Determination of Salient View Point of Volume Data

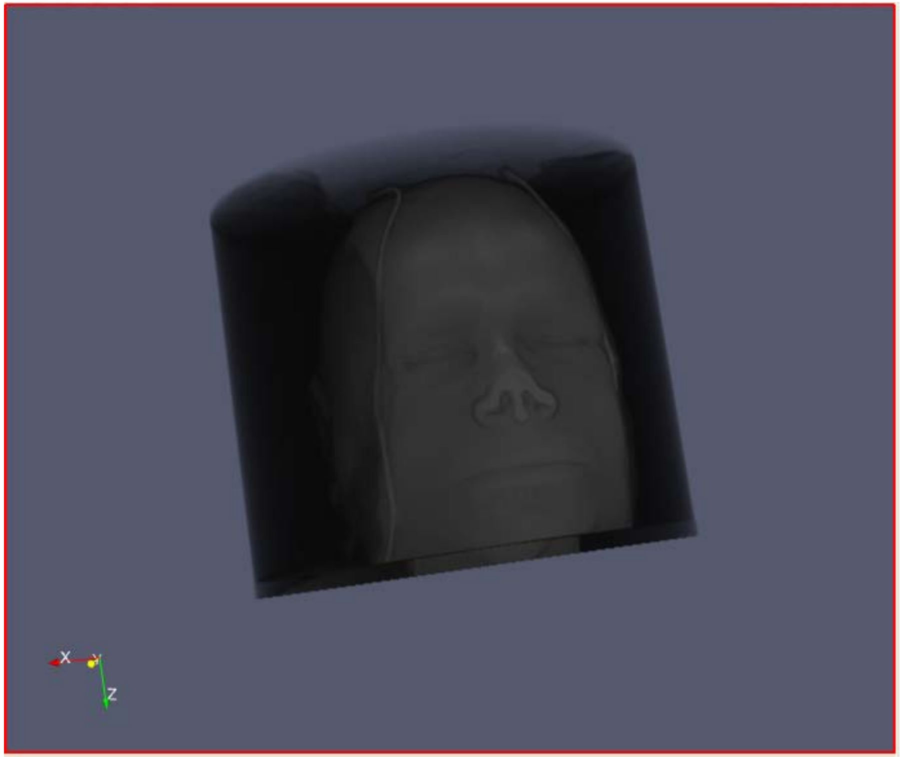
Cheng Yuan HT080111R

Problem Formulation

- Input
- preprocessing
- Output
- Definition
- Formulation

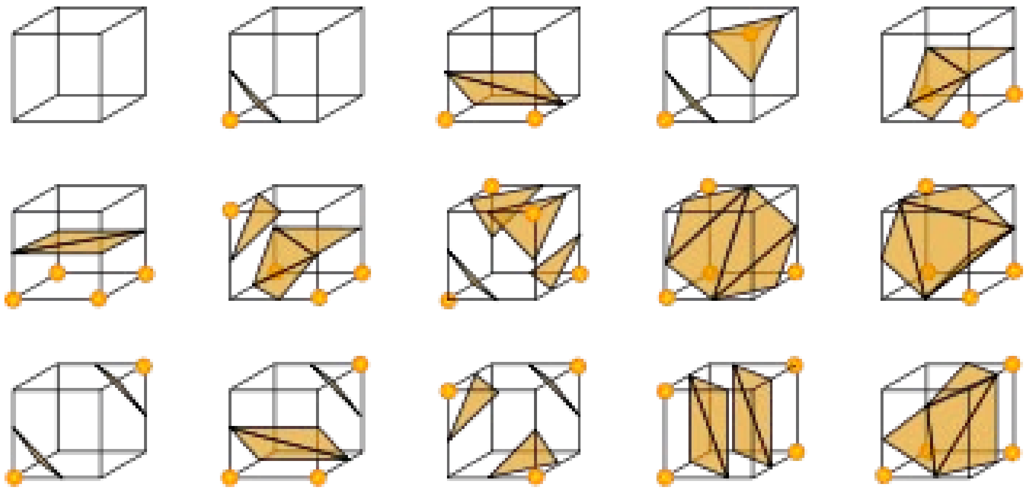
Input

- The initial input is the head 3D volume data.
  - Voxel values vary from 0 to 4095.



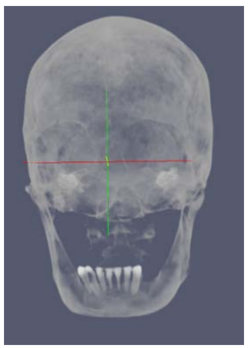
Preprocessing of the Input

- The skull is what we are interested in .
- Because the density of the skull is higher than other parts of the head. The scalar values of the skull are larger than others in the CT volume.
- So we can define a threshold Θ, and extract the skull by filtering out the voxels with scalar value greater than Θ.
- Based on this observation, I use the marching cube method to get the mesh model M for Θ to represent the skull.



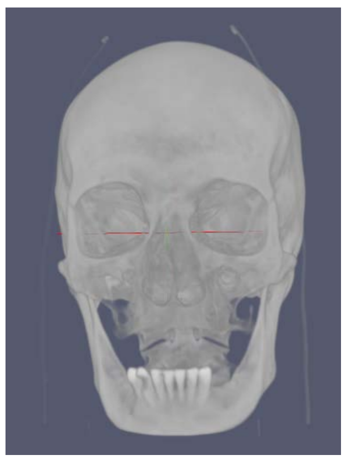
Different meshes corresponding to different Θ values

- By experiments, the best value for Θ is 1150.



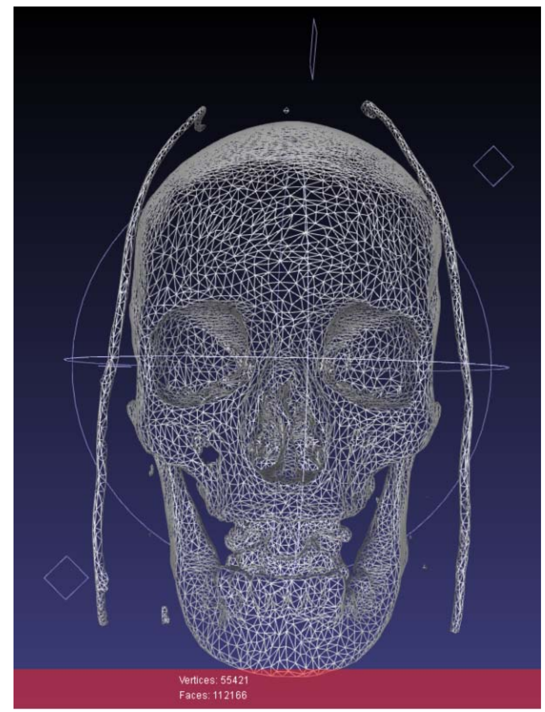
Θ=2207.74

Θ = 735.913



Θ = 1150

Marching Cube

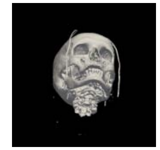


Output

- The output should be rendered result for the salient view.

Definition

- What are the candidate views?
- What is saliency?
- What is a salient view?

Views 

- There are 3 assumptions about the candidate views.

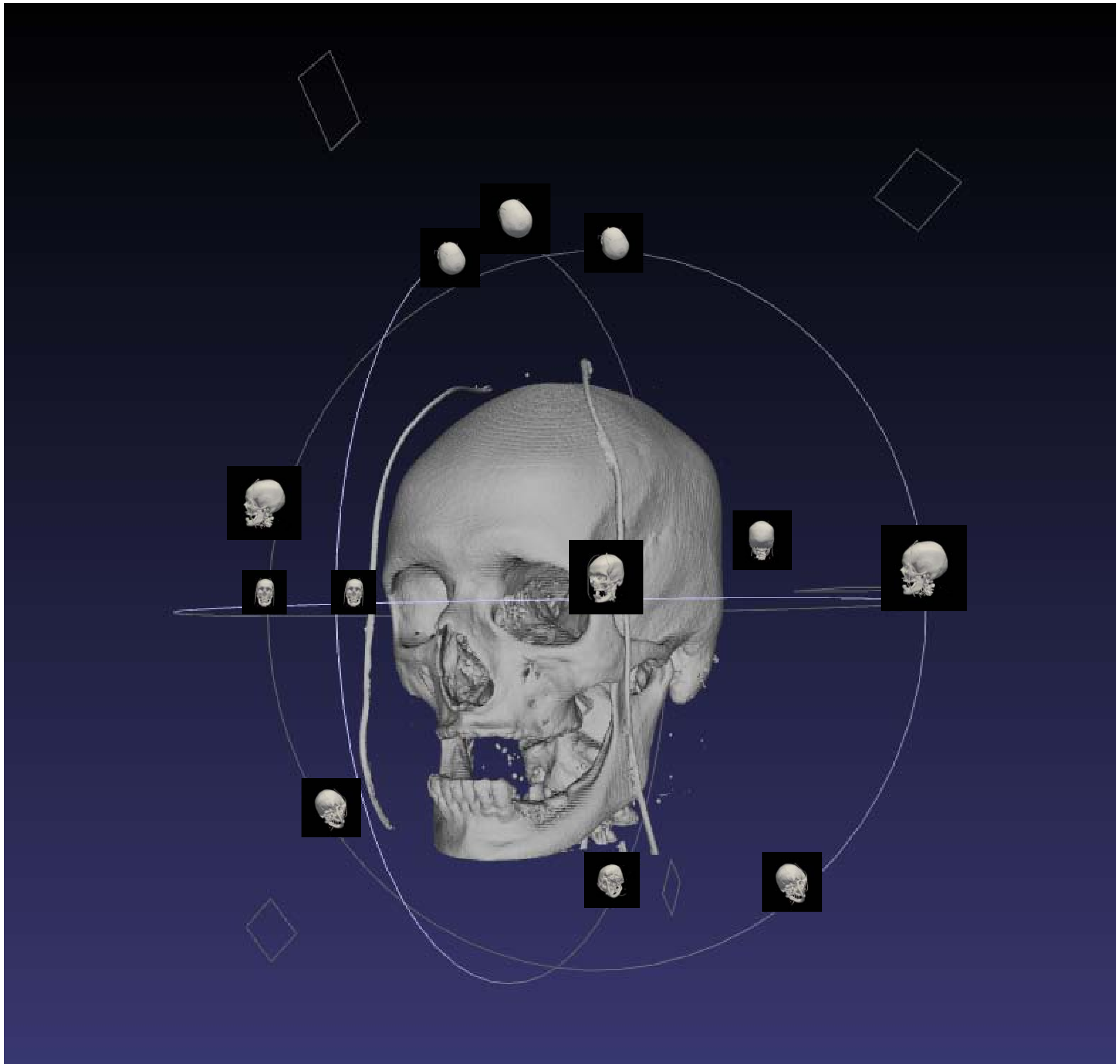
To ignore the influence of distance, the distance from the camera to the skull center is set to a constant value d. Thus the camera can only be placed on a sphere.

The focal point of the camera is set to be the center of the skull.

The view up direction is the same as the skull's up direction. This avoids uncomfortable views.

- With this 3 assumptions, one candidate view can be represented by the camera position. The camera position is a longitude-latitude pair.
- With the model in the scene, Lets note the image captured by camera (a, b) as I(a, b, M)

Views Sphere



Definition

- What are the views?
- What is saliency?
- What is a salient view?

Entropy

- For a random variable α, the entropy is

$$E = -\sum p_i \log_2 p_i$$

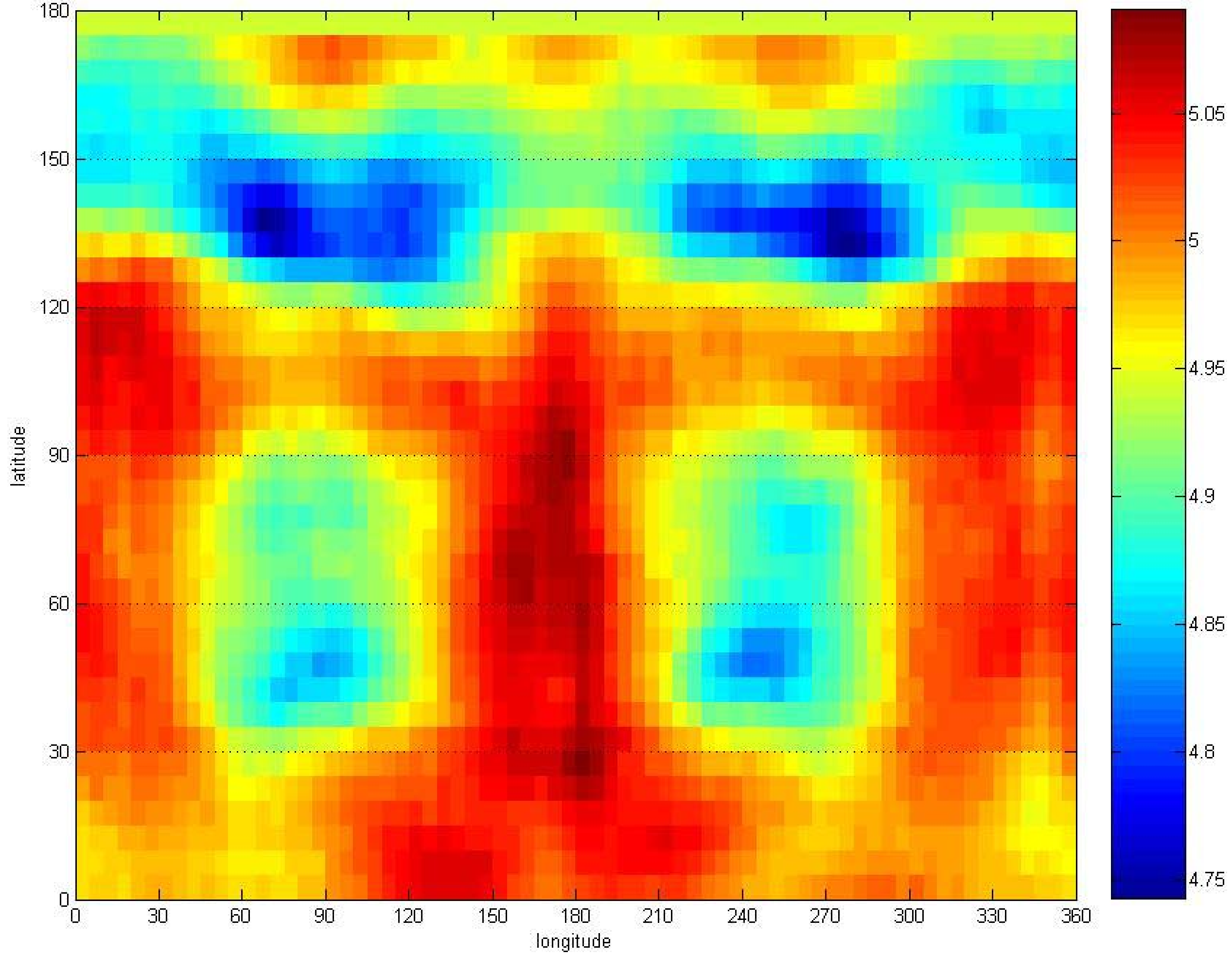
  - Where the p_i is the possibility that α have the i'th value
- For an image I , the entropy is defined as

$$E(I) = -\sum_{i=0}^{255} p_i \log_2 p_i$$

  - Where p_i is the percentage of pixels having intensity i .(the intensity ranges from 0 to 255)
- For the pixels with intensity 0 are from the back ground, we should avoid their influence on our salient view selection. I modify the definition to:

$$E(I) = -\sum_{i=1}^{255} \frac{p_i}{(1-p_o)} \log_2 \frac{p_i}{(1-p_o)}$$

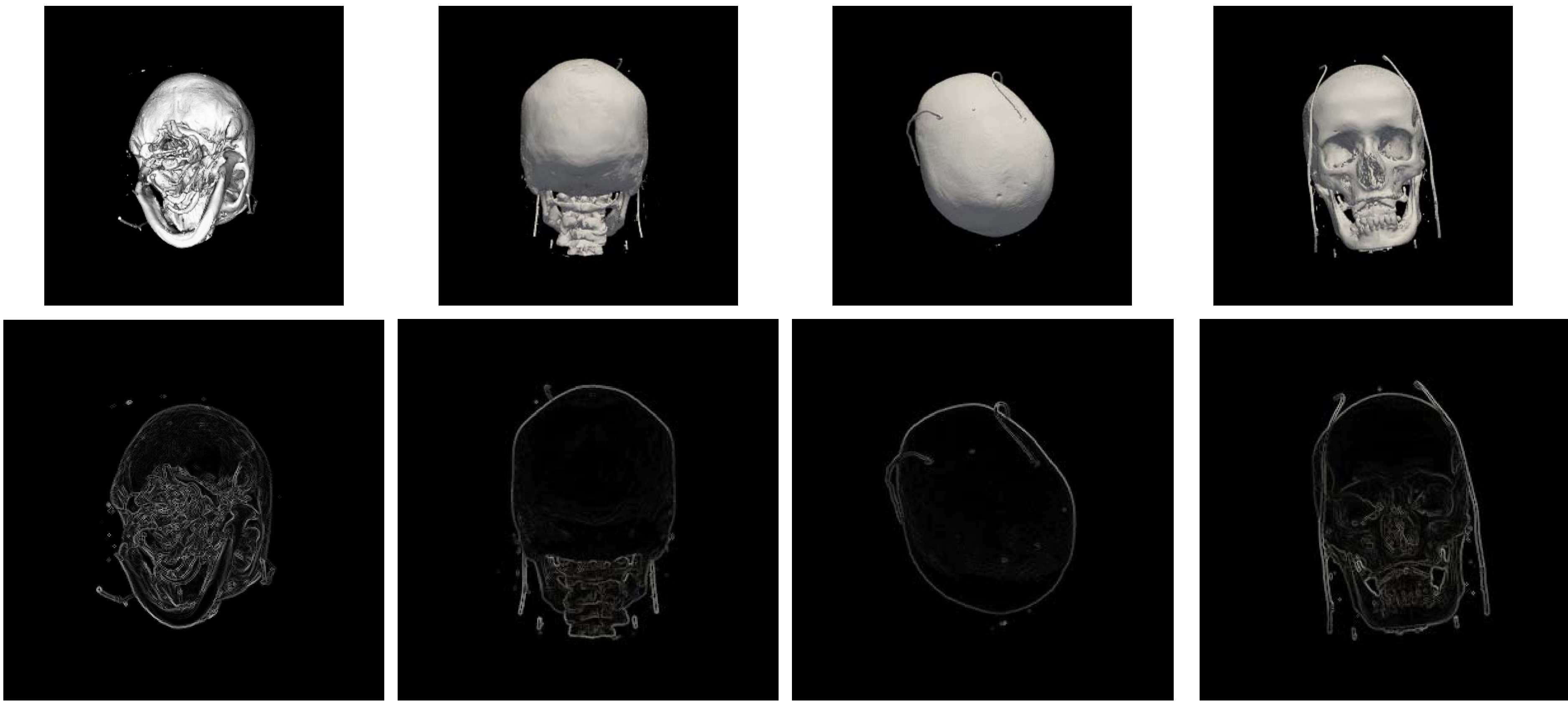
Entropy



From the definition of Entropy, we see that the Entropy represents the hierarchy.

