

Automated Contour Detection with Surface Generation on Volumetric Datasets

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Presentation Structure

- Volumetric Datasets
- Medical Imaging
- Segmentation
- **Blind Traversal on Edge Algorithm (BTE)**
- Volume Visualization
- Surfaces Generation
- Final Results
- Conclusions and Final Comments
- Future Works

Volumetric Datasets

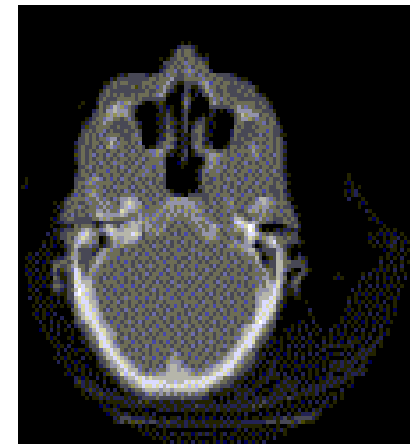
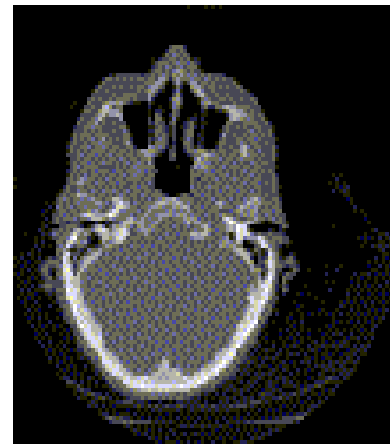
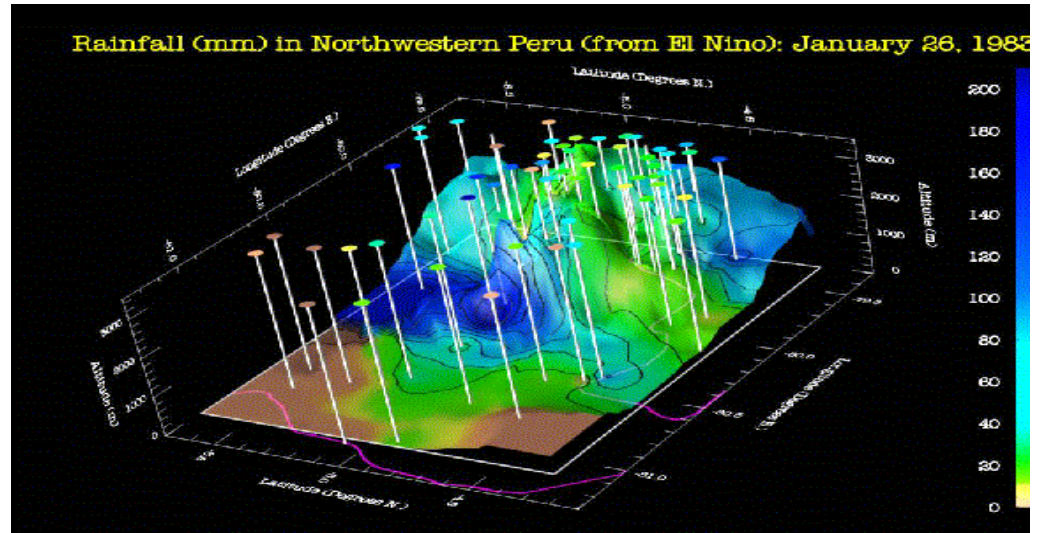
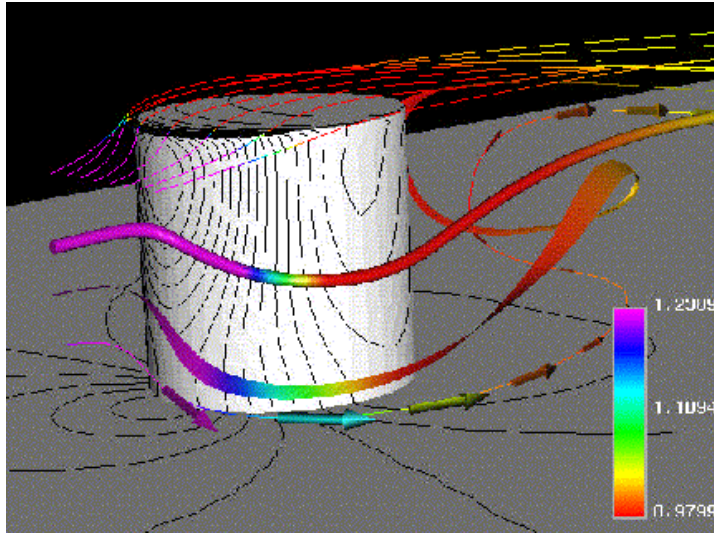
Describes three-dimensional objects.

Acquired by CT, MRI, PET, and/or Sonogram machines.

Useful for inspection, modeling and simulation.

Used in medical field, Microscopy, Mechanical Engineering, and many other scientific and engineering areas.

Volumetric Datasets - Applications



Medical Imaging

Processing of medical information, coded as images, using computer graphics and scientific visualization techniques.

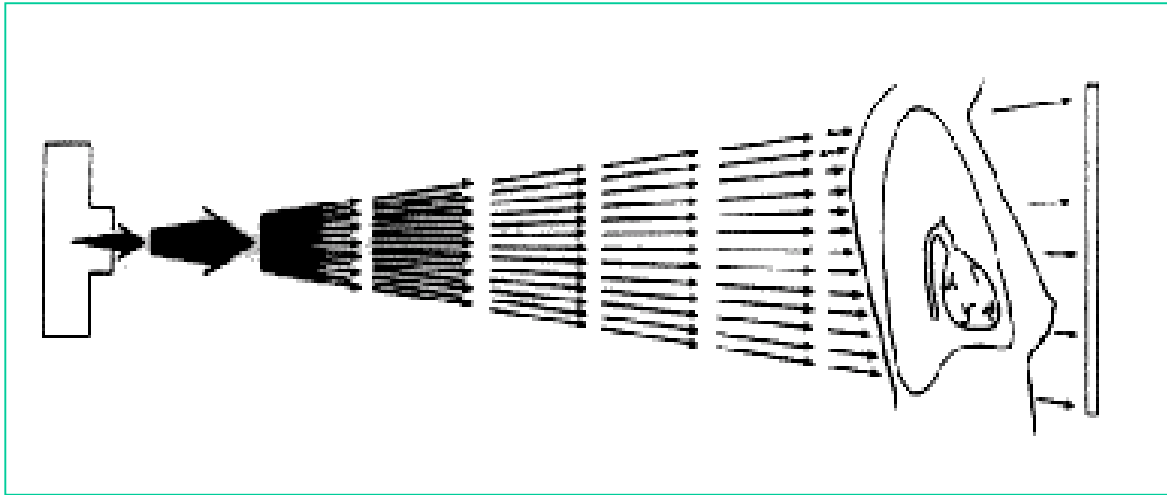
The purpose is to provide computer-aided techniques to diagnostics and planning of treatment or surgery.

Images can be acquired by techniques such as MRI and CT.

Medical Imaging

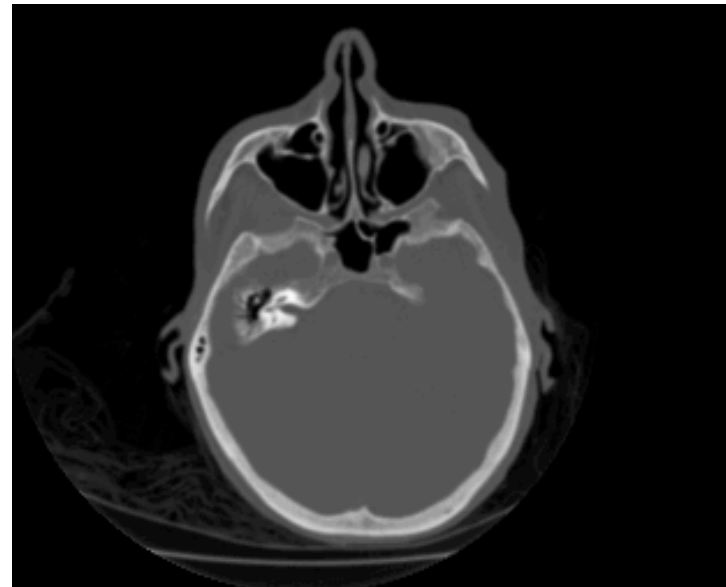
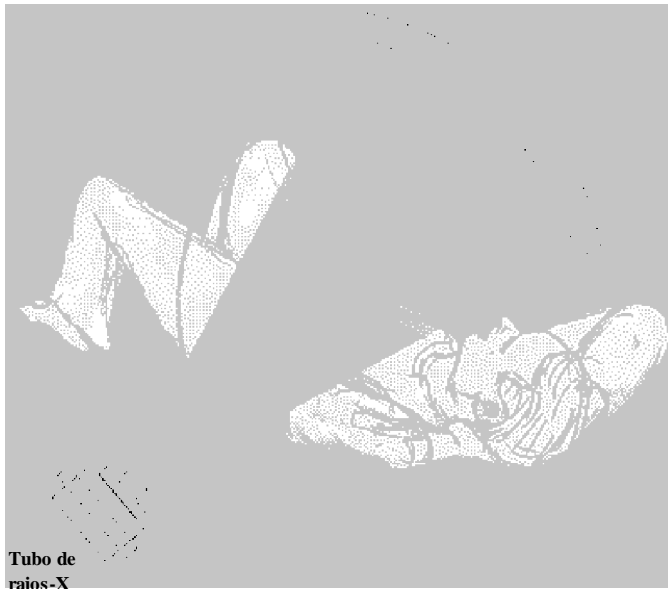
Diagnostic Imaging Modalities

