ASSIGNMENT 4

SUBJECT CODE: CS 6630
SUBJECT: SCIENTIFIC VISUALIZATION

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PART A

Color Compositing Transfer Functions

FILES USED

CODE FILE: composite_trans.tcl, isosurface.tcl
DATA FILES PROVIDED:mummy.50.vtk , mummy.80.vtk, and mummy.128.vtk.
VTK PIPELINE:

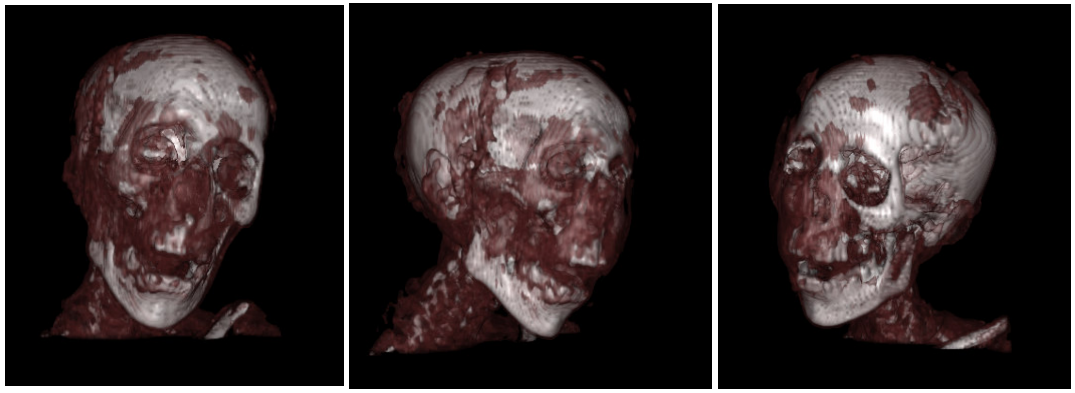
mummy.128.vtk-->STRUCTUREDPOINTSREADER+VOLUMERAYCASTCOMPOSITEFUNCTION-->VOLUMERAYCASTMAPPER-->OUTPUT1

PIECEVISEFUNCTION+COLORTRANSFERFUNCTION-->VOLUMEPROPERTY-->OUTPUT2

OUTPUT1+OUTPUT2--->VTKVOLUME

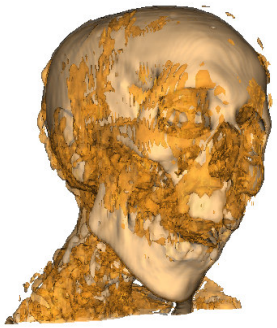
The file provided for visualizing using direct volume rendering was mummy.128.vtk. It was a binary file of a CT scan of a head of a mummy. Actually, the datasets have been resampled from the original scan, in order to lower the resolution (making it faster to visualize). This file is fed to the vtkStructuredPointsReader filter to read the data. The data is also fed to vtkvolumeraycastcompositefunction filter which performs compositing of samples along the ray. Both the outputs are then attached to the vtkVolumeRayCastMapper filter which performs basic ray casting operations like transformations and clipping. Then the vtkPiecewiseFunction is used to map scalar values into an opacity or an opacity per unit length value. Then vtkColorTransferFunction is used to map scalar values into a color. Both the filters are connected to vtkVolumeProperty filter. Both the major outputs are fed to the vtkVolume which holds the transformation information such as position, orientation and scale and pointers to the mapper and property for the volume.

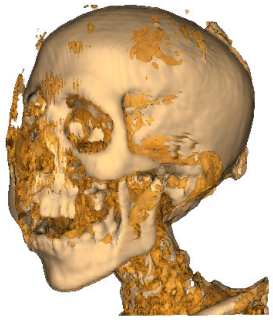
Two images of head of a mummy rendered using volume rendering are shown below.



Rendering the Mummy Using Isosurfacing

The file isosurfaces.vtk performs isosurfacing on mummy data. The isovalue for skin is 82 and 120 for bone. Following are the images of the mummy head using isosurfacing.

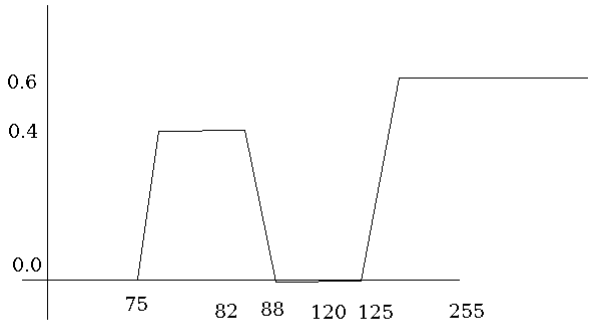




QUESTIONS:

1] Describe your transfer function, what relationship do they have to the isovalues shown in your isosurface rendering?

Ans] Figuring out appropriate transfer functions was little bit hard and time consuming. Finding isovalues in the previous assignment was easy compared to figuring out the approriate transfer function. When i started out rendering the data on some random values i was getting different portions of the mummy. using trial and error is time consuming but helps to explore the data well.Then I tried to set the transfer function around isovalues of the different material present in the data. The isovalue for skin is 82. so I set the opacity 0.4 for the range of values 78-82. For the values 75 and 88 I set it to 0.0 opacity. The isovalue of the bone is 120. So I set the opacity 0.0 for the range of isovalues 88-125. The data with isovalues smaller than 75 are mapped with opacities 0.0 and the data with isovalues greater then 125 are mapped on the opacity 0.6. The images were rendered well using these opacity values. Setting transfer function around the isovalues helps to render better and clear images.



2] Do you think volume rendering the mummy dataset offers a clear advantage over isosurfacing?

Ans] Using direct volume rendering has some advantages as well as disadvantages over isosurfacing. In case of volume rendering we can assigne opacities and color to range of values where as this is not possible in case of isosurfacing. The disadvantage of direct volume rendering is that the rendering is very slow which is time consuming. The isosurfacing is better for fast data exploration and rendering.

PART B

Maximum Intensity Projection Renderings

FILES USED

CODE FILE: mip_trans.tcl
DATA FILES PROVIDED:mummy.50.vtk , mummy.80.vtk, and mummy.128.vtk.
VTK PIPELINE:

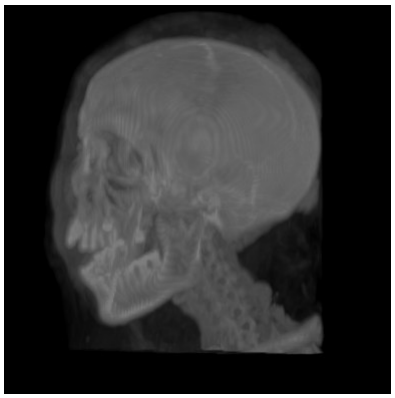
mummy.128.vtk-->STRUCTUREDPOINTSREADER+VOLUMERAYCASTMIPFUNCTION-->VOLUMERAYCASTMAPPER-->OUTPUT1

PIECEVISEFUNCTION+COLORTRANSFERFUNCTION-->VOLUMEPROPERTY-->OUTPUT2

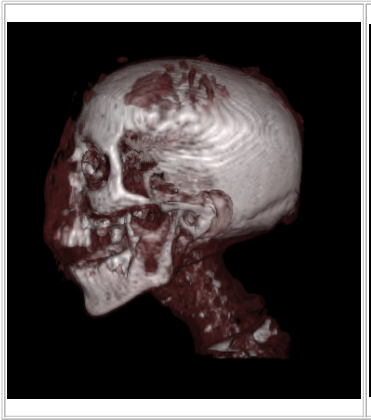
OUTPUT1+OUTPUT2--->VTKVOLUME

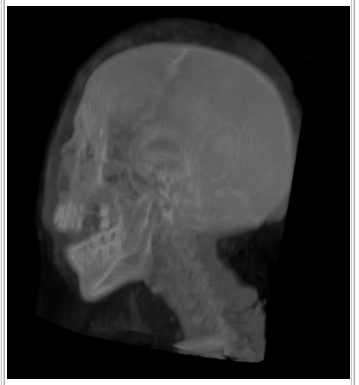
In this part I used maximum intensity projection(MIP) to do volume rendering of the head of the mummy with volume ray casting method. The vtk pipeline for rendering is very similar to the above except the use of vtkVolumeRayCastMipFunction filter instead of vtkVolumeRayCastCompositeFunction filter. vtkVolumeRayCastMIPFunction is a volume ray cast function that computes the maximum value encountered along the ray. this filter generates gray scale images using ray casting.

Following is the image of the mummy head using MIP filter.



The head of a mummy rendered using vtkVolumeRayCastCompositeFunction filter and vtkVolumeRayCastMipFunction filter are as follows





3] Compare the two images. What are some advantages and disadvantages of MIP versus compositing-based volume rendering?

Ans] Both methods have some advantages and disadvantages. Composite based rendering provides rendering of fine details of parts being rendered. For instance the hole near the mouth and ear are rendered very well. But is does not provide overall information of the data. This method also enhances the depth information of the data very well. The MIP rendering gives overall view of the data but does not provide depth information well.