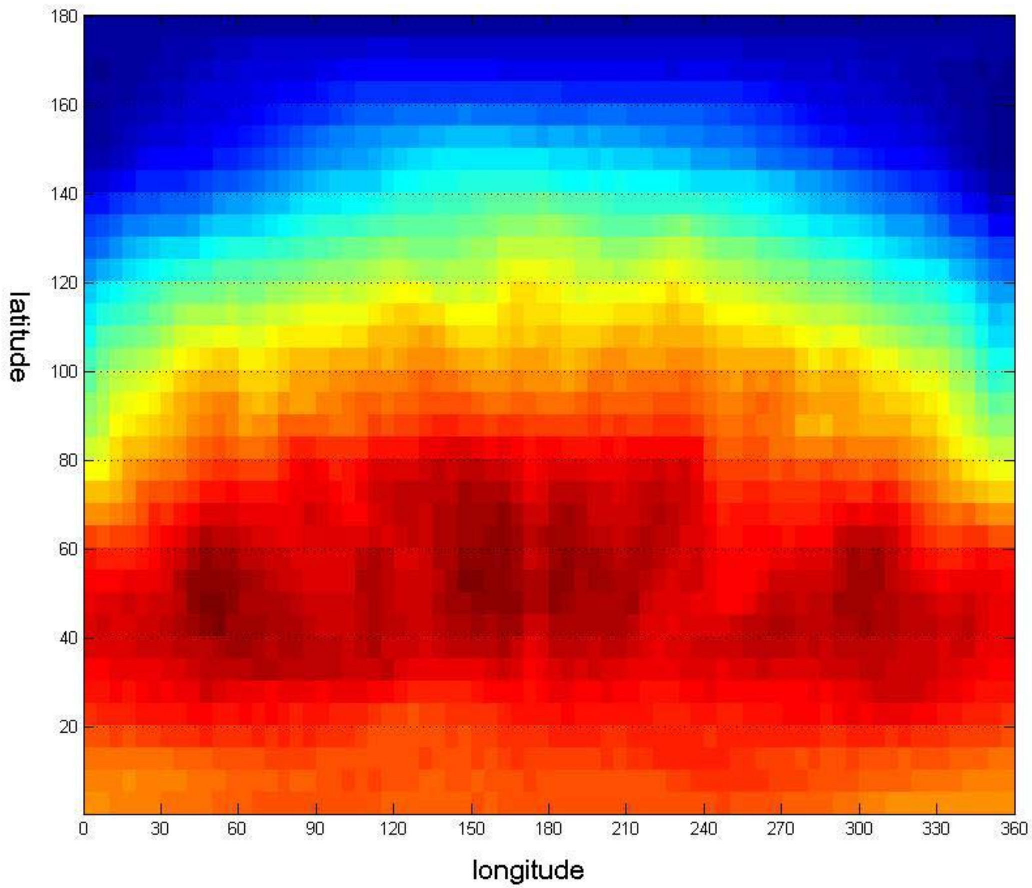
Gradient of an image

- The gradient of an image represents the edges in the image.
- More edges: view is more complex.



Sum of Gradient

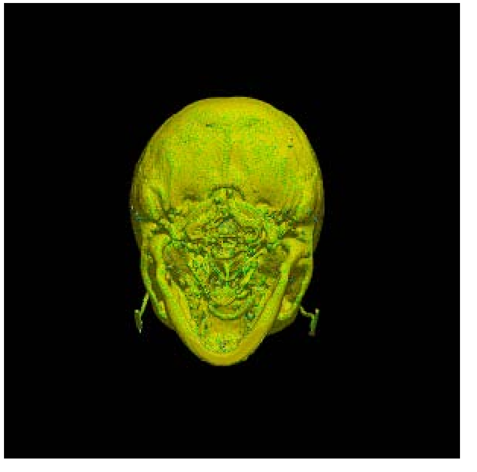
$$G(I) = \sum_{pixel(x,y)\in I} \sqrt{gradient(x,y)_x^2 + gradient(x,y)_y^2}$$



Curvature

- The curvature can represent the geometry information on the model surface.
- So average curvature is also one of the potential candidate for saliency measurement.
- But from the experiments, we see that the curvature contained in a view is not proportional to human sense.

Average curvature = 0.801566

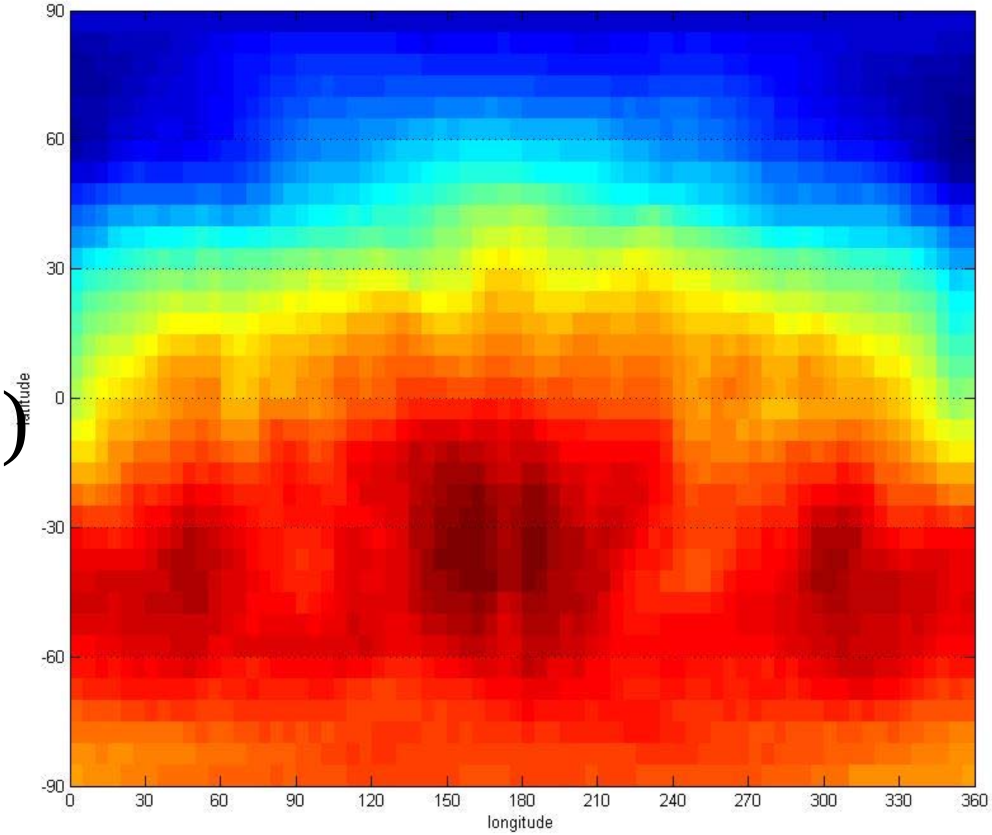


Average curvature = 0.886199

Saliency definition in this project

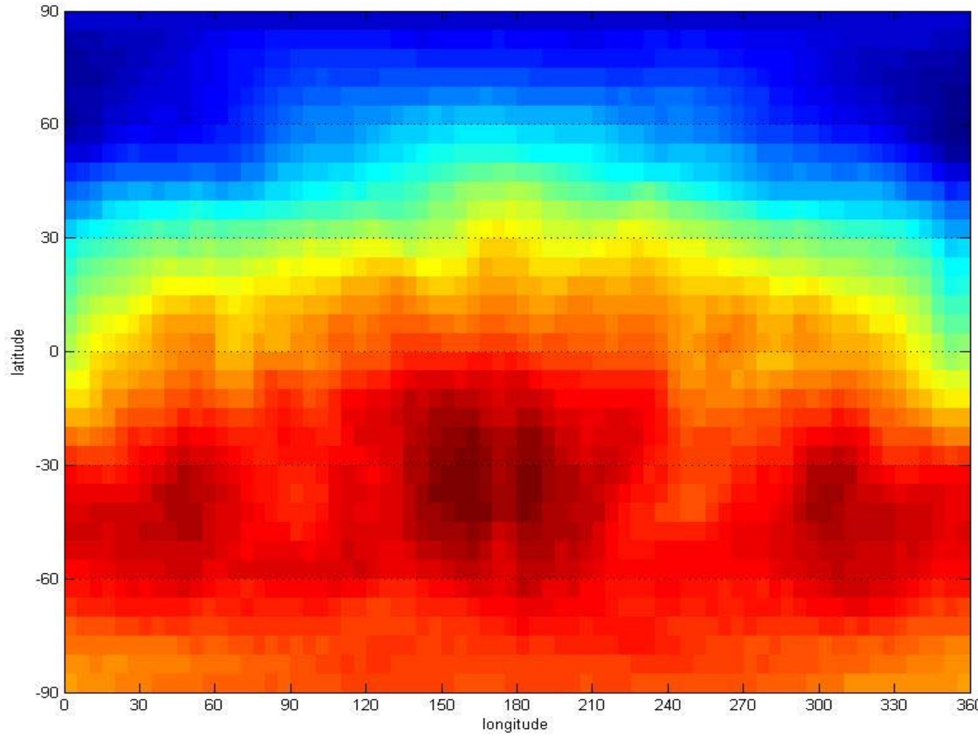
- I use the weighted combination of entropy and gradient to represent the saliency S in a view.

$$S(I) = E(I) + wG(I)$$



- The w is set to balance the contribution of E and G.

Saliency in this Project



S(I(a,b,M)) = E(I(a,b,M))+wG(I(a,b,M))

Definition

- What are the views?
- What is saliency?
- What is a salient view?

Salient View

- Salient view is the view with the maximum saliency.
- Then the Problem can be defined as:
  - Given the preprocessed mesh model M, find the camera position (a, b) that maximizes:

$$S(I(a,b,M)) = E(I(a,b,M)) + wG(I(a,b,M))$$

  - where

$$G(I) = \sum_{pixel(x,y)\in I} \sqrt{gradient(x,y)_x^2 + gradient(x,y)_y^2}$$

$$E(I) = -\sum_{i=1}^{255} \frac{p_i}{(1-p_o)} \log_2 \frac{p_i}{(1-p_o)}$$

Algorithm

- Overview
- Gradient descent

Algorithm

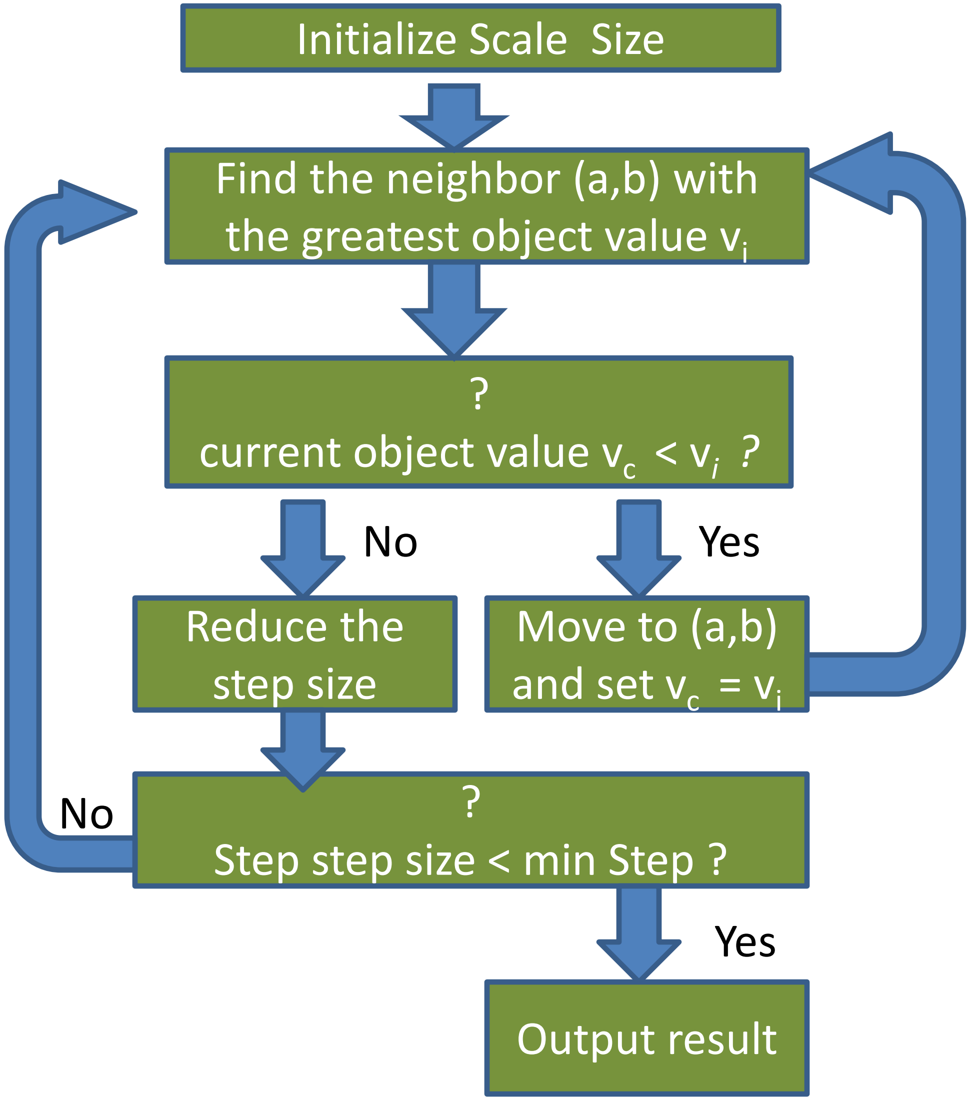
- 1. Randomly generate a set of initialize position
- 2. Gradient Ascent to find a set of local maximum from the start points.
- 3. Select the best one from the local maximums.

Algorithm

- Overview
- Gradient descent

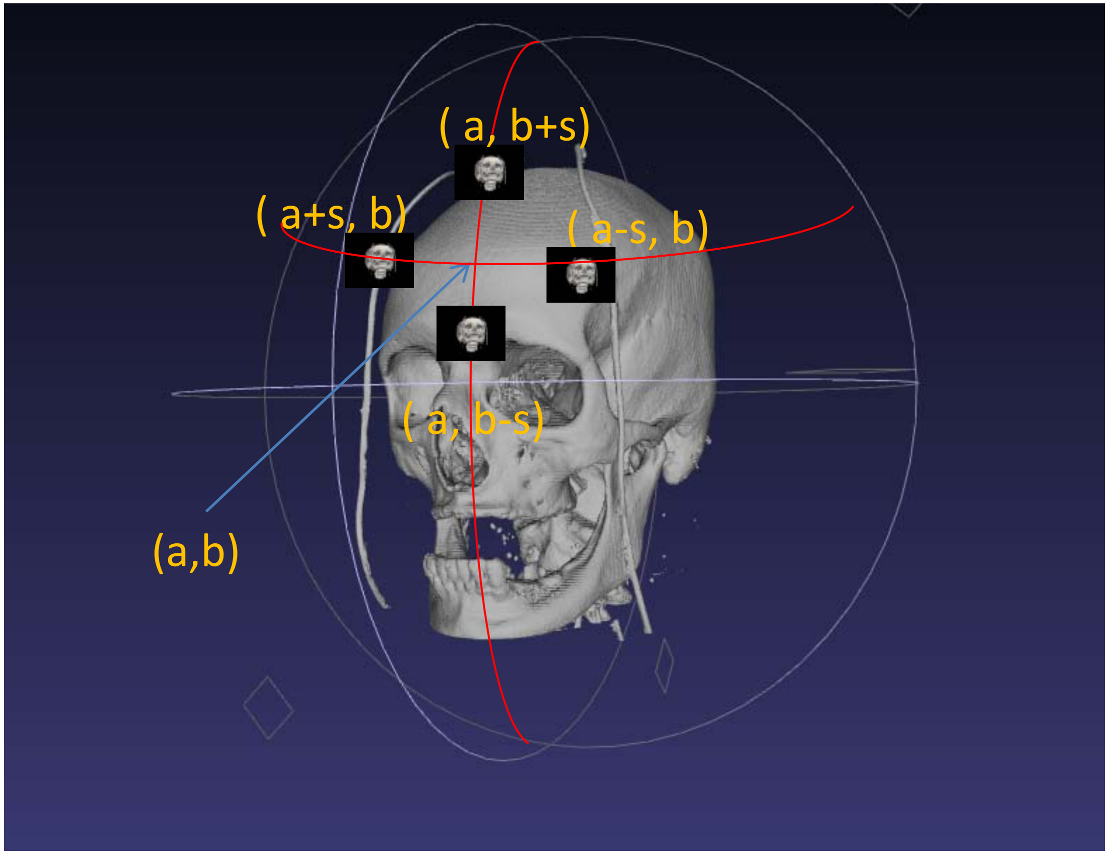
Gradient Ascent

- Gradient Ascent Search
  - Initialize;
  - While (stepSize > minStep){
    - While(still have improvement){
      - Select the neighbor (a_i , b_i) who has greatest object value v_i;
      - If v_i > current object value, move to (a_i , b_i), and set current object value to v_i;
    - }
    - Reduce stepSize to stepSize*f; (f was set to 0.5)
  - }
  - Output result;



Neighbors

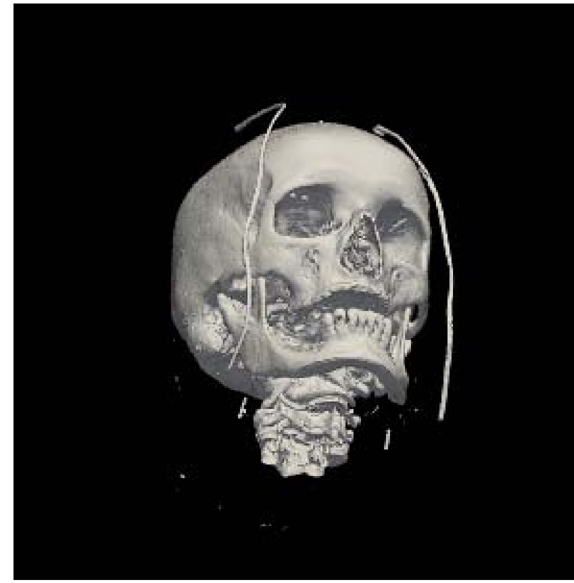
- The neighbors of view (a,b) at scale s are:
  - N((a,b)s) = { (a+s, b), (a-s, b),(a, b+s),(a, b-s)}



