VGP352 – Week 8

◊ Agenda:
  – Interior mapping
  – Parallax textures
  – Displacement mapping
Interior Mapping

Remember the excellent “debris” demo by Farbrausch?
Interior Mapping

✧ Remember the excellent “debris” demo by Farbrausch?
  – Isn't it odd that you can't see inside the windows?
Interior Mapping

- Determine the location *inside* the building that is visible *without* adding geometry
Interior Mapping

- Determine the location *inside* the building that is visible *without* adding geometry
  - The drawing suggests the answer: use raycasting
  - Create virtual walls, ceilings, and floors inside the building at regular intervals
Interior Mapping

Calculate the point of ceiling intersection
- Assume all calculations are in object space
- Exterior intersection point and ray direction are given

\[ I_y = \left\lfloor \frac{E_y}{h} \right\rfloor \times h \]
**Interior Mapping**

- **Parametric equation of V:**
  
  \[ p = V + \vec{V}t \]

  where \( \vec{V} = E - V \)

- Calculate the value of \( t \) where \( p_y = I_y \)
  
  \[ I_y = V_y + \vec{V}_y t \]

  \[ I_y - V_y = \vec{V}_y t \]

  \[ \frac{I_y - V_y}{\vec{V}_y} = t \]

- Use \( t \) to calculate the rest of \( I \)
Interior Mapping

- Perform similar calculations for walls
  - The intersection with the smallest $t$ is used
  - Use resulting $I_{xy}$ to generate a texture coordinate

- Can add extra fake walls to represent items in the rooms
  - Textures for the fake walls should be mostly transparent
  - Has issues if the viewer can see in corners
    - See paper for more details
Parallax Textures

- Normal / bump maps give shading cues to surface shape
  - No changes to silhouette
  - No self occlusion
Parallax Textures

- Normal / bump maps give shading cues to surface shape
  - No changes to silhouette
  - No self occlusion
- Parallax textures address the second problem
  - