An Improved Algorithm for Fractured Femoral Head Segmentation from CT

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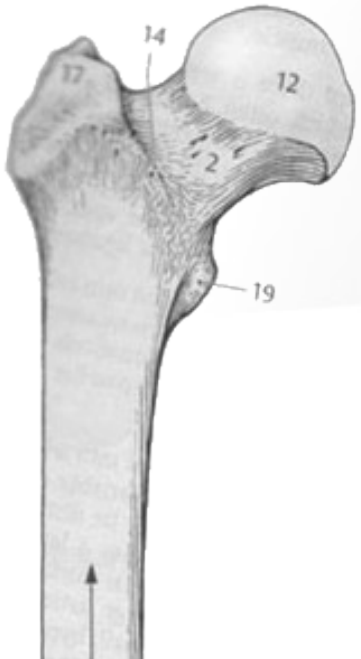
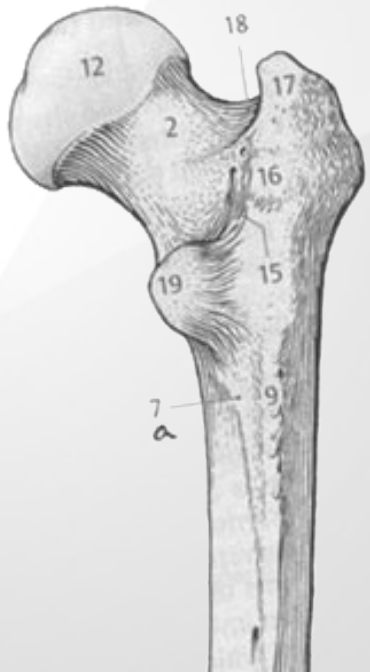
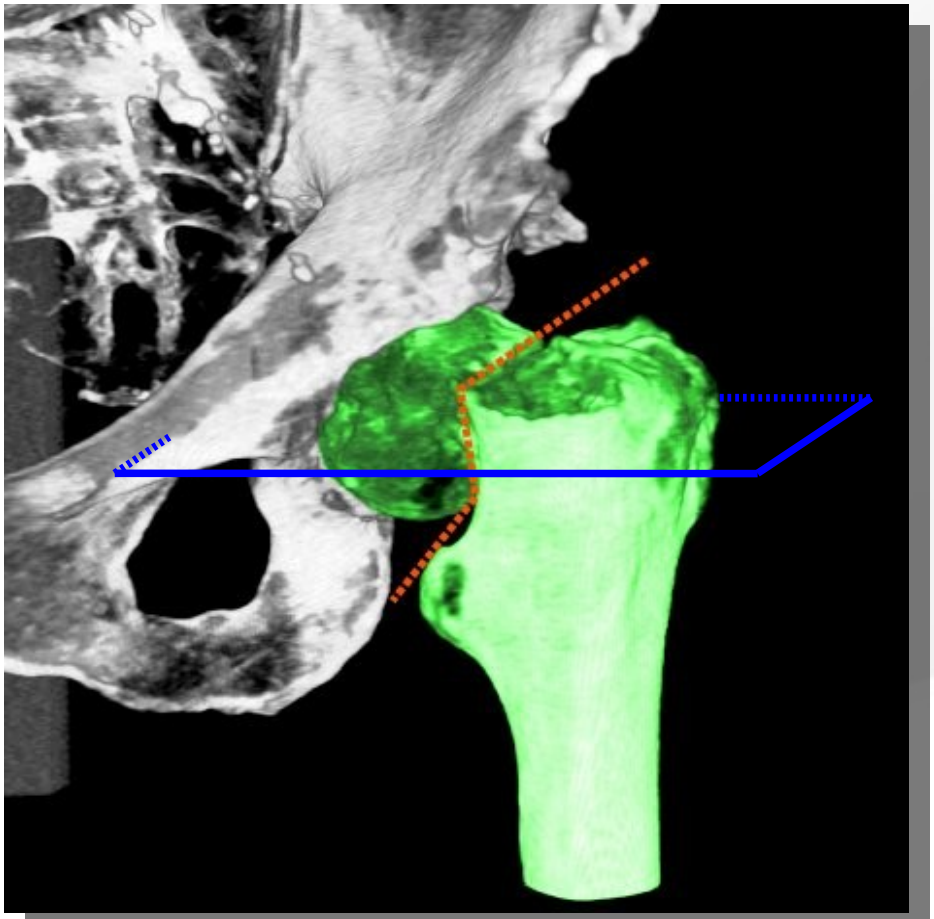
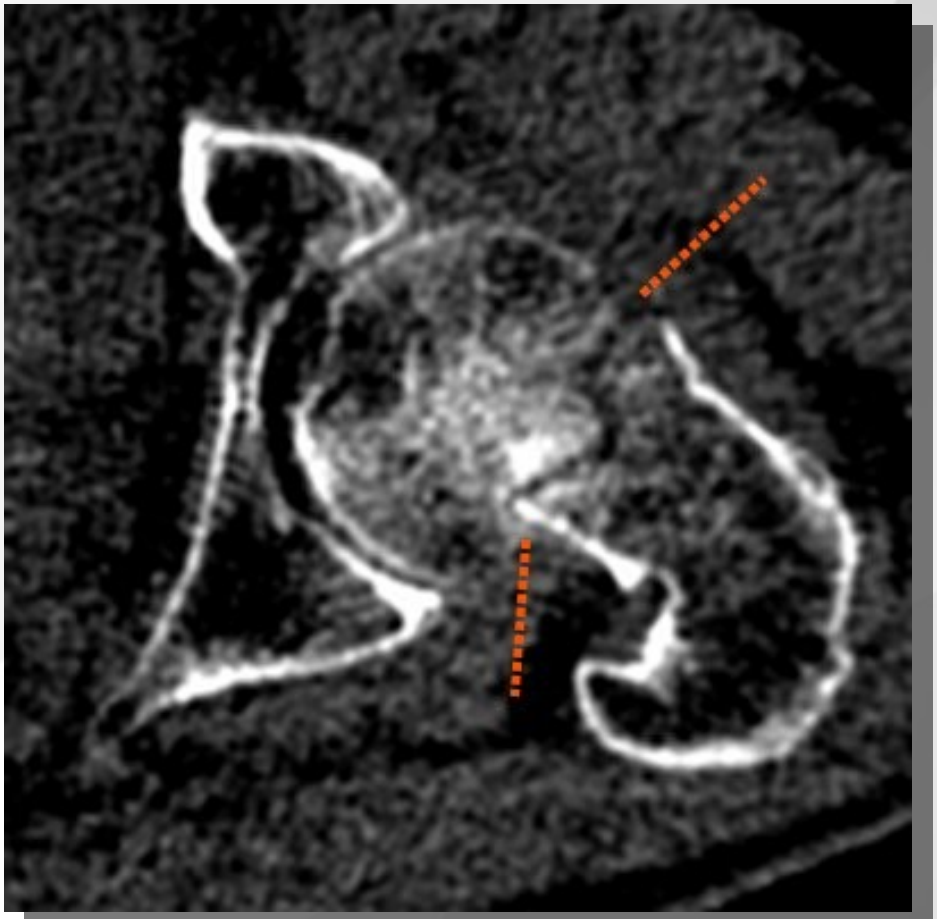


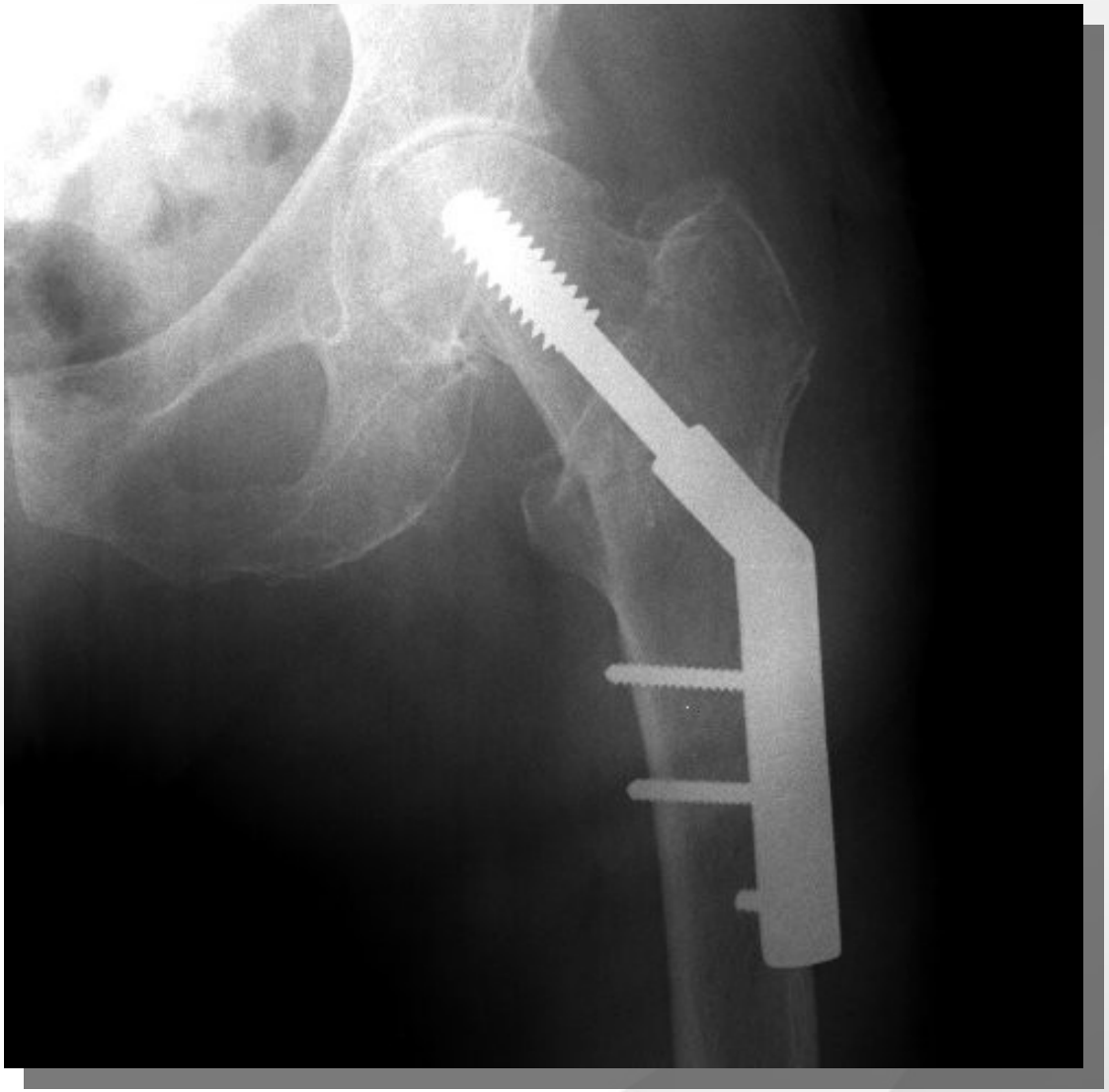


Femoral neck fracture





Screw treatment



Segmentation strategy

(1) User-defined control points

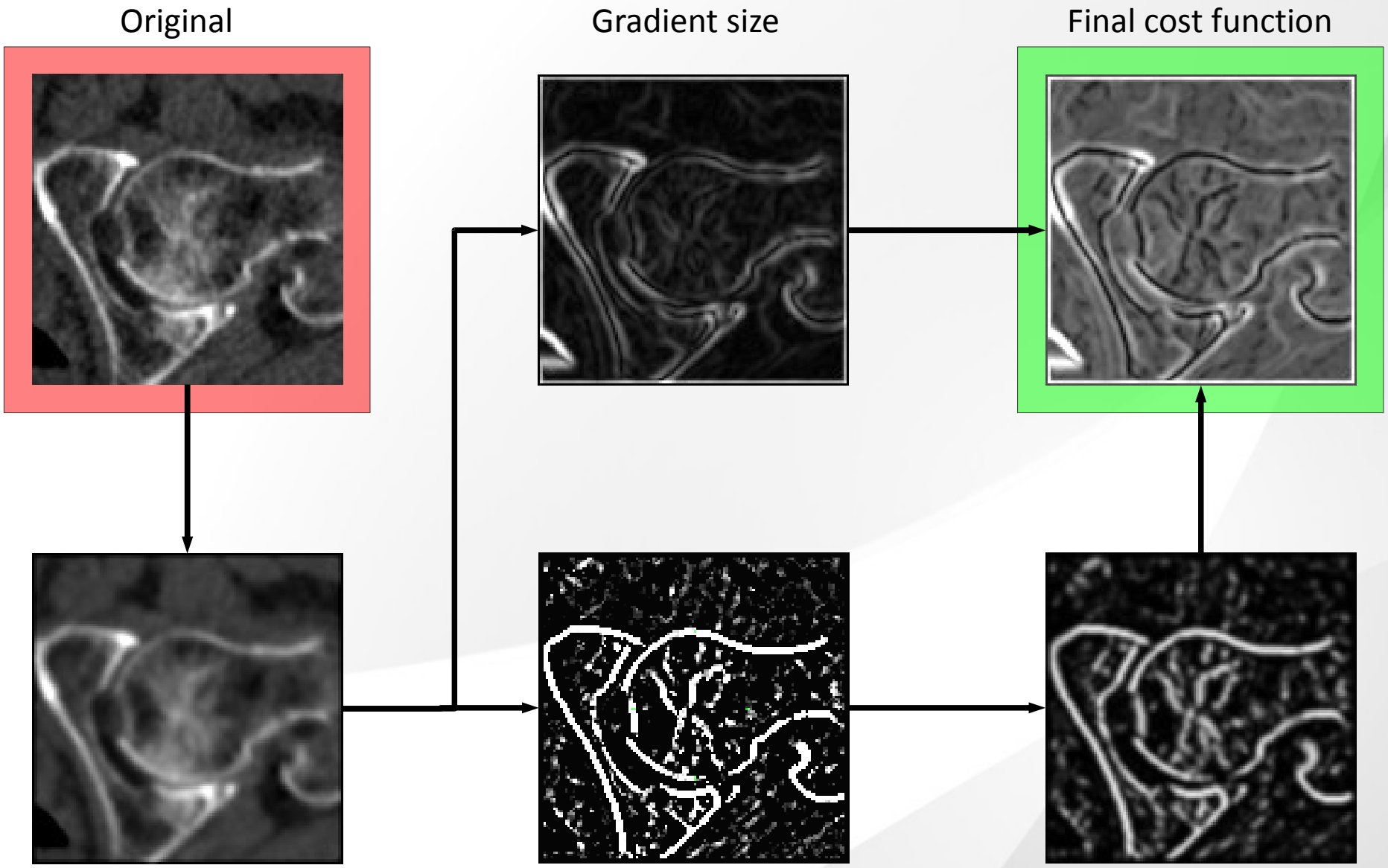
(2) Preprocessing

(3) Segmentation

(4) Postprocessing

(5) Statistical analysis

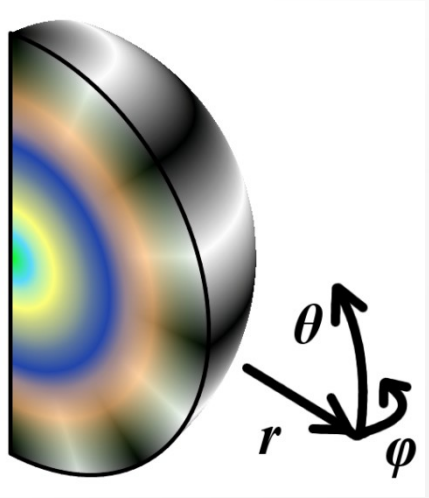
Preprocessing

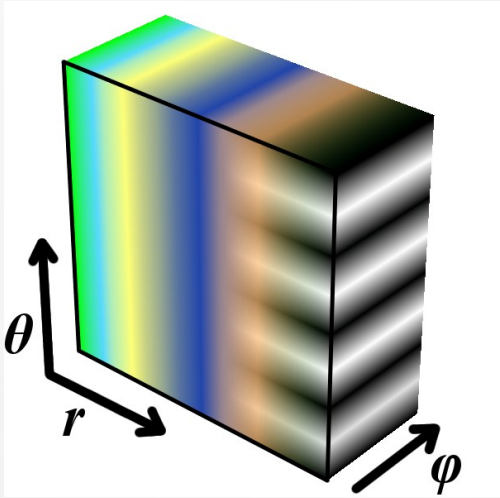


Segmentation

- Uses spherical coordinates and different data walkthrough than our previous work
- Avoids problems of slice-by-slice methods
- Based on shortest path search, but neighbour points on shortest paths relaxed, so that they do not diverge too much

Spherical transformation





$$r = \sqrt{x^2 + y^2 + z^2}$$

$$\varphi = \arctan 2(y, x)$$

$$\theta = \arccos\left(\frac{z}{\sqrt{x^2 + y^2 + z^2}}\right)$$

$$x = r \cdot \cos(\varphi) \cdot \sin(\theta)$$

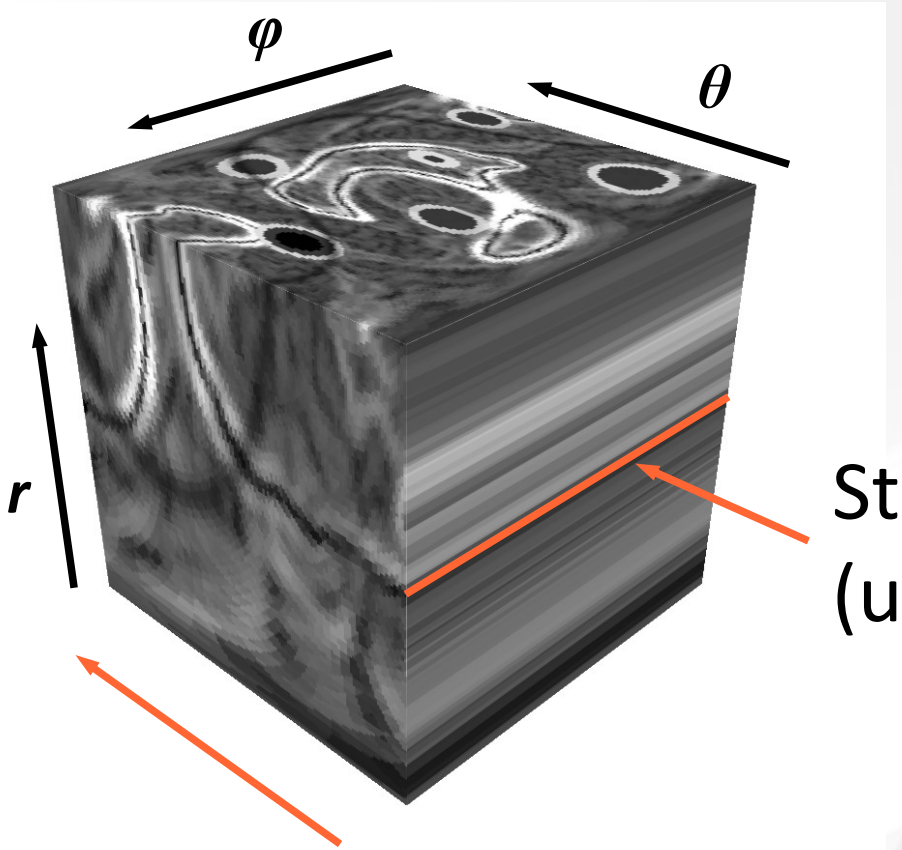
$$y = r \cdot \sin(\varphi) \cdot \sin(\theta)$$

$$z = r \cdot \cos(\theta)$$

Primary polar point

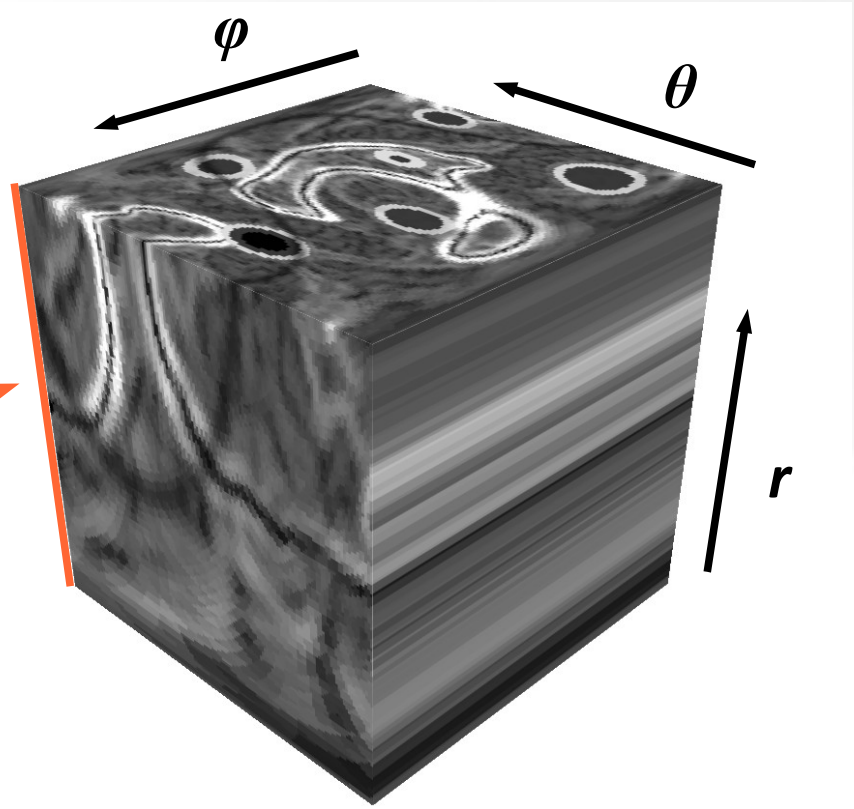
- User selects one primary control point, which is taken as the pole for spherical transformation
- Before the transformation from spatial to spherical coordinates a rotation is performed to move the pole to an axis (for example +Z)