X-Ray



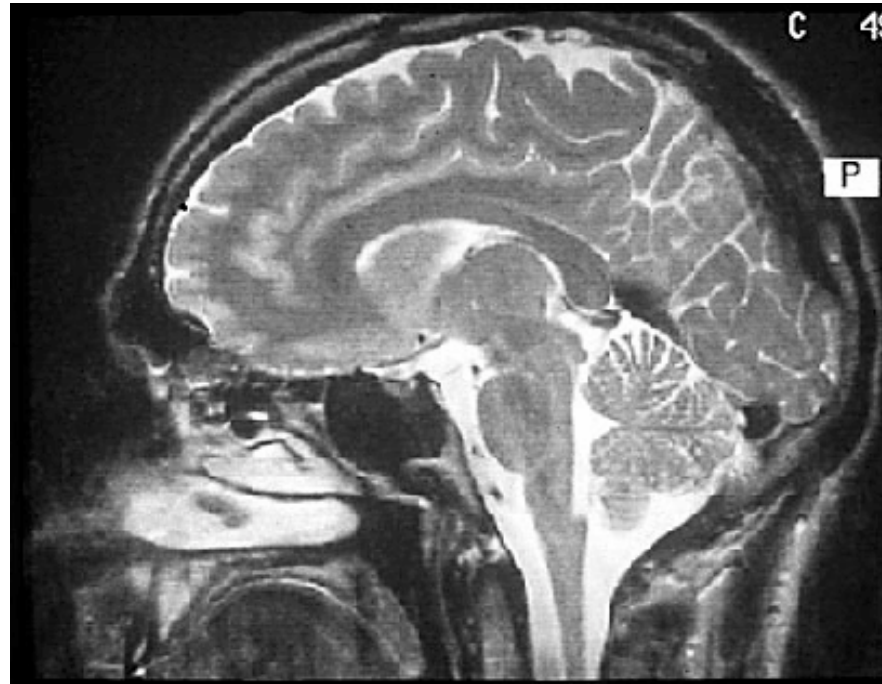
Medical Imaging Diagnostic Imaging Modalities

Computed Tomography (CT)



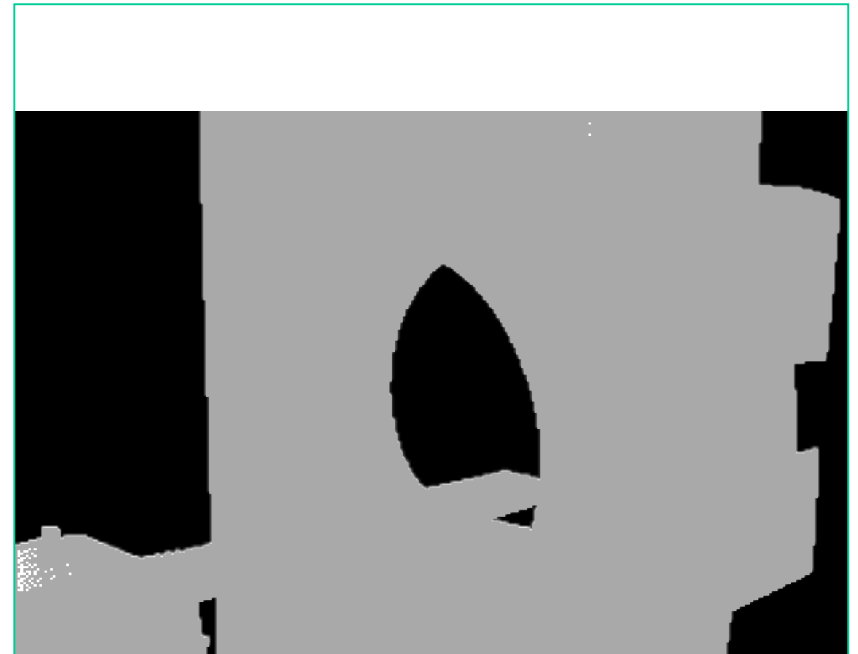
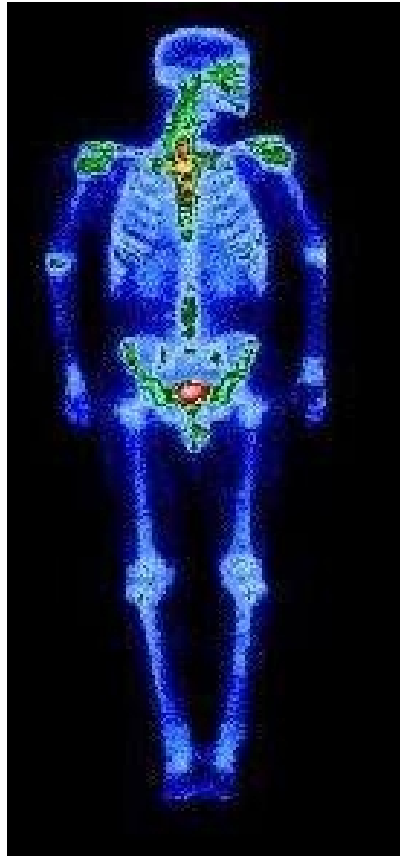
Medical Imaging Diagnostic Imaging Modalities

Magnetic Resonance Imaging (MRI)



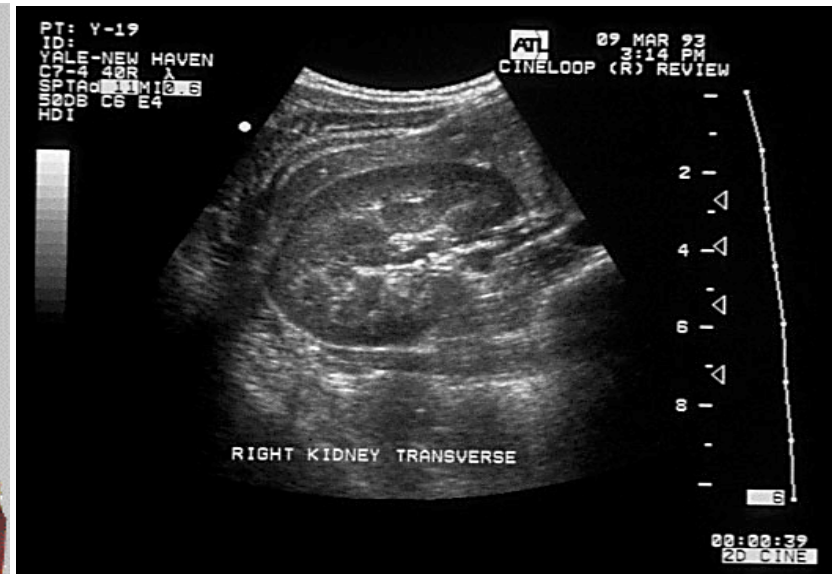
Medical Imaging Diagnostic Imaging Modalities

Nuclear Medicine



Medical Imaging Diagnostic Imaging Modalities

Ultra-sound

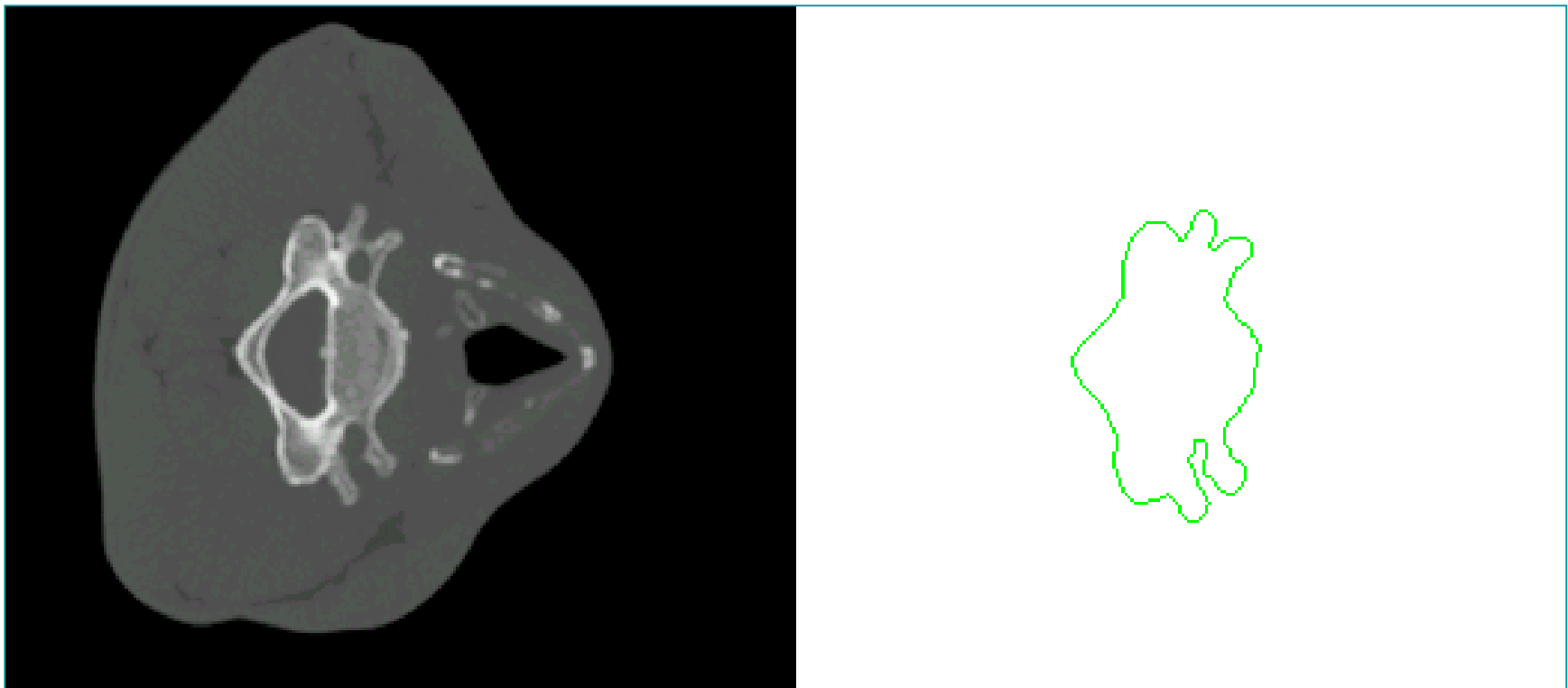


Medical Imaging Main Problems

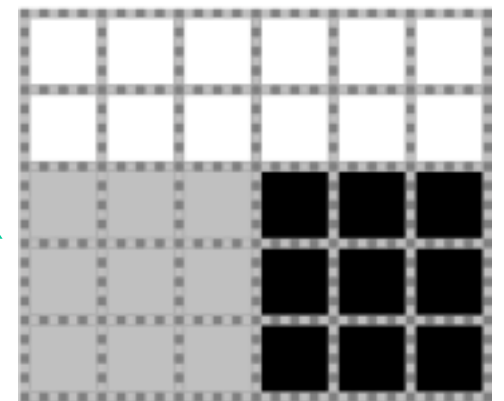
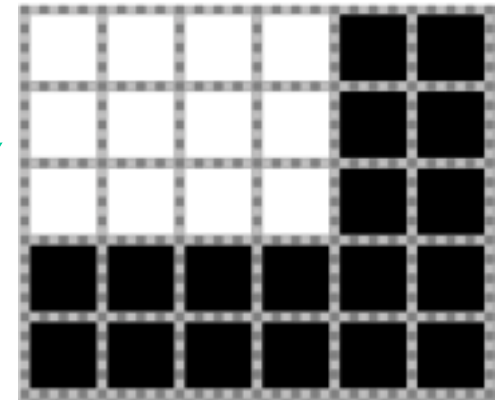
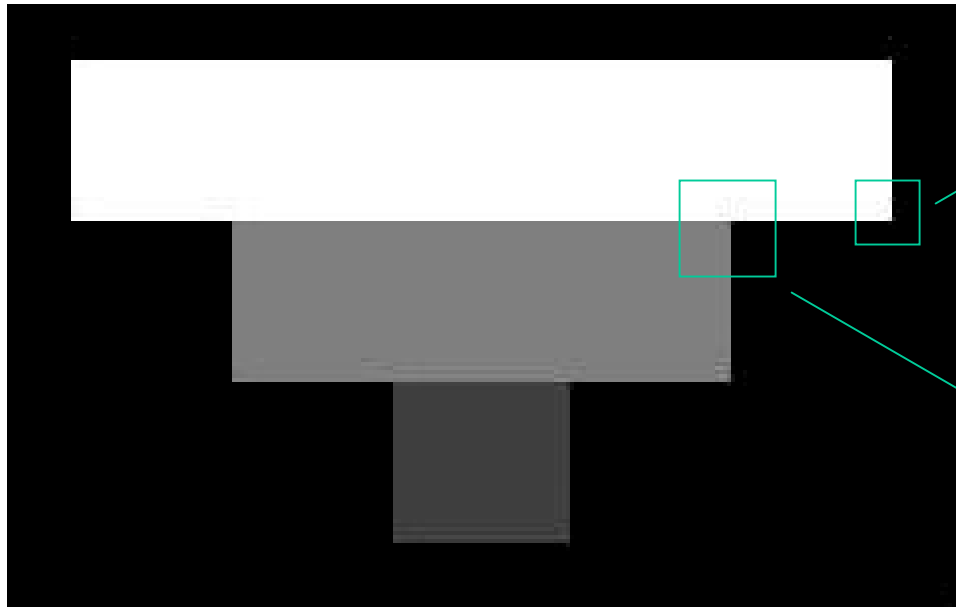
- Filtering
- Segmentation ←
- Recognition
- Data Fusion
- Matching

Segmentation

Extracts regions of interest (ROI) from images for subsequent processing.



Segmentation Edge Pixels

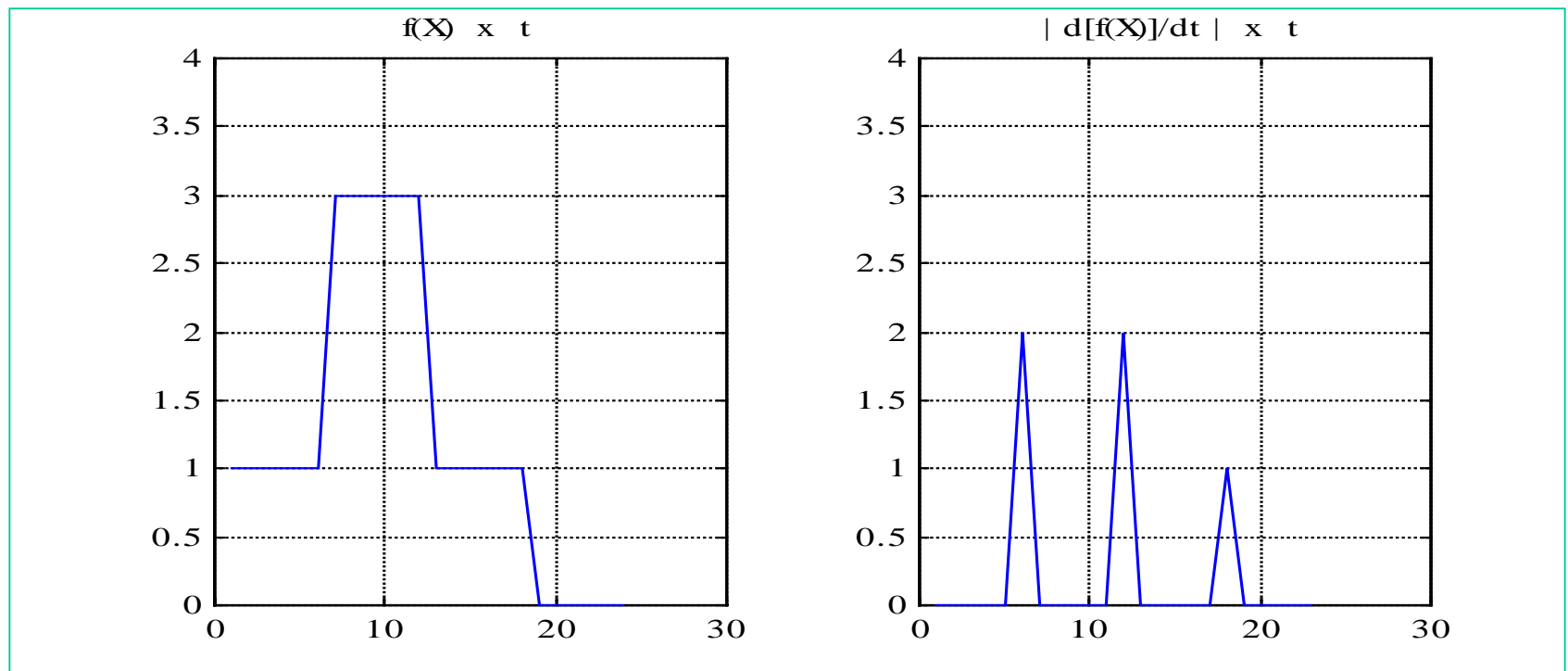


Segmentation Edge Detection Techniques

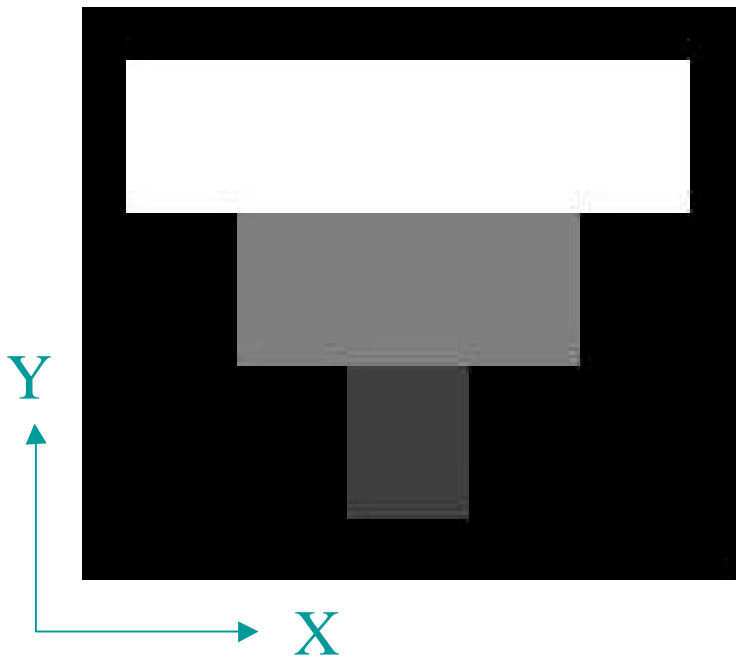
- Local Processing
Only based on image's information.
- Global Processing
Uses mathematical models and image's information.

Segmentation Derivative Operator

Rate of change of a function.



Segmentation Gradient

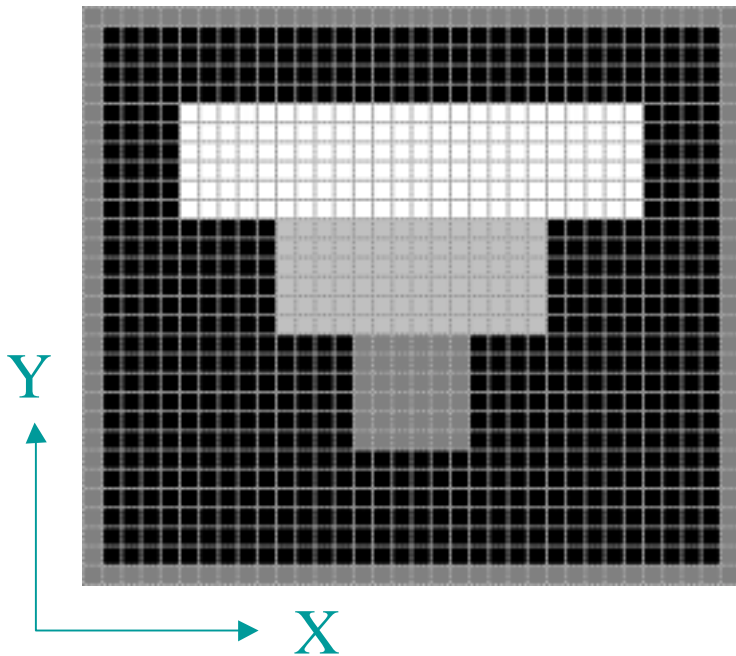


Images are two-dimensional functions.

We have to consider the principal directions X and Y.

$$\nabla I(x, y) = \left(\frac{\partial I}{\partial x}, \frac{\partial I}{\partial y} \right)$$

Segmentation Gradient



Images are discrete functions.

Gradient is approximated by central differences as shown below.

$$\nabla_x I(x, y) = I(x-1, y) - I(x+1, y)$$

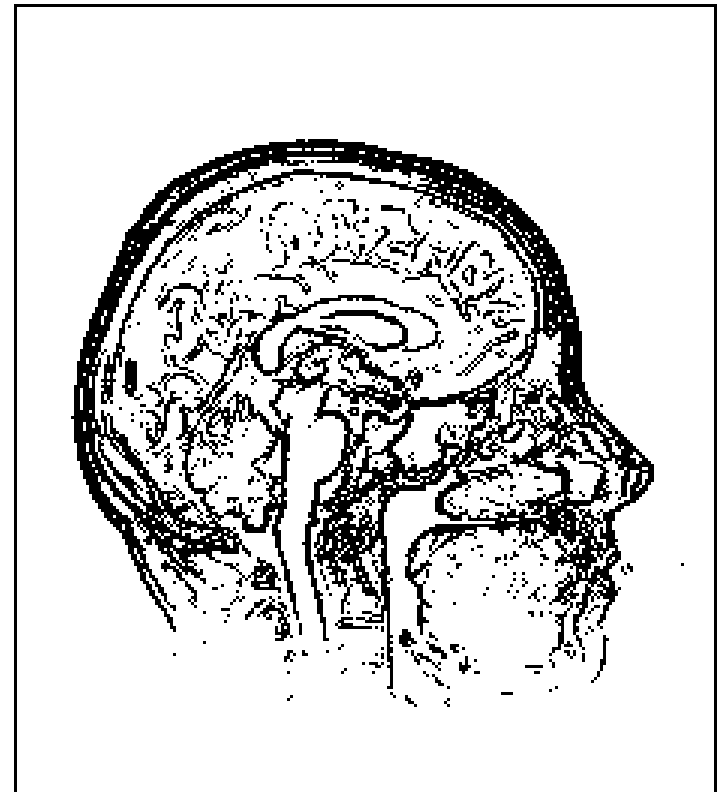
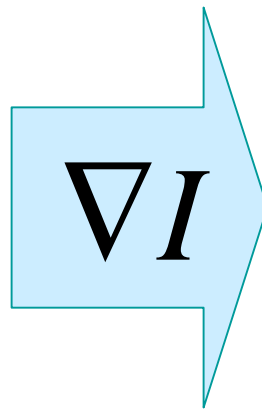
$$\nabla_y I(x, y) = I(x, y-1) - I(x, y+1)$$

Segmentation Gradient

Computing the magnitude of gradient vector, we can “measure” the change at each pixel.

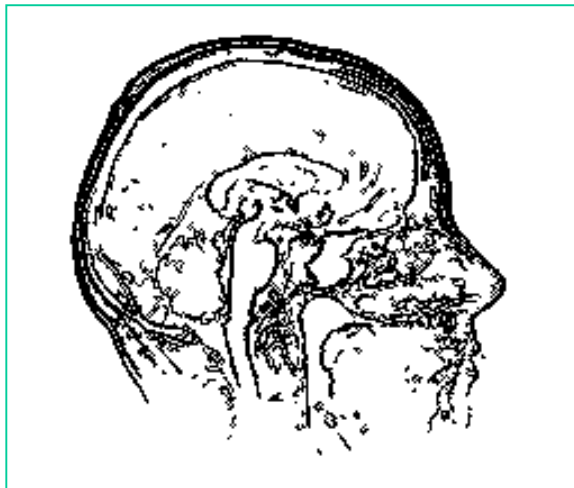
$$|\nabla I(x, y)| = \sqrt{(\nabla_x I(x, y))^2 + (\nabla_y I(x, y))^2}$$

Segmentation Gradient

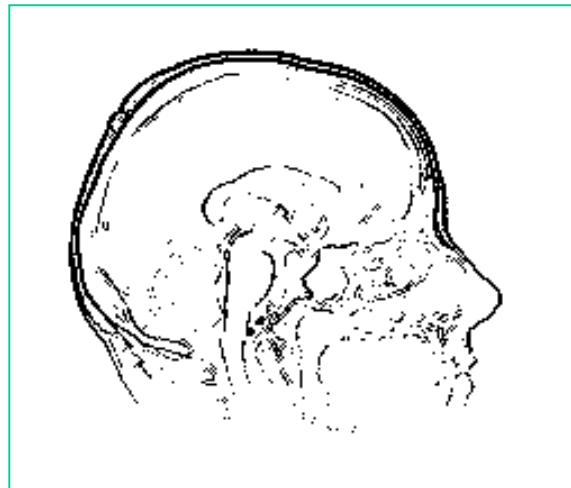


Segmentation Thresholding

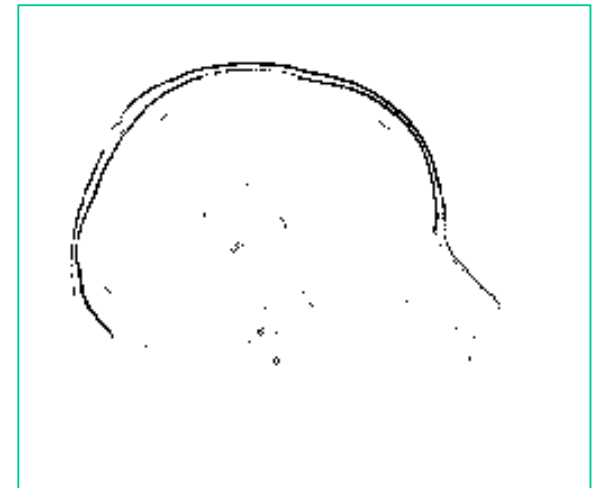
Edges pixels with gradient's magnitude higher than a specified threshold is said to be an edge pixel.



Threshold=0.1



Threshold=0.2



Threshold=0.4

Segmentation Thresholding

We must consider:

- Diagnostics imaging modality.
- ROI's characteristics.

Image's histogram provides useful information for an adequate threshold value's choice.



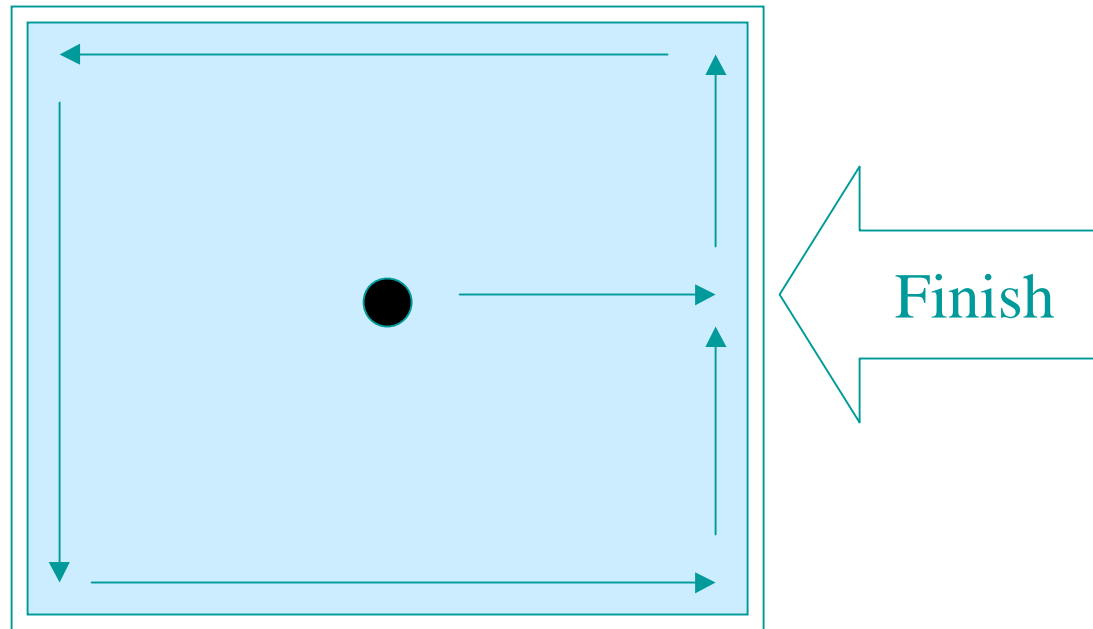
Segmentation Edge Linking

Techniques to connect edge pixels with similar properties.

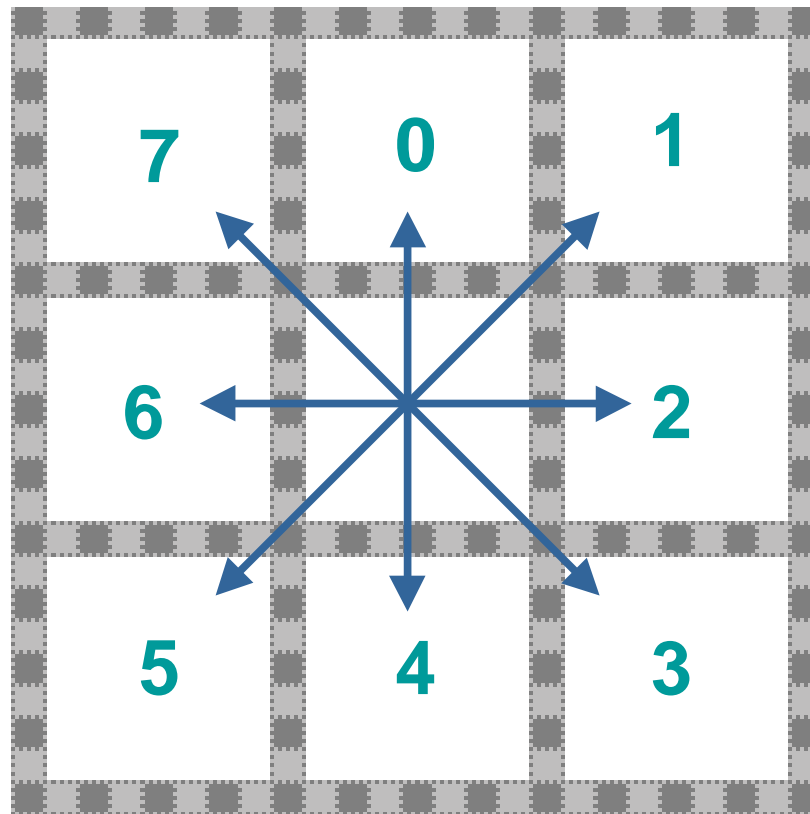


Blind Traversal on Edge Algorithm (BTE)

Let's suppose that . . .



Blind Traversal on Edge Algorithm (BTE) Scanning Codification



Blind Traversal on Edge Algorithm (BTE) Algorithm Listing

```
Current_Position ← Start_Position;
```

```
do
```

```
    Find the position of the first edge pixel in the  
    neighborhood;
```

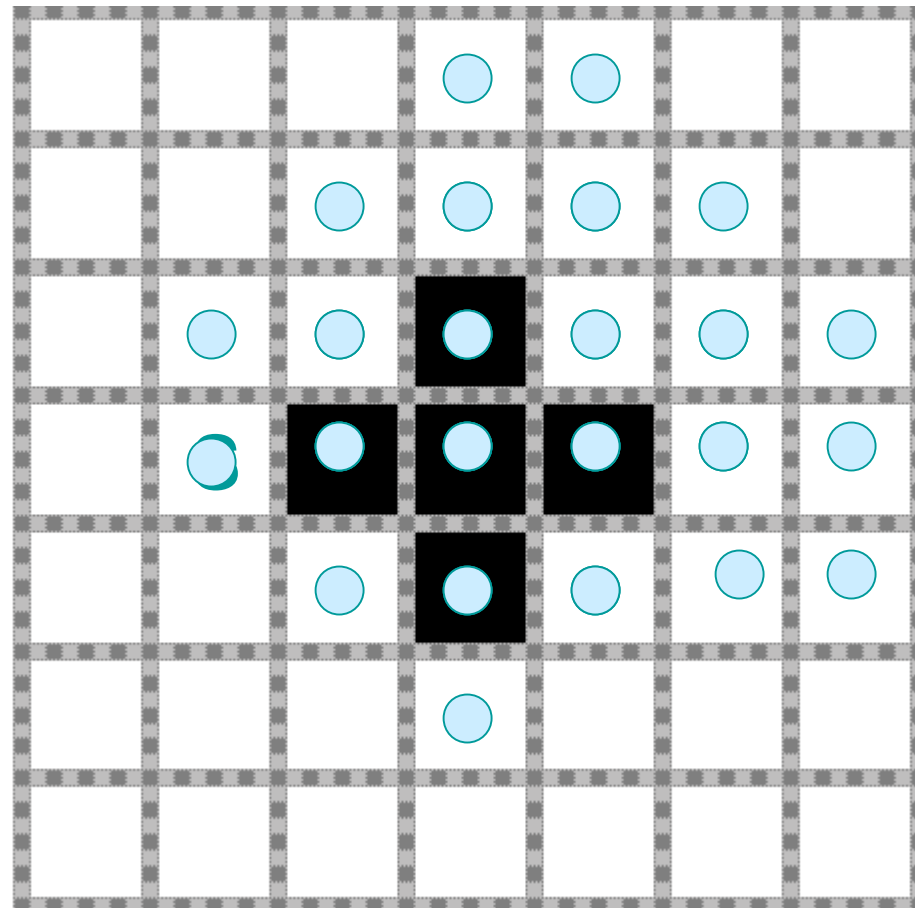
```
    From this position, find the first pixel that is not an  
    edge pixel;
```

```
    Store this position;
```

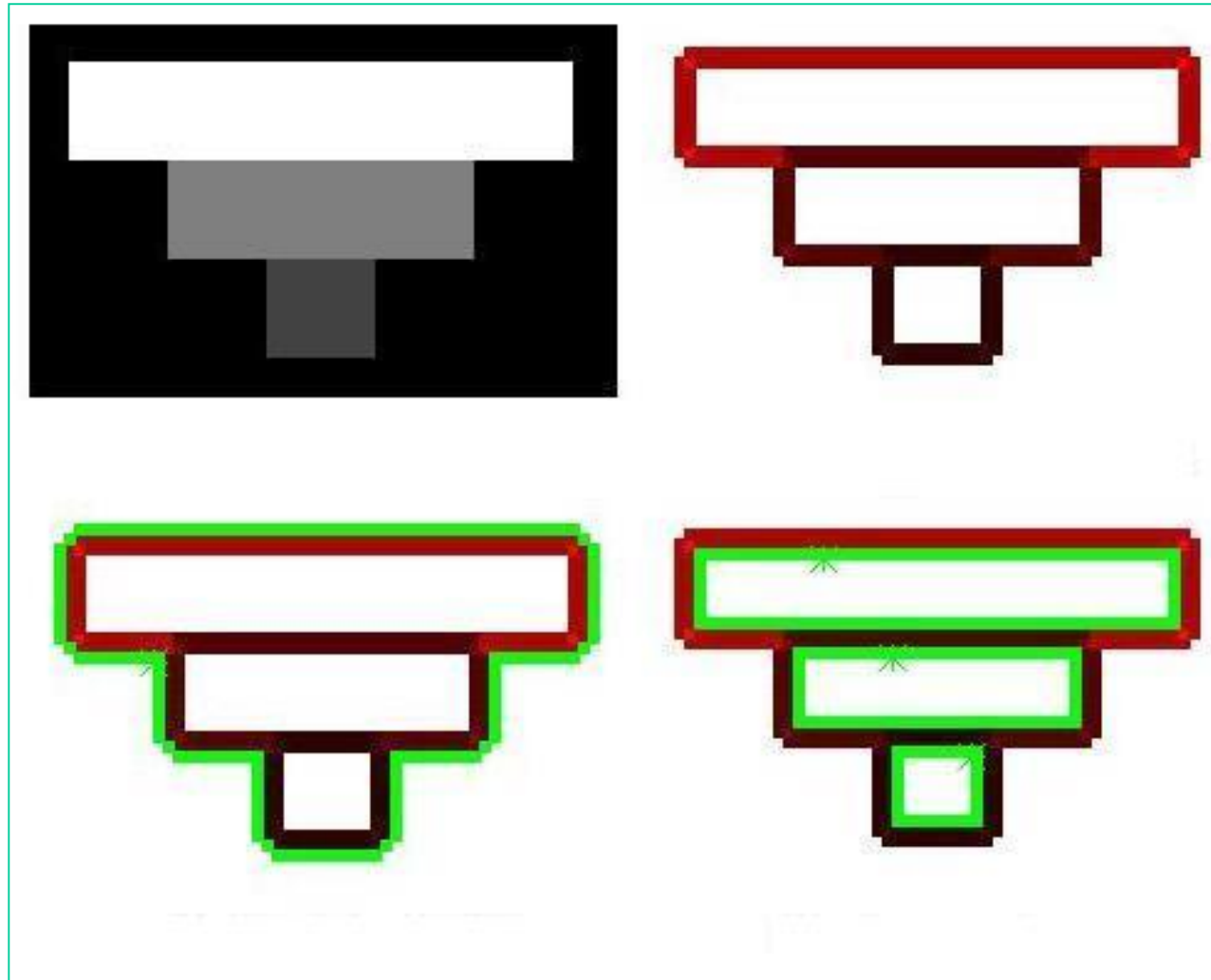
```
    Do Current_Position equals to this position;
```

```
while (Current_Position ≠ Start_Position);
```

