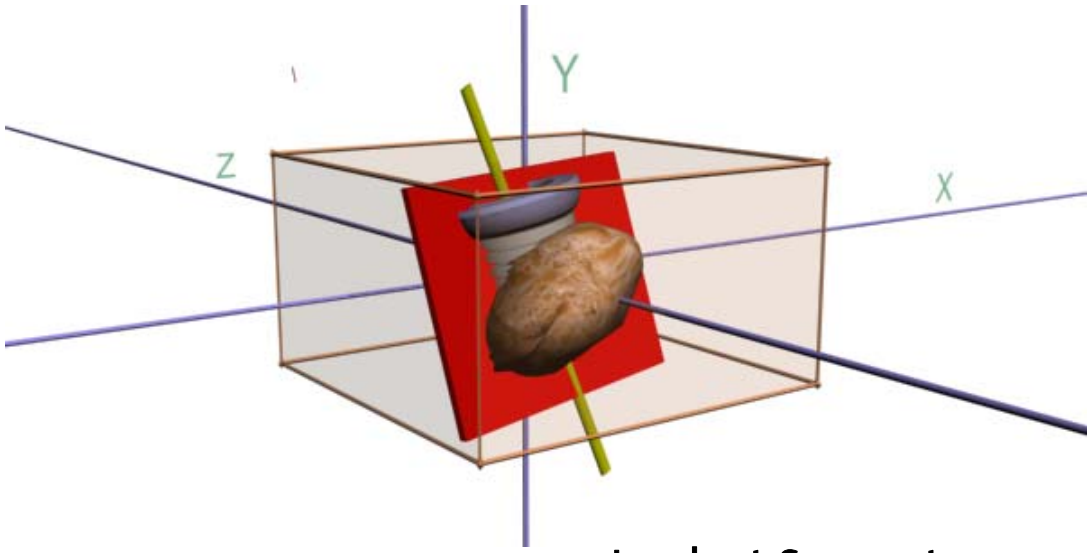
Step II

- Chamfer-matching is not enough
  - Rotation about the implant's symmetry vector (**ISV**) required
- The distance between two center of thread crests ~ 0.4 mm, that is ~35 pxls
- The implant can rotate around ISV up to about 10 degrees before the threads are shifted one pixel

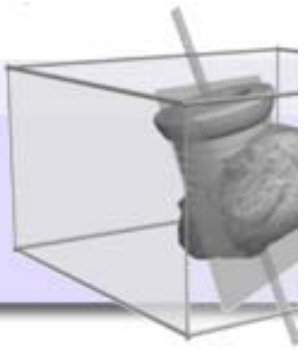


Implant Symmetry Vector

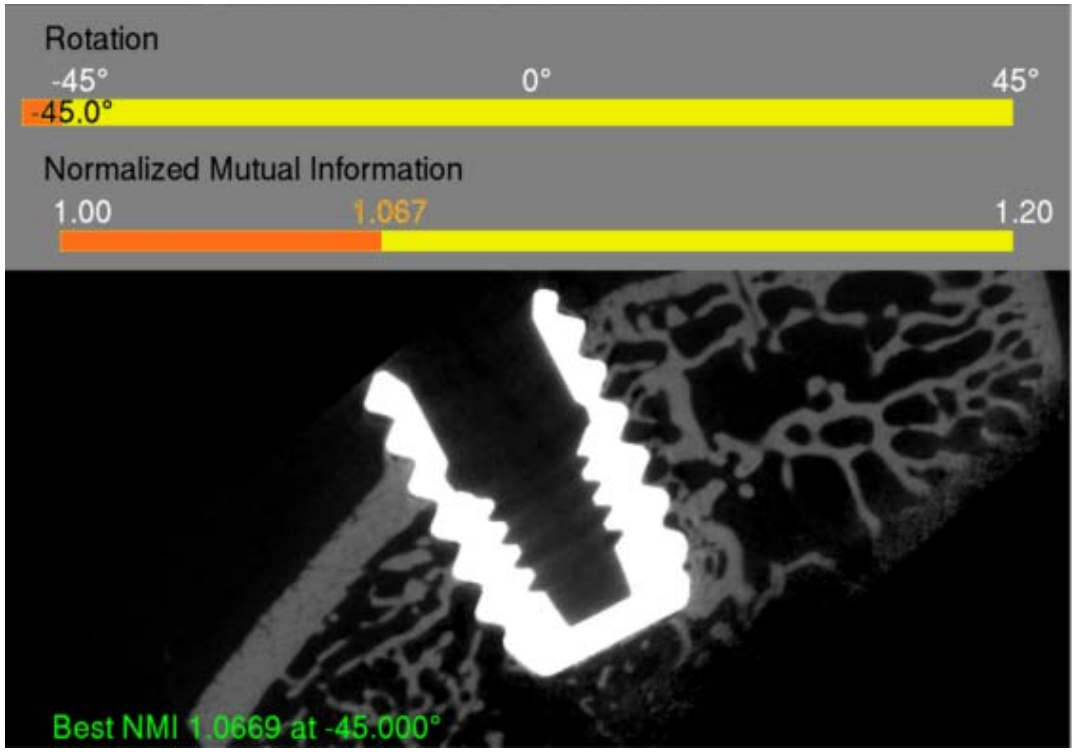
- The axis where the variance of the segmented implant is largest is considered to be the ISV
- This axis is found using PCA
- Optimal rotation found by maximizing Normalized Mutual Information

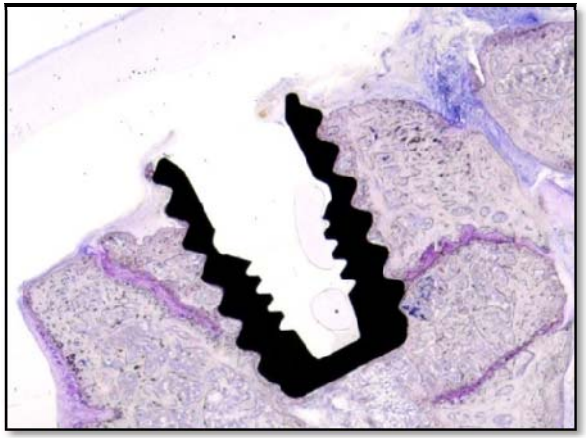


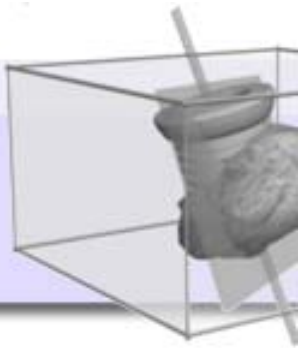
Implant Symmetry Vector (ISV)



Rotation about Symmetry Axis

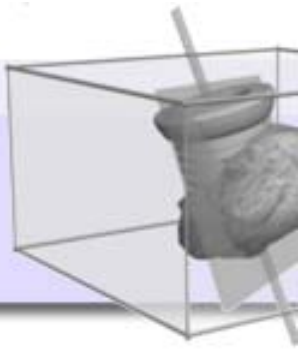




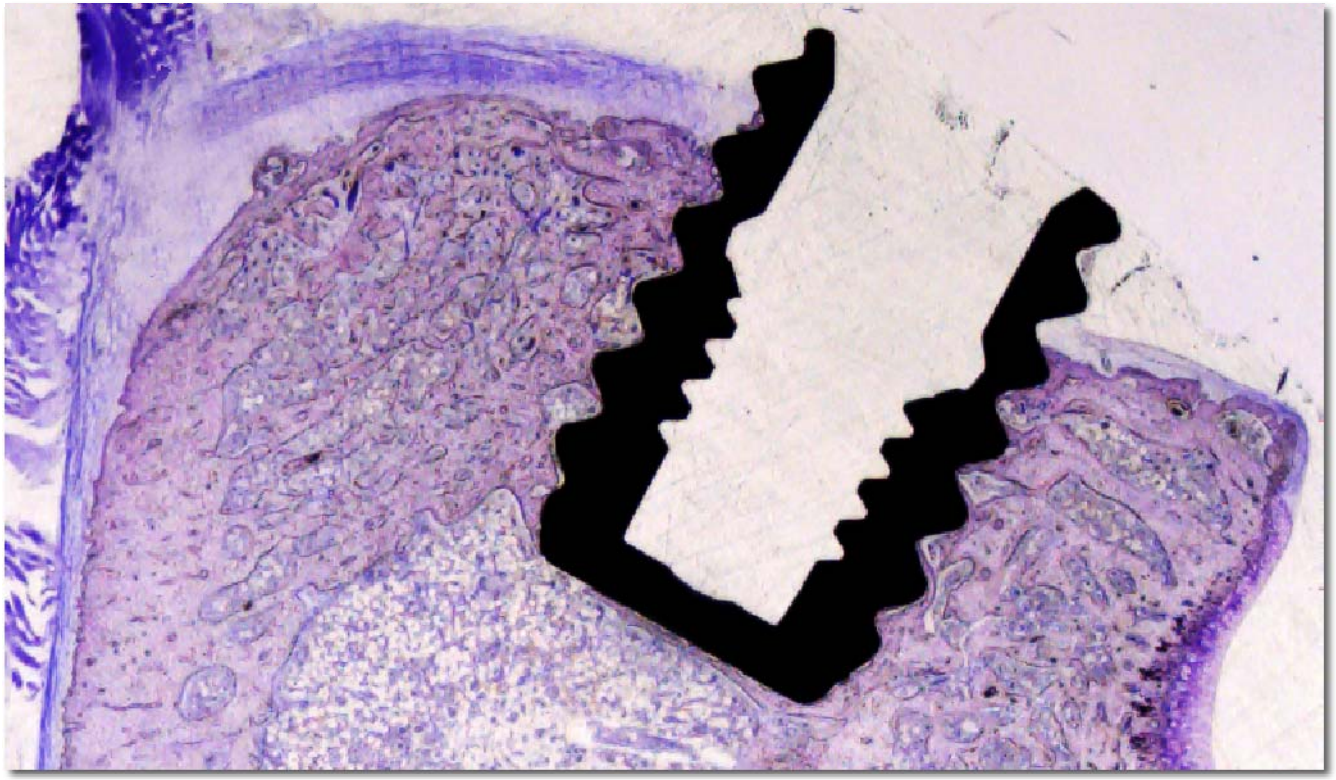


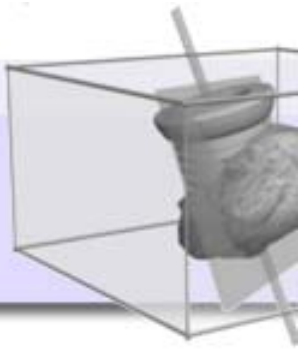
Making use of the GPU

- **Extracting slice from a volume**
  - This operation in Matlab is indeed time consuming
  - Rather done on the GPU
- **Obstacles:**
  - Fitting the volume into the texture memory
  - **Matlab and C++ interaction**
    - Solved in Linux by *shared memory, piping*
    - In Windows ?
  - OpenGL Utility Toolkit requires a window

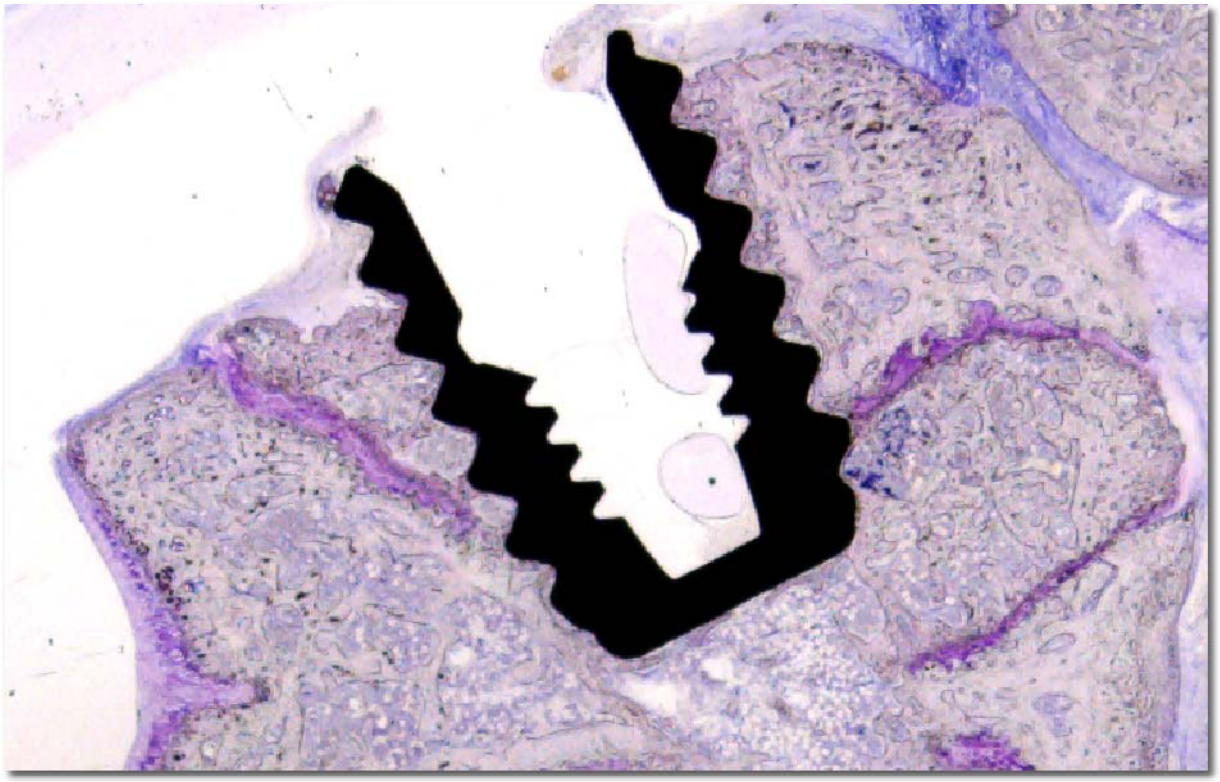


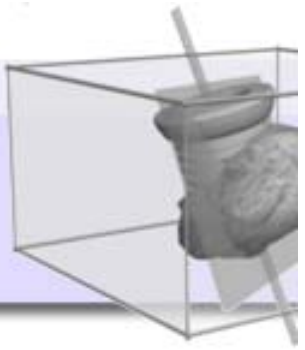
Results: Sample I





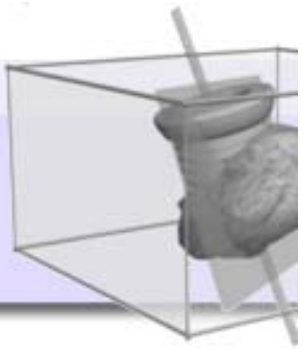
Results: Sample II



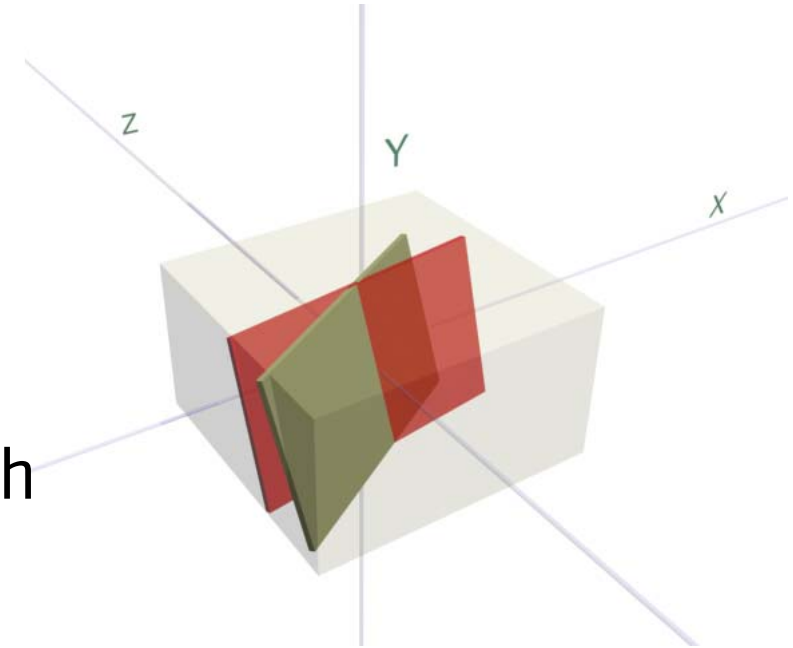


Result III

Method Verification

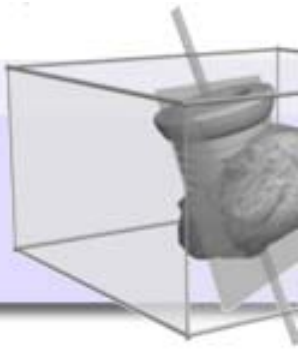


- No ground truth
- Performance evaluated on monomodal registration:
- A slice from the volume with known coordinates is extracted
- This slice is then registered with the volume
- The average difference of the vertices is considered the registration error



Red slice: manually extracted slice
Green slice: registered slice

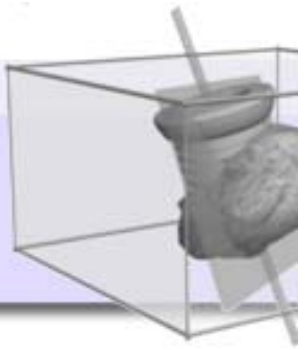
Registration Error



	Failed registrations (error > 5%)	Error among successful registrations
No noise	4%	0.60%
Gaussian noise added (σ= 0.05)	16%	1.70%

~7 min / registration

Conclusions & Discussion



- Robust and reliable using Chamfer Matching
  - that is: when the segmentation is performed easily
  - Large number of initial positions required
  - shown to give yield a more reliable result than Simulated Annealing
  - GPU acceleration necessary for fast registration of large volumes

Thank you for your attention!

Greatly acknowledged:

[illegible], Johansson,

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