PART C

FILES USED

CODE FILE: composite_trans.tcl
DATA FILES PROVIDED:mummy.50.vtk , mummy.80.vtk, and mummy.128.vtk

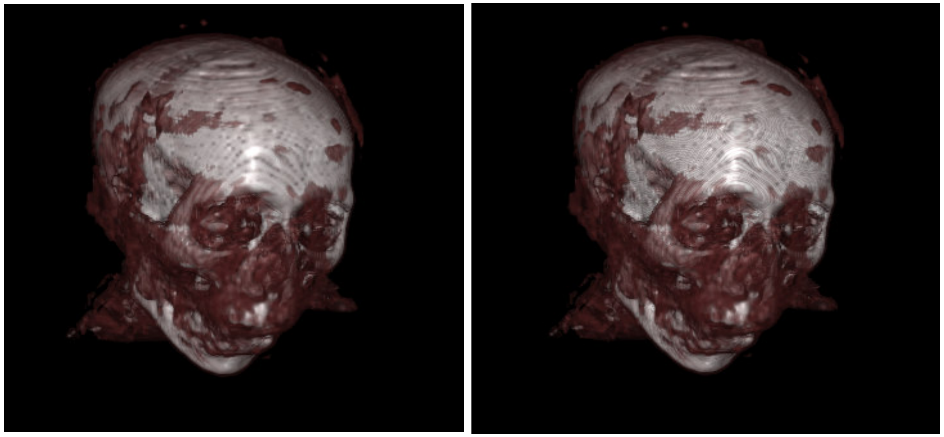
Direct volume rendering is a very flexible process. There are many parameters (in addition to the transfer function) which will effect the final image. we were required to explore three parameters: sample distance spacing, interpolation type, and dataset resolution.

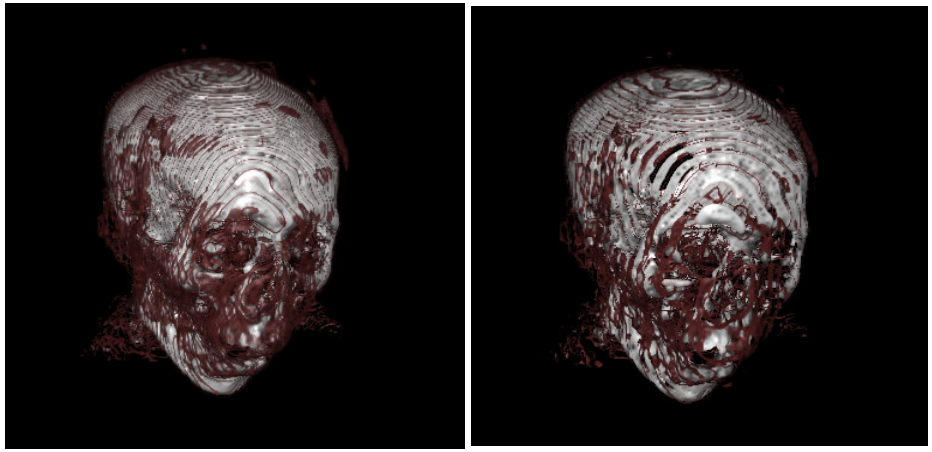
Sample Distance Spacing

We can set the sampling distance using SetSampleDistance method of vtkVolumeRayCastMapper. It specifies the sampling distance for ray casting the data.

4] What is the relationship between image quality, rendering time, and sample distance?

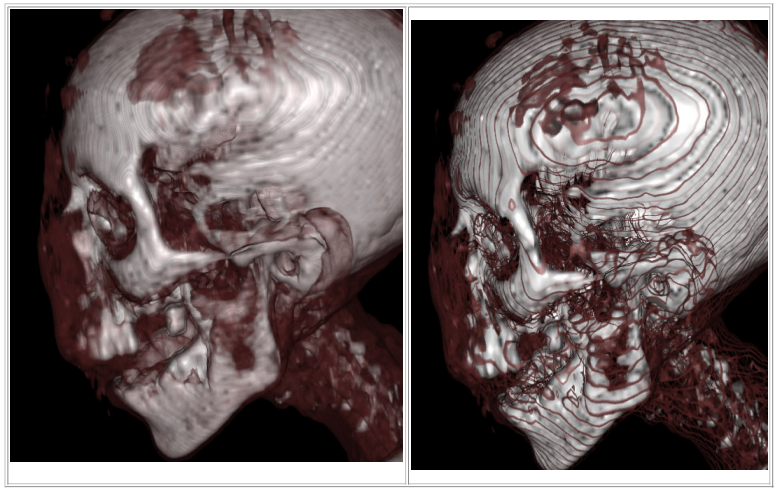
Ans] As the value of sample distance increases the rendering time decreases and quality of the image decreases too. But as the sampling distance decreases the rendering time increases along with the quality of the image.
Below are the images which are rendered using different sampling distance values. The top row has images with values 0.2 and 0.5. The second row has images rendered with sampling values 3.0 and 7.0. The top row images are rendered well with very fine detail whereas in bottom row images we can see some data loss due to increase in the sampling distance value.