Experiment Results

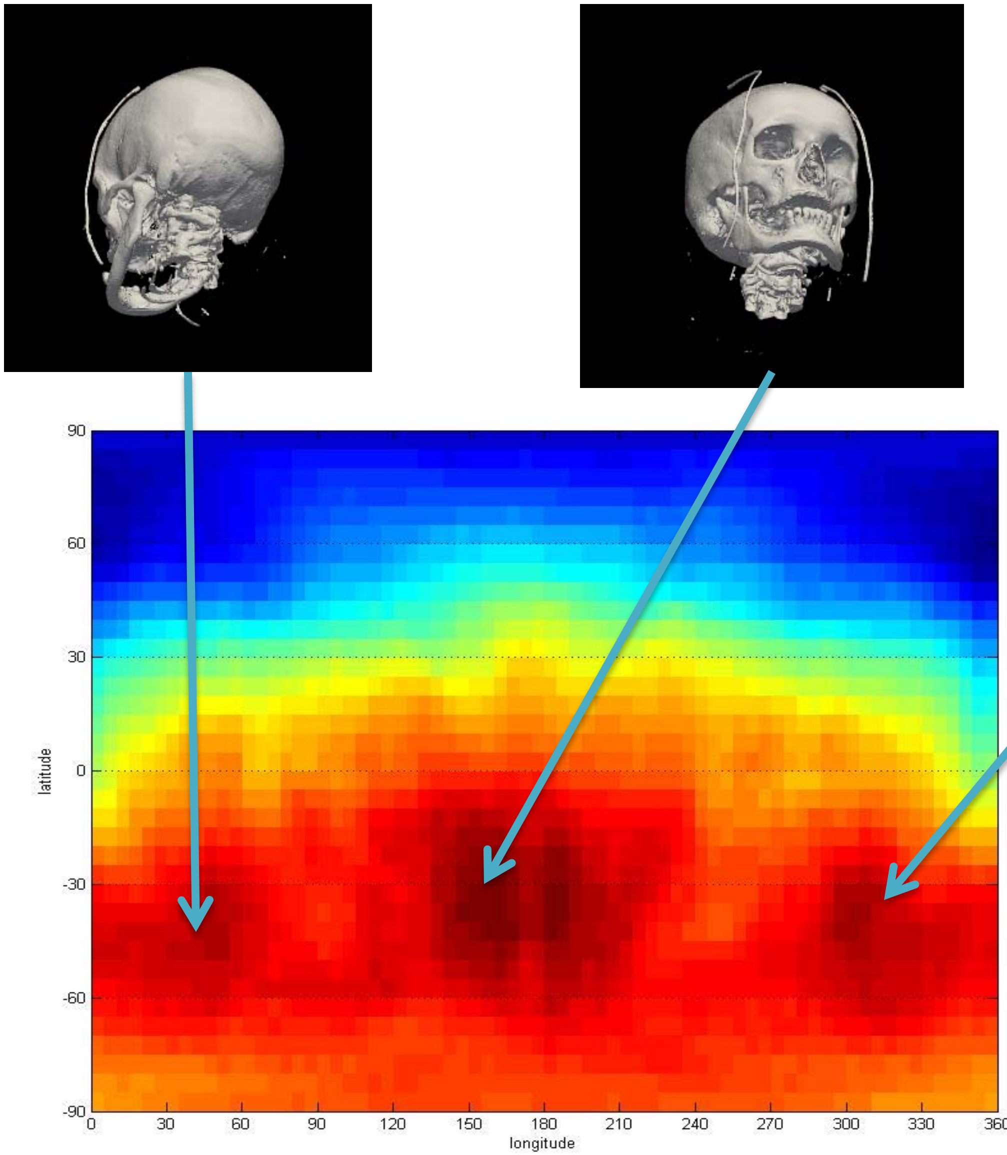
10 attempts
S = 8.1073

100 attempts
S = 8.10909



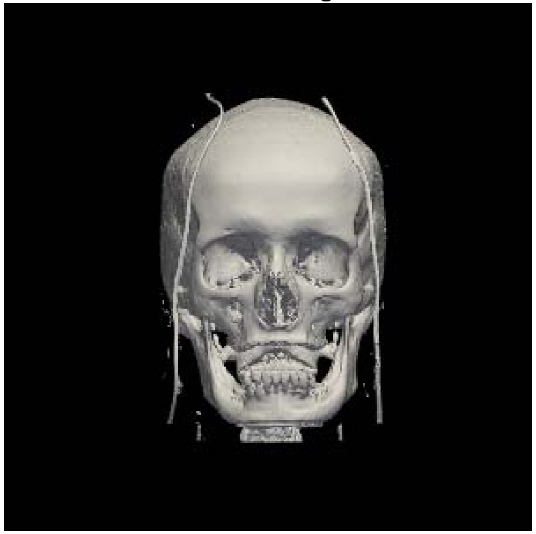
500 attempts
S = 8.31996

Local Minimums

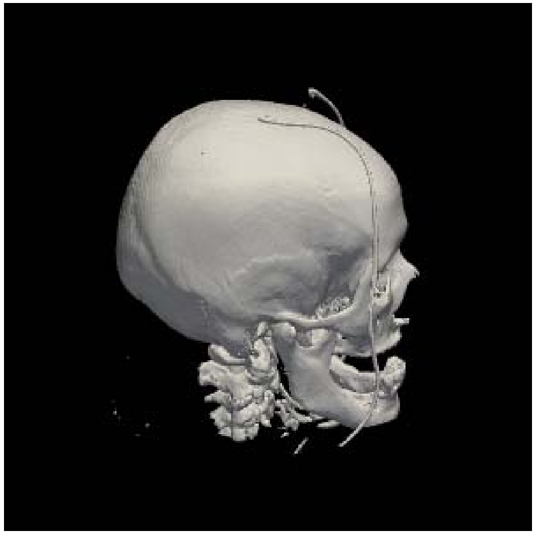


For we use multiple initialization, we will not suffer from the locals

Compared with other Saliencies



S = Entropy



S = w * Curvature + Entropy

S = Sum of Gradient

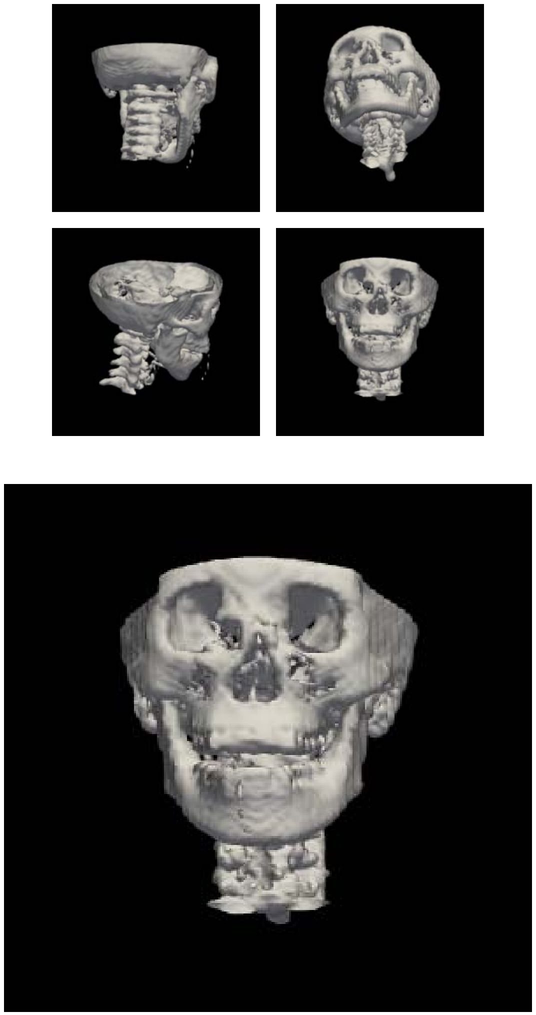
S = Mean Curvature

Compared with other Saliencies

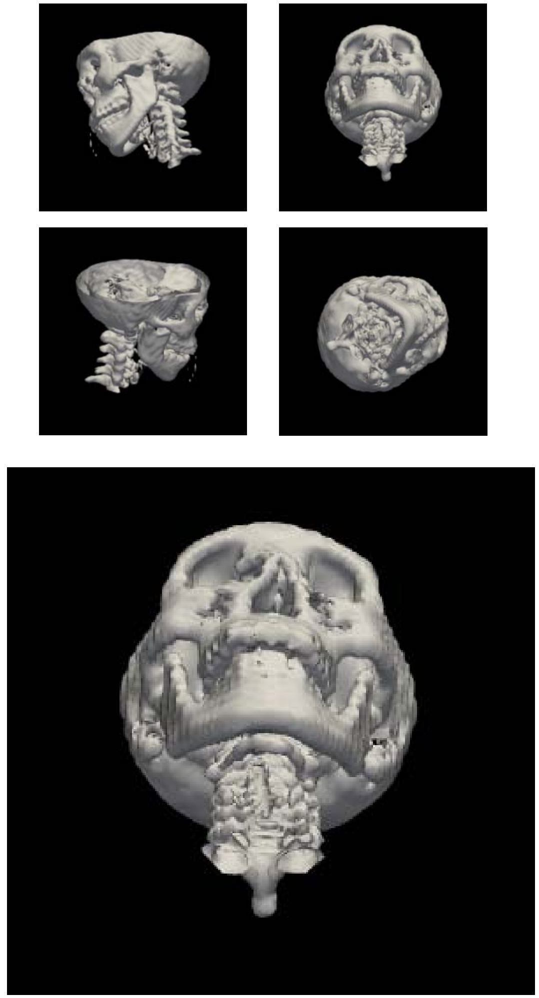
$S = E + wG$