First walkthrough



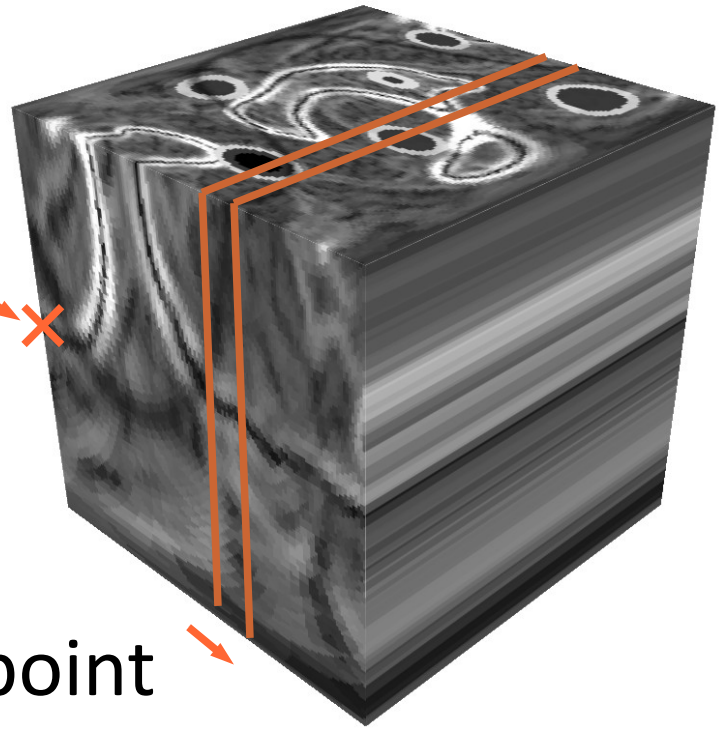
Find second pole

Search for the smallest value



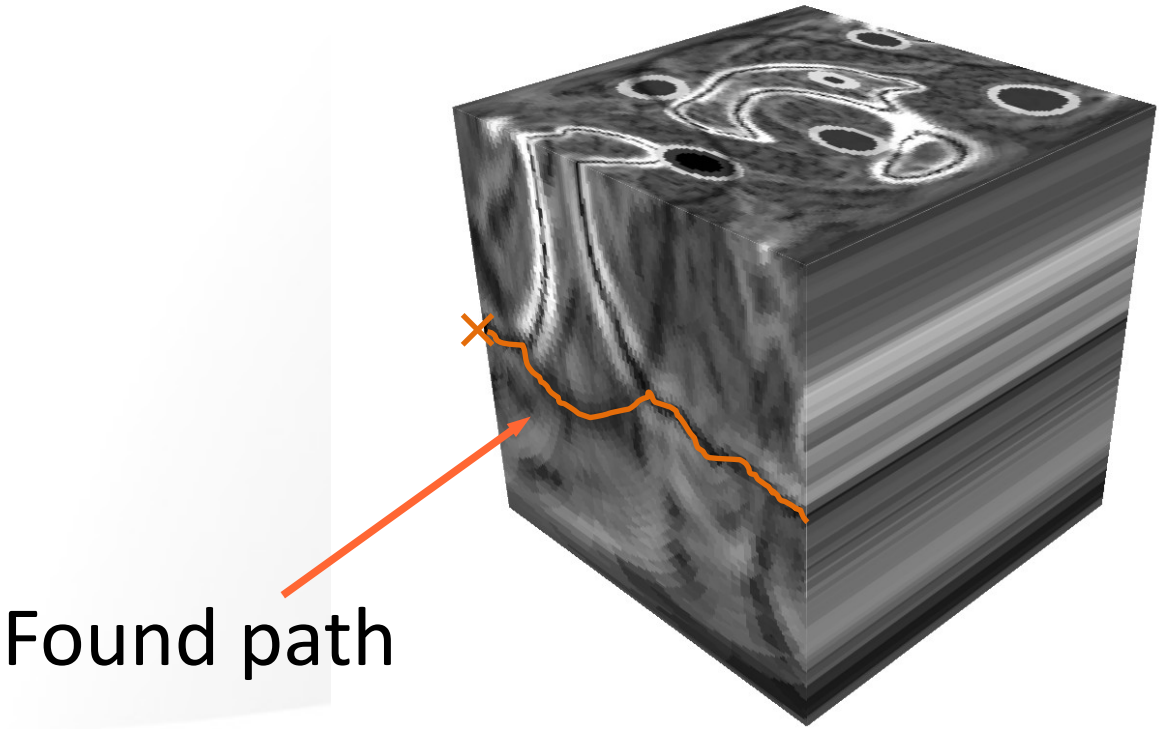