Blind Traversal on Edge Algorithm (BTE) Execution Sample

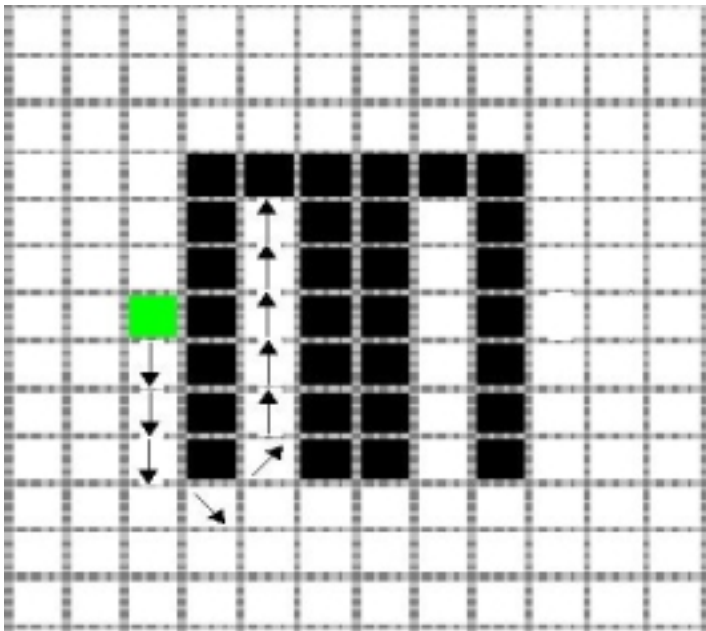


Blind Traversal on Edge Algorithm (BTE) Simple Test

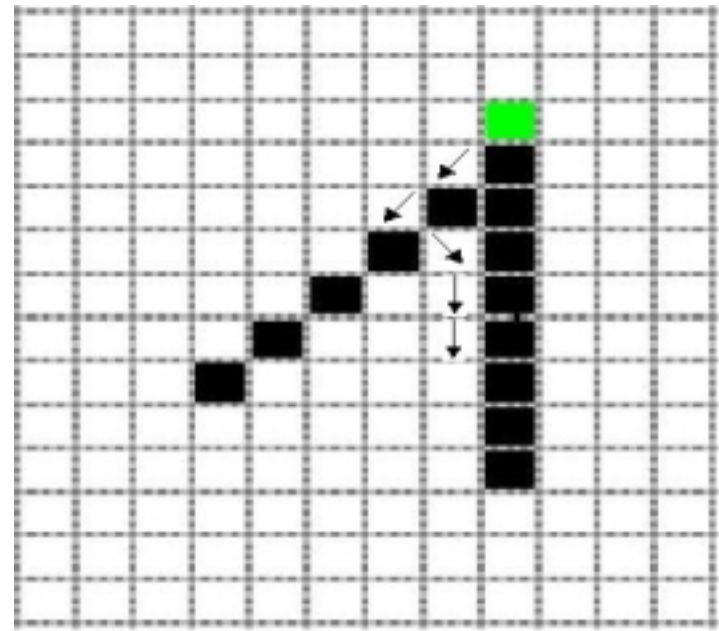


Blind Traversal on Edge Algorithm (BTE)

Detected constraints

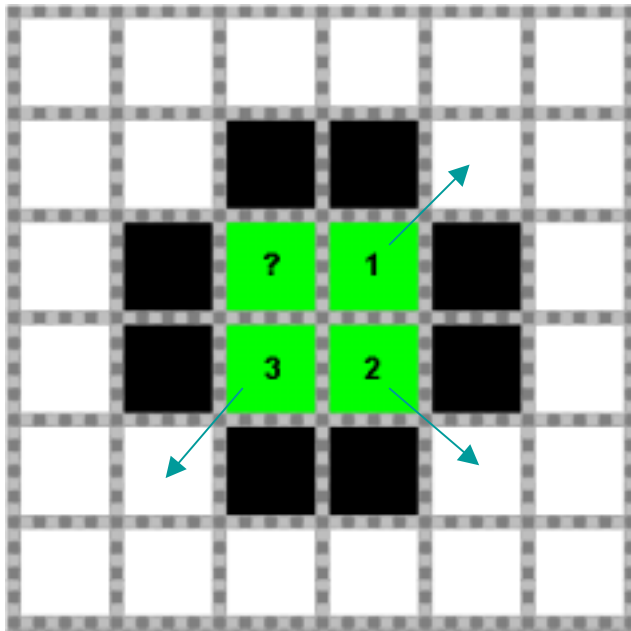


Canyon problem

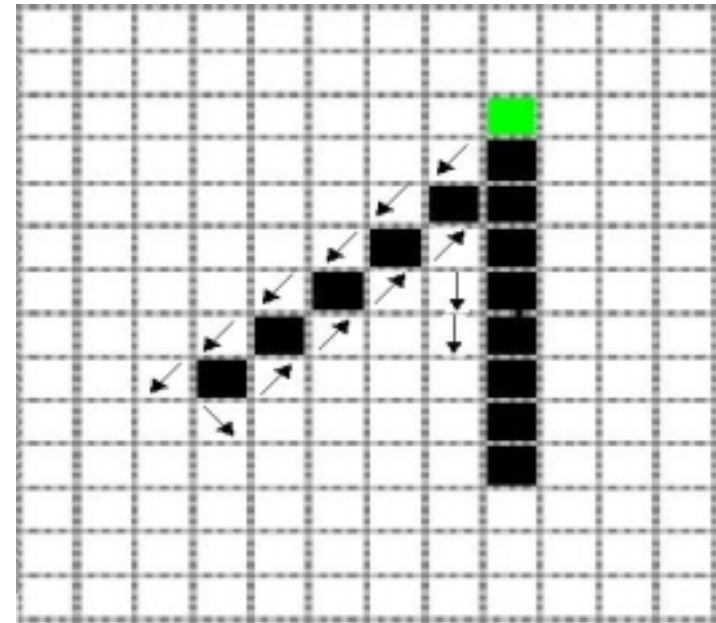


Shortcut problem

Blind Traversal on Edge Algorithm (BTE) Shortcut Problem's Solution



Detection

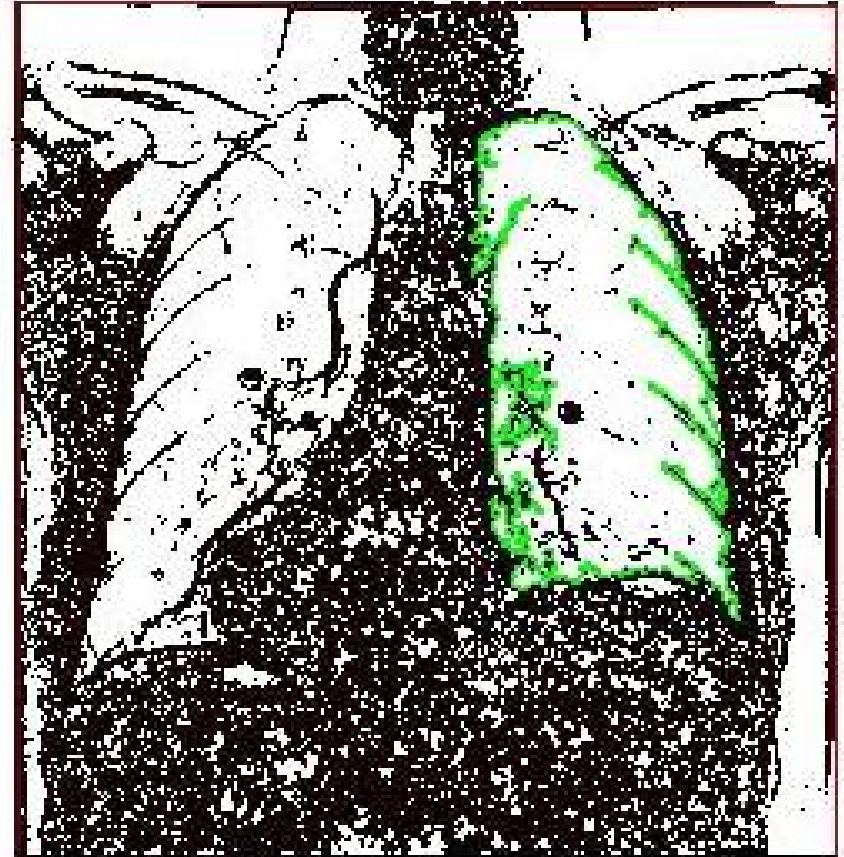


Correct path

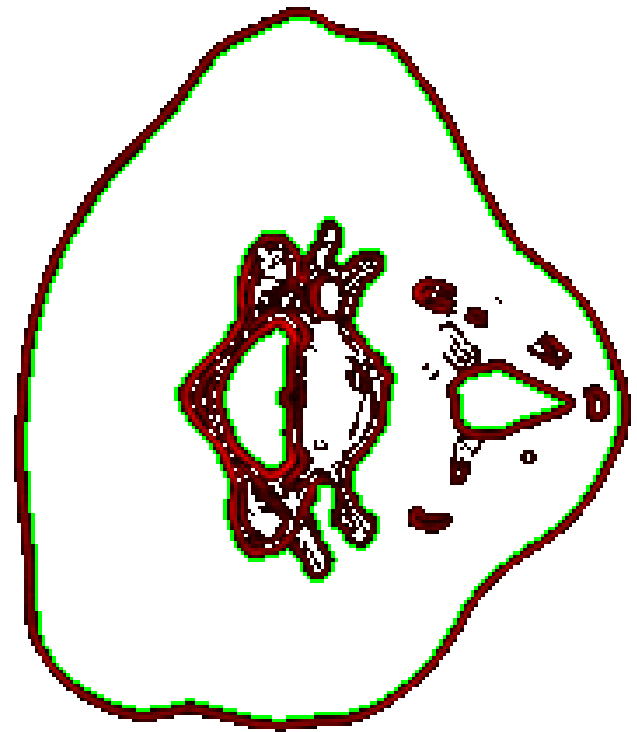
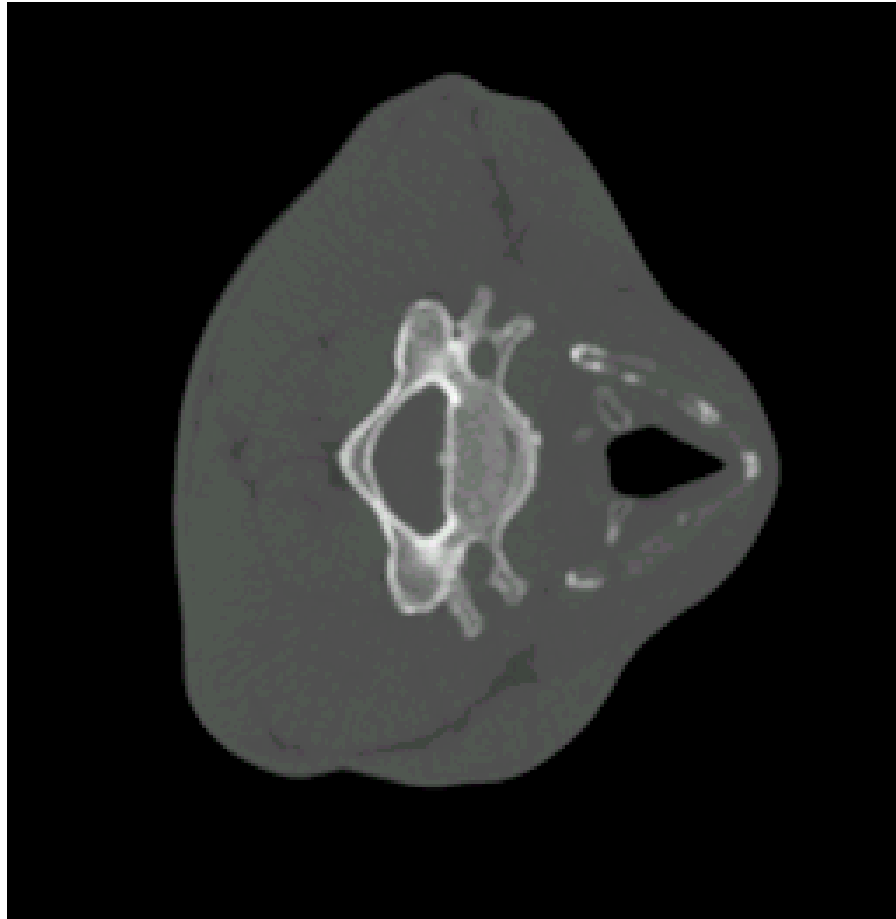
Blind Traversal on Edge Algorithm (BTE) Practical Results