Apply to Another Skull

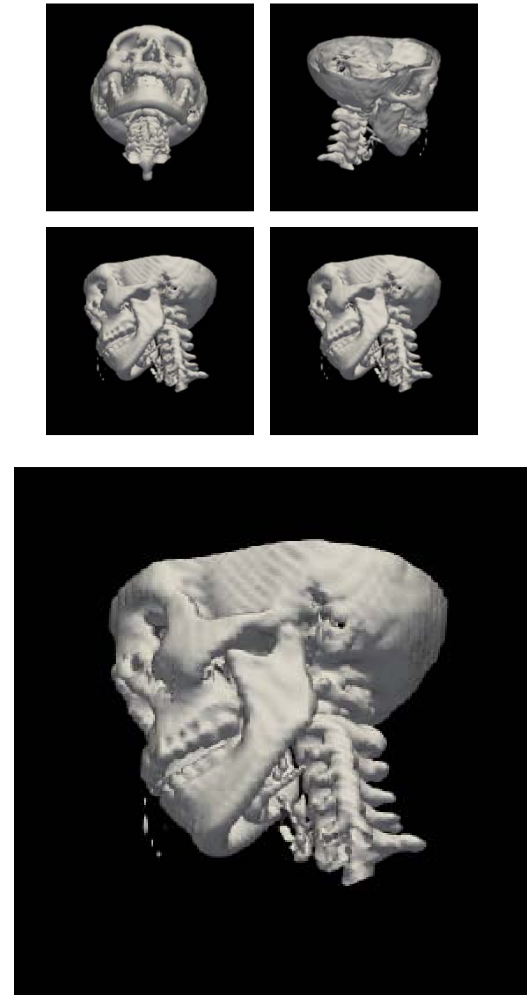
Locals



Max over 100 iterations E



Max over 100 iterations E+G



Max over 100 iterations E+2G

More results

- Damage Based Saliency
  - Skull fractured detection
  - Saliency is based on the fracture degree

Future Work

- Human Perception Based Saliency
  - Survey or Human perception experiments to generate model
  - Model-Instance registration
  - Correspondence based mapping of Saliency
- Damage Based Saliency
  - Fracture detection
  - Fracture degree measurement

QA?