Second pole

Starting pole for backtracing



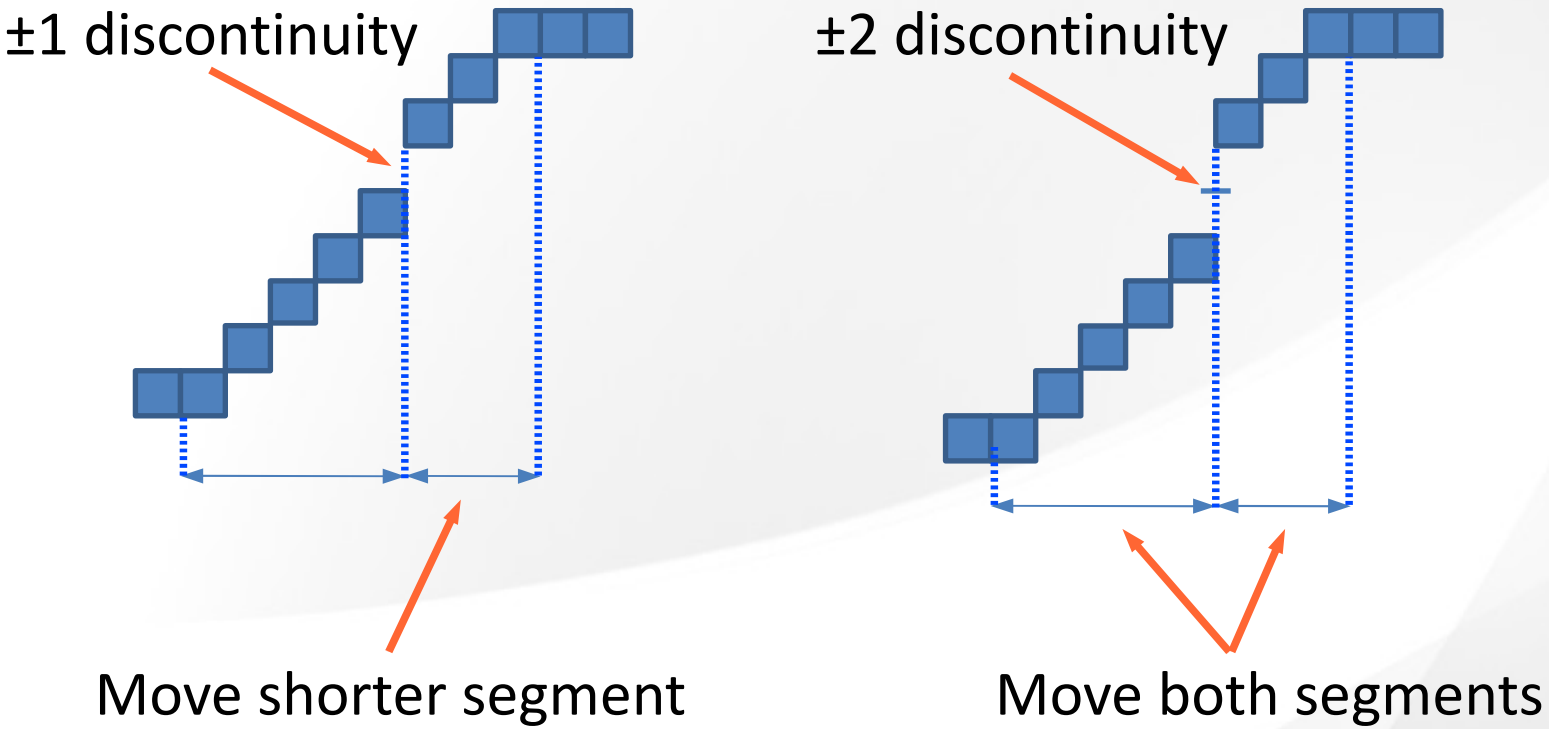
Step for each path point along descending values with relaxation