Blind Traversal on Edge Algorithm (BTE) Practical Results



Blind Traversal on Edge Algorithm (BTE) Practical Results



Volume Visualization

Uses Computer graphics techniques to visualize scalar and vector datasets defined on multi-dimensional grids.

Volume Visualization Methods

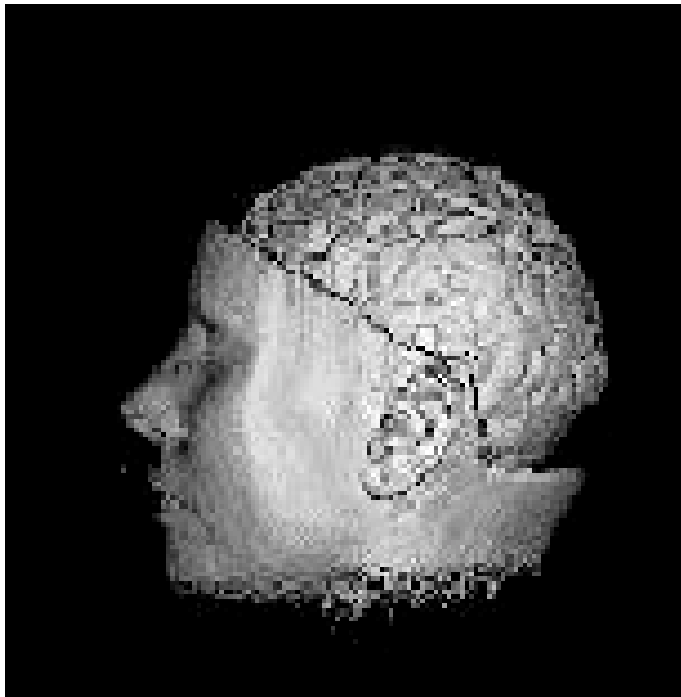
- Volume Rendering

Maps elements directly into screen space without using geometric primitives as an intermediary representation.

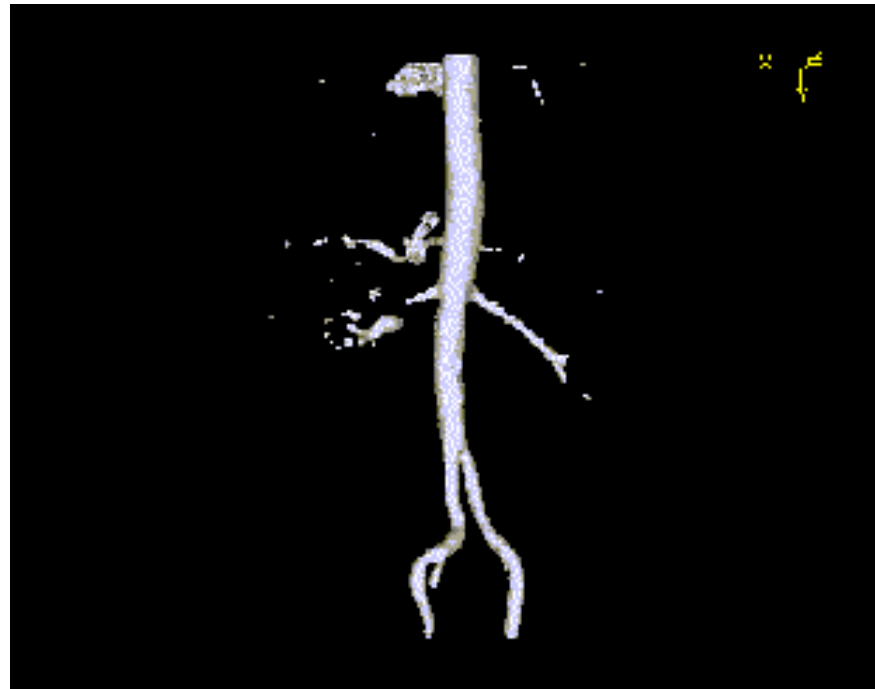
- Surface Fitting

Fits geometric primitives to constant-value contour surfaces in volumetric datasets.

Volume Visualization Samples



Volume Rendering



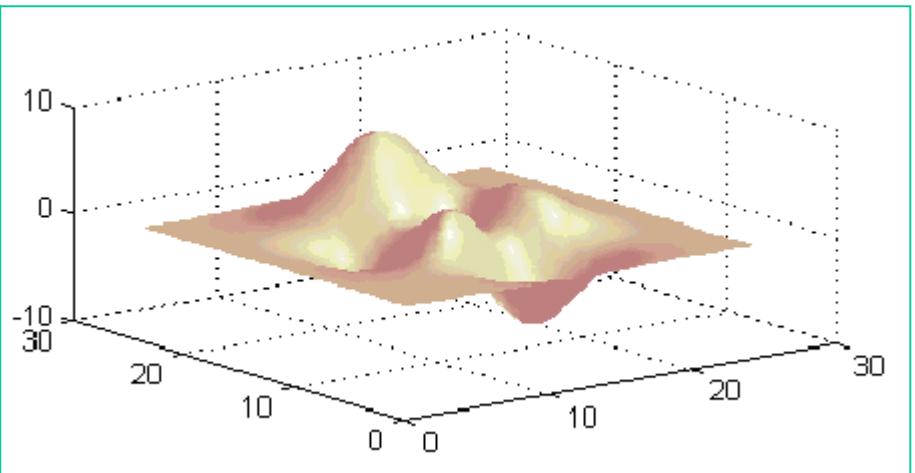
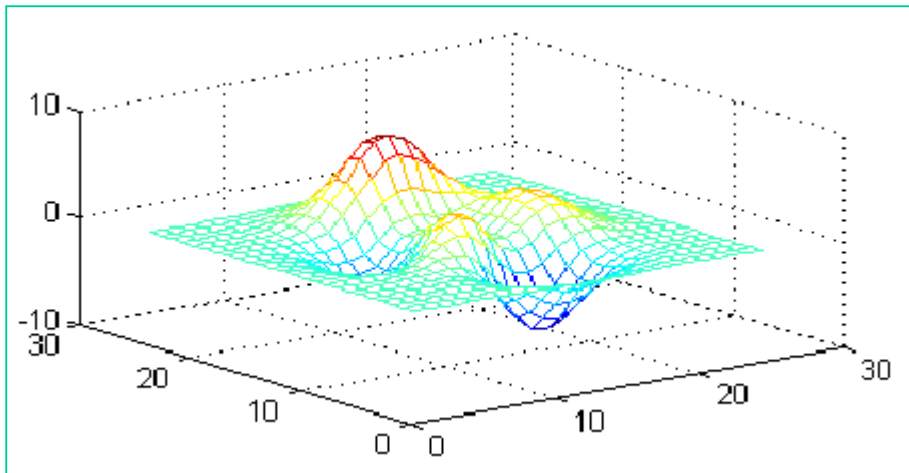
Surface Fitting

Surface Generation Contour-Connecting Algorithm

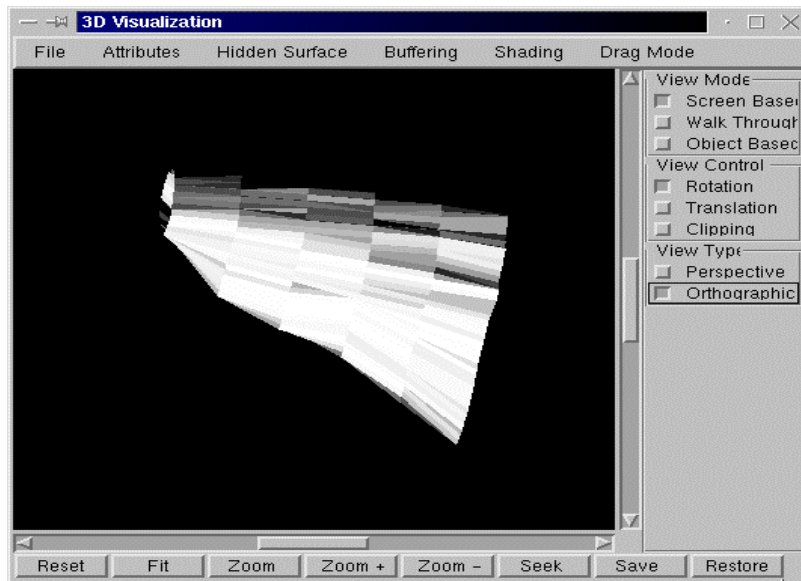
The basic idea is to trace closed contours at each slice of data and then connect between contours in adjacent slices using a mesh of triangles.