5] Give an example of a feature in the dataset which can be lost by increasing the sample distance too much?

Ans] Below are the images which explains how data is lost by increasing the sample distance too much. First image has sample distance of 0.3. It show the details fo the data very well like teeth, hole near the mouth and ear. The second image has been rendered using the value 3.0 which clearly shows some fine details are loss like near the mouth and ear. The image at the right shows very well that the some of the data is completely lost as the sampling distance is increased too much.



6] Is there a sample distance that seems "small enough", so that smaller distances offer no clear advantage?

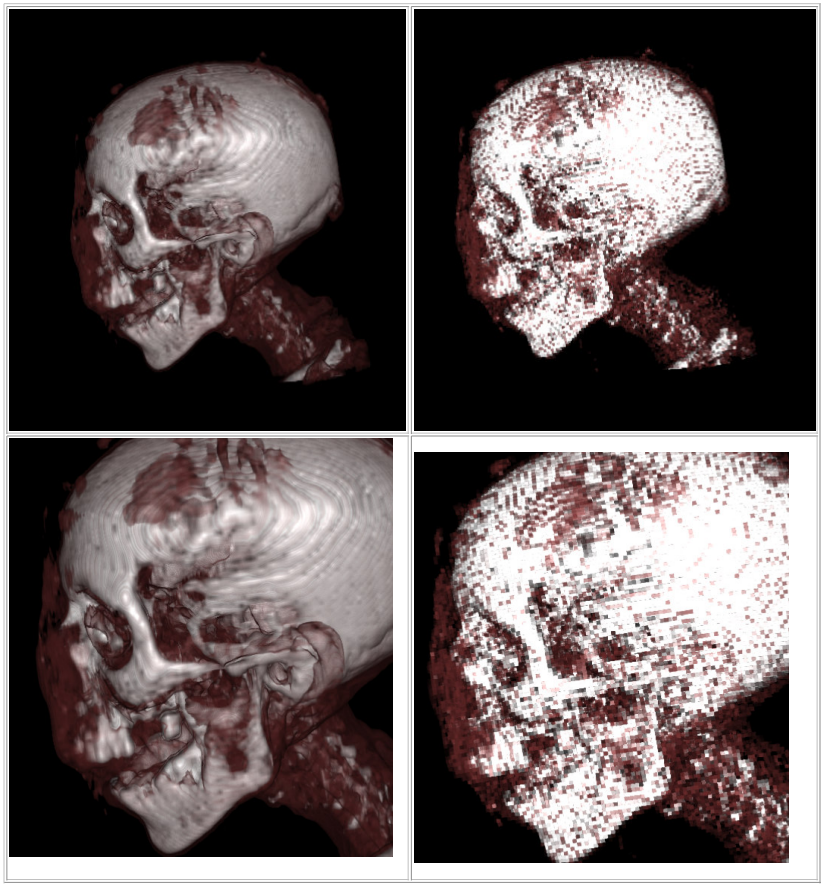
Ans] Observing the above two images I think that the image with the sample distance value 0.5 is not that different than the image with 0.5 value in case of clarity. There is not much clear advantage over the first image so I believe 0.5 is the "small enough" sample distance value.

Interpolation method

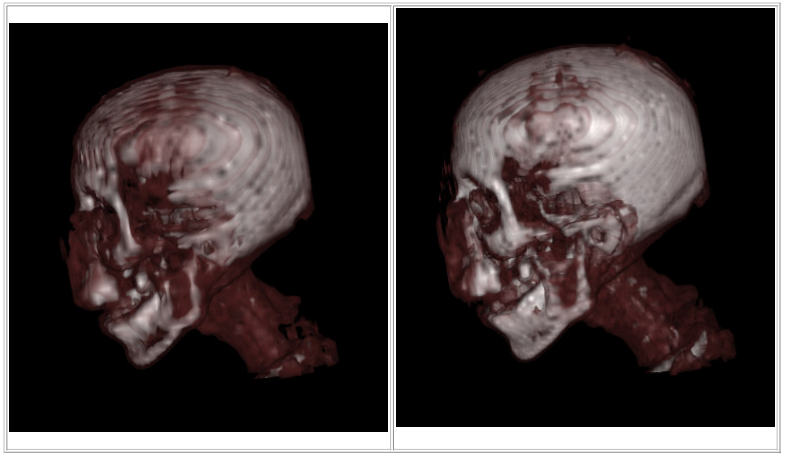
7] Describe and demonstrate the differences between the two different interpolation methods.

Ans] There are two different interpolation methods that can be used to produce the volume renderings. They are nearest neighbor and trilinear interpolation.

The nearest neighbor method simply selects the value of the nearest point, and does not consider the values of other neighboring points at all. The algorithm is very inexpensive to implement, and is commonly used in real-time 3D rendering to select color values for a textured surface.In the Nearest Neighbor technique, the transformed pixel takes the value of the closest pixel at the grid point in the pre-shifted array. Rendering using nearest neighbor method is much faster than trilinear method. Trilinear interpolation is the name given to the process of linearly interpolating points within a box (3D) given values at the vertices of the box. The output using trilinear interpolation method is better in quality than the image obtained using nearest neighbor method. The left images are rendered using Linear interpolation mathod and right images are rendered using Nearest neighbor method.



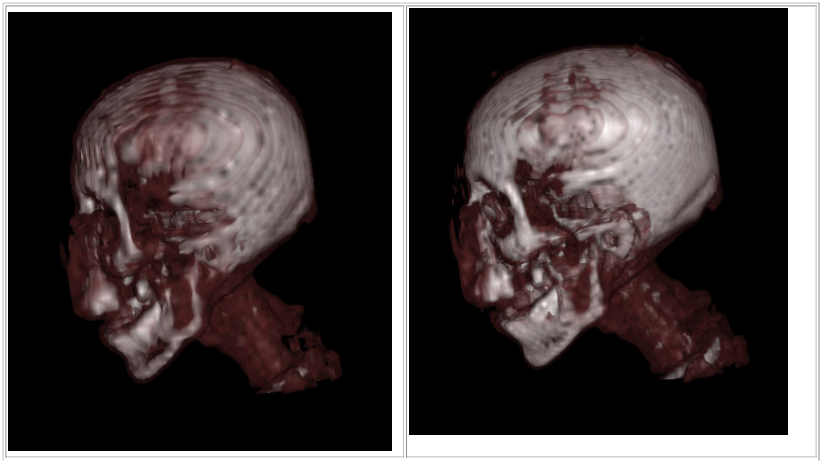
Dataset resolution

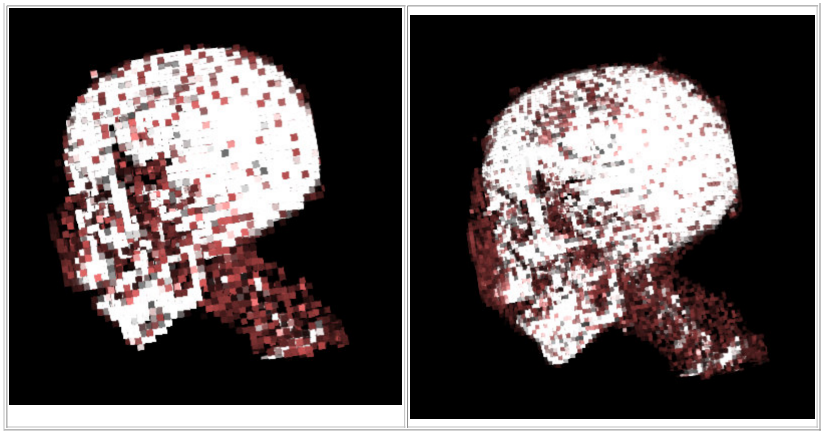


8] Demonstrate how image quality can be improved with higher resolution data. Are there features that are present in mummy.80.vtk but missing in mummy.50.vtk?

Ans] The quality of the image is affected by the changes in the resolution of the data. As the resolution of the data increases the quality of the images also increase. Above images explains well about this. The features of the mummy rendered using mummy.80.vtk are more defined and clear like the regions near mouth, teeth and ear. The output using mummy.50.vtk shows how important is the resolution of the image to get better quality output. Much of the data is not precise and defined.

9] How does increasing the dataset resolution change the difference between the two interpolation methods?





Ans] Increasing the dataset resolution increases the quality of the image no matter which interpolation method is being used. Top row shows the outputs using trilinear method. The higher resolution output shows more precise information and provides smooth images. The bottom row outputs are rendered using nearest neighbor interpolation method. As we can see these outputs are not very clear and smooth as in case of trilinear method.