Start finding paths



Curve relaxation

- Curve is divided into discontinuous segments



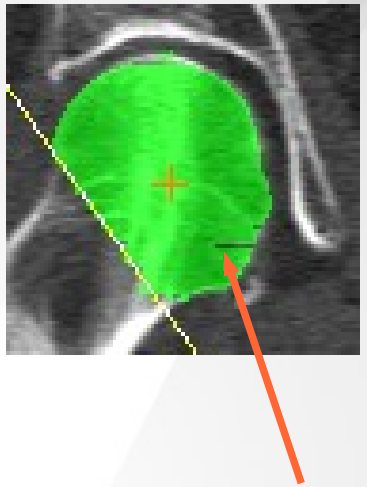
Optional control points

- Optional control points locally decrease the cost function
- Subtract *f(d)* from the original cost function, *d* is the euclidean distance to the control point

$$f(d) = \frac{K}{\lambda} \cdot \exp\left(- \frac{d}{\lambda} \right)$$

Advantages

- Very fast processing through dynamic programming
- Easy to run in parallel
- No “thin holes” in the volume that make problems during morphological operations

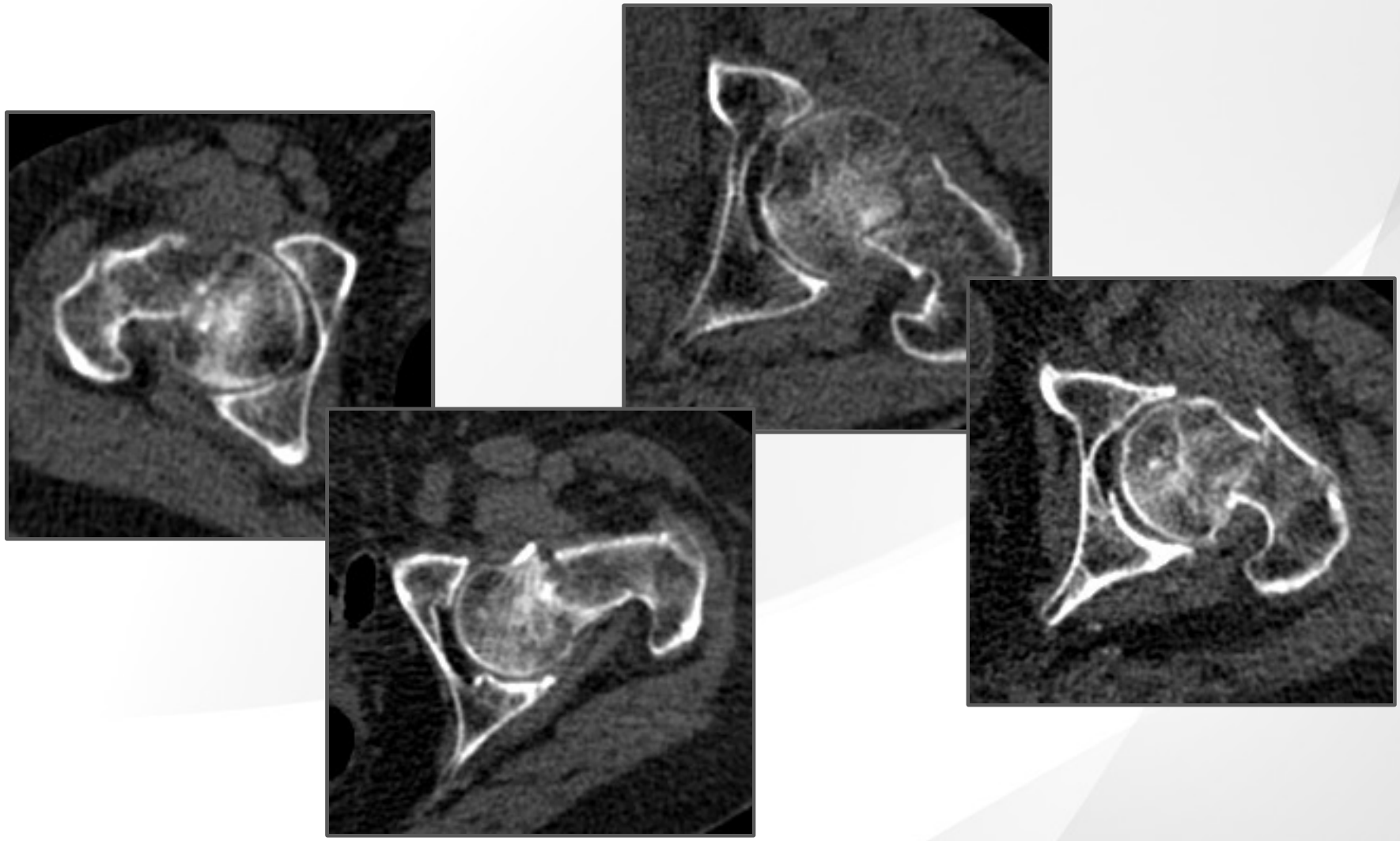