Surface Generation Polygons Rendering

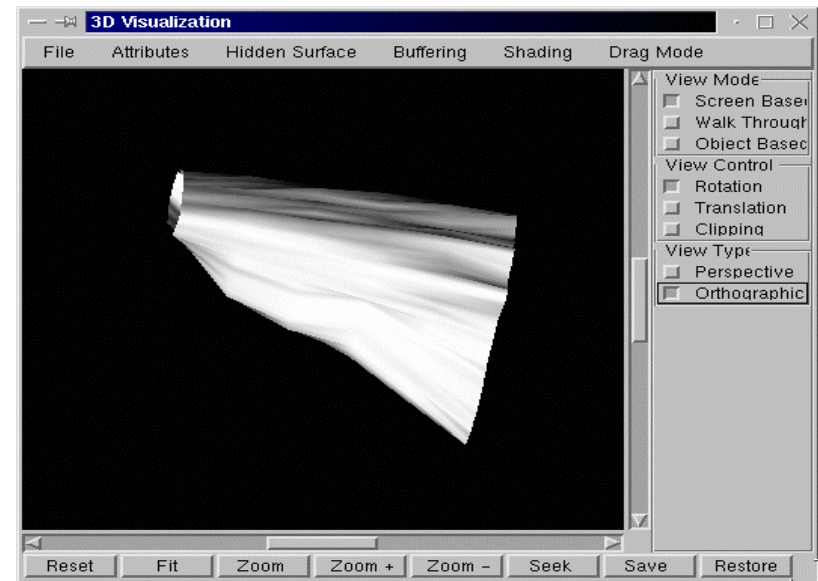
Applying models of light and color to polygons meshes in order to obtain mesh visualization as a solid surface.



Surface Generation Polygons Rendering

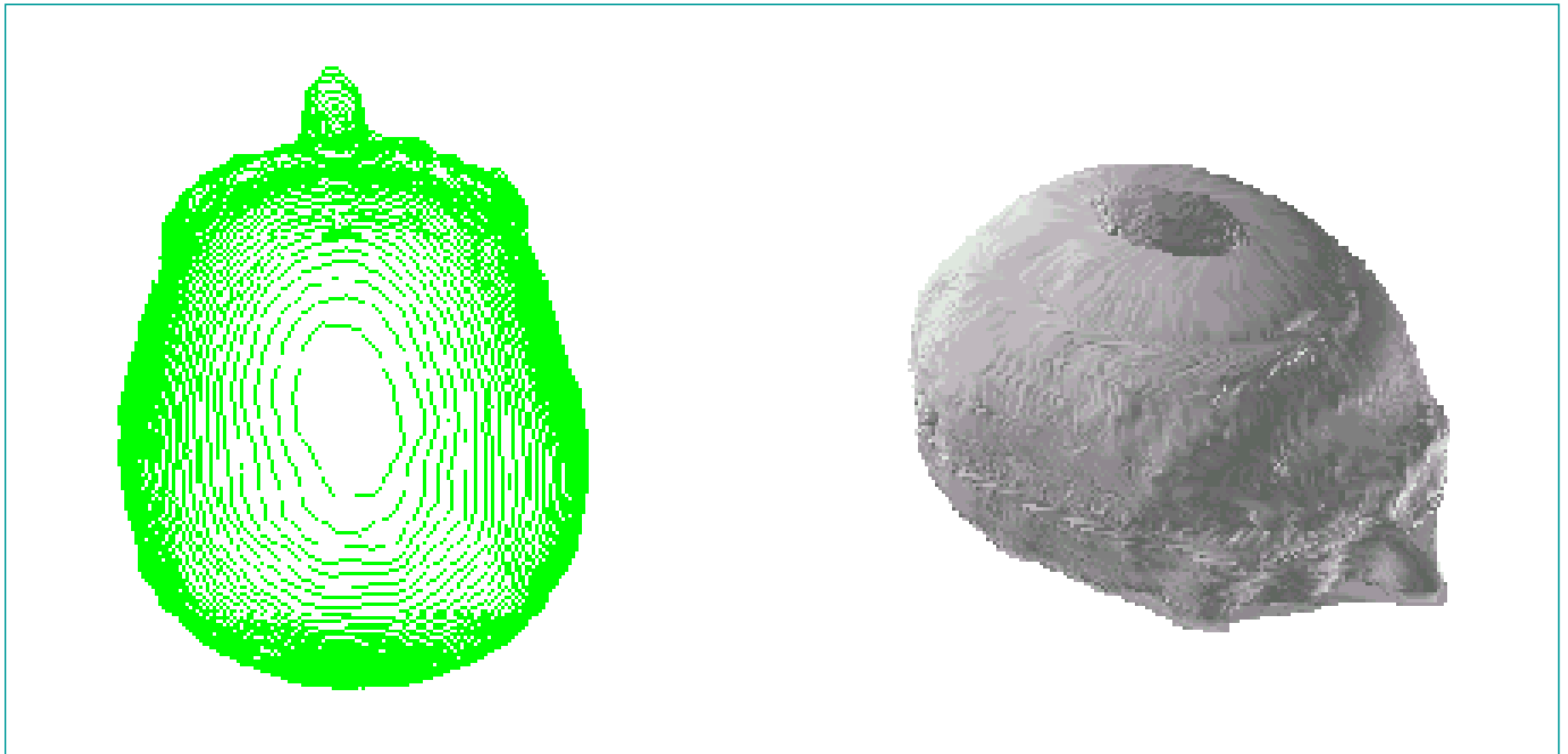


Surfaces' Normals
(Gouraud)



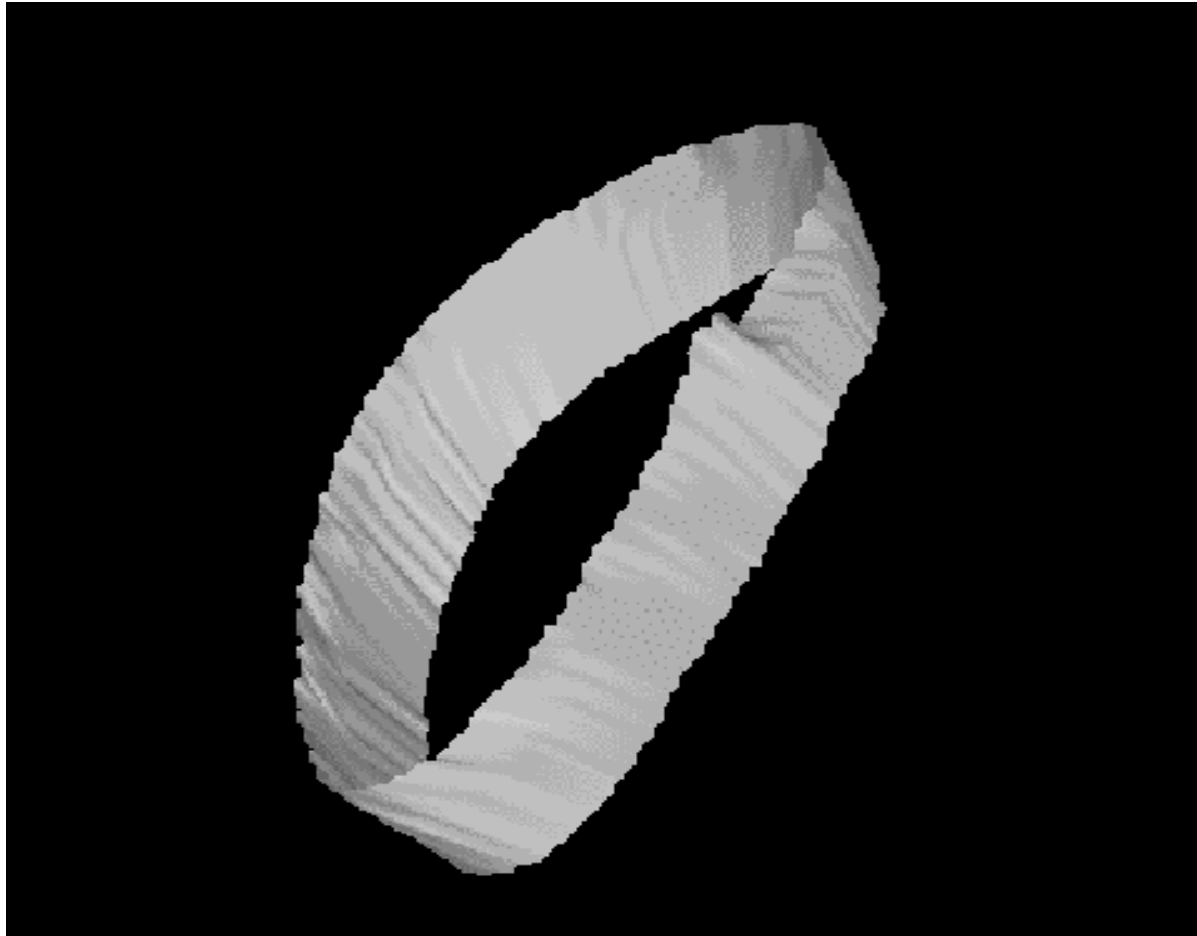
Vertices' Normals
(Phong)

Final Results



Tomografia computadorizada da cabeça

Final Results



Ressonância magnética dos rins

Conclusions and Final Comments

- Comparing the results, the technique has proven to be a good alternative to extract information on volumetric datasets.
- We expect to reach better results enhancing the mesh generation.

Future Works

- Contours detection using parallel computing.
- Enhance the mesh generation in order to improve the quality on surfaces' visualization.