CAV Assignment 2

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Aim

- Produce visualisation of Human Head volume data
- Attempt to convey “good” or “important” information
  - Skull, Skin, Form & Shape, etc
- Attempt to hide “bad” or “useless” information
  - Artefacts, Noise
- Interactive if possible

Approach

- Ray Traced Volume Renderer
- Step through Volume by some method
- Use Transfer functions to map scalar value to color
- If skin/bone are clear and visualisation is good then should get mark of 60%
- Bonus Marks
  - *Ray Tracing in 3D*
  - *Trilinear Interpolation*
  - *Volume Illumination*
  - *Shear Warping*

Voxel Traversal

- Decide how to traverse into the volume
- Start by showing the volume from different axis
- Decide when to stop traversal
  - Theshold Value
  - Maximum Value
  - Average Value
  - Composite Value
- How you accumlate values as you traverse is important

Transfer Functions

- Map some scalar value to some color/opacity
- Designed to best visualise the data range
- Important to show skin/bone etc
- If unsure design several which show different things well
- It can help to plot histograms to see distributions of density values.

3D Ray Tracing

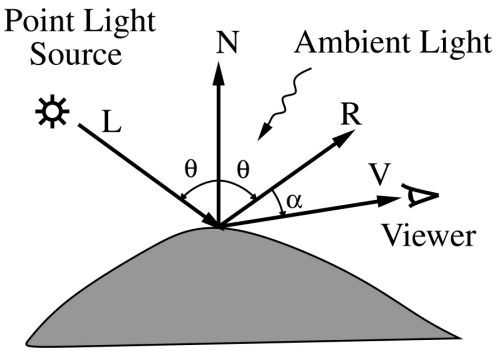
- Algorithm
  - For each pixel find its clip space coordinates (x, y). These are in the range (-1, 1)
  - Augment with depth value to get near-clip-plane and far-clip-plane coordinates (x, y, -1) and (x, y, 1)
  - Multiply these into world space using the *Inverse Projection Matrix* and the *Inverse View Matrix.*
  - These are the endpoints of your viewport pixel ray in world space

Volume Illumination

- Illumination can help us better understand 3D structure of volume information
- Displays Visual Cues such as surfaces
- Highlights important gradients and makes them clear
- Allows for ISO surface display

Volume Illumination

- Voxels can *scatter light*, *reflect light*, or *absorb light*
- Fully modelling scattering is very expensive
- For now just model absorption, reflection
- Use regular Phong Shading Model
- Requires Normals



a)

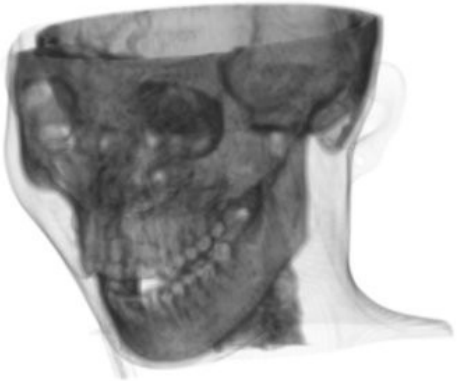
Estimating Normal from Volume

- 3D Volume has no “normal” only a gradient
- Calculate Gradient using Midpoint Method
- Use it to find vector going in *direction required*
  - E.G From Most Dense to Least Dense

$$nx = V(x-1, y, z) - V(x+1, y, z)$$
$$ny = V(x, y-1, z) - V(x, y+1, z)$$
$$nz = V(x, y, z-1) - V(x, y, z+1)$$

$$N = (nx, ny, nz)$$

  - Or from current value to required ISO value



Result

- Illuminated Volume

Demo Program

- “include” - Place your header (.h) files here
- “src” - Place your source (.cpp) files here
- “obj” - Intermediate build folder
- “Volume.cpp” - Program entry point
- “head” - Volume data
- “Makefile” - Config file to build the project
- “README” - Instructions for use

Demo Classes

- Matrix
  - Contains Matrix classes (for 2x2, 3x3 and 4x4)
  - Feel free to use and extend where needed
- Vector
  - Contains Vector classes (for 2, 3, 4)
  - Again, feel free to use and extend
- Volume
  - Used to load and access Volume Data

Demo Functions

- Draw()
  - This is called every frame, it is where your logic should go, both for calculations and rendering.
  - Currently it traces in 2D and terminates once it reaches a density over a given value.
  - It then outputs the colour of that density
  - This is the main function you should edit

Demo Functions

- KeyEvent()
  - Here you can add interactive controls for keyboard presses.
  - See also “glutSpecialFunc”, “glutMouseFunc”, “glutMotionFunc” to add other kinds of interaction
- main()
  - You can add initialisation code here

Compiling & Running

- Compiling
  - Providing everything in correct place...
  - Just run “make”
  - Run “make clean” to remove any intermediate build files.
- Running
  - Just run “./Volume”
- Any other problems contact me

Example...

How to get started

- Program some form of Transfer Functions
  - Gradient mapping range [0 - 1] to colours
- First trace into the volume in 2D
- Use density data as opacity
- Afterwards attempt to trace in 3D
- Don't attempt to speed up code before it works
  - “Premature optimisation is the root of all evil” - Donald Knuth

Example 2...

Lab session Task

- Designing a really basic transfer function...

FAQ

- Is the head volume meant to be a cube?
  - Yes. If you can account for one axis being smaller great! Otherwise you wont be marked down.
- Can I use OpenGL to do the 3D viewport?
  - No and it wont work properly anyway. Always use glVertex just to draw pixels.

Any Questions?