- Many datasets segmented with much less control points (thus user interaction is much faster)

Disadvantages

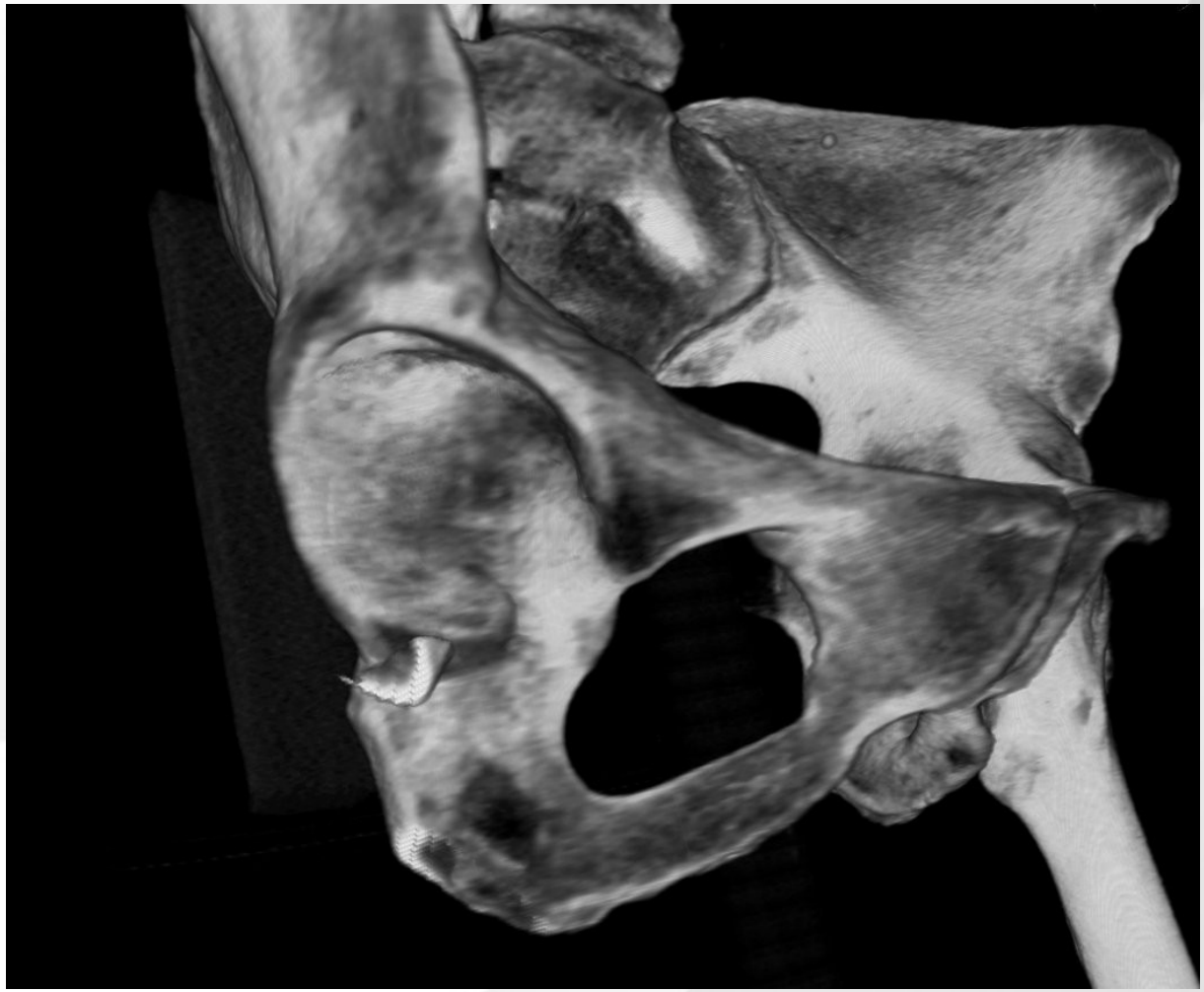
- A little bit weaker control abilities (weaker control points)
  - Some patients need more control points
- Due to the relaxation method some “spikes” may still appear
  - For smoother results some optimization method may be used
- Still sensitive to the control points location (like our older slice-by-slice method)

Fractures



Another utilization

- Virtual acetabulum inspection
- Allows to inspect the inner part of hip joint for fractures



Thank you
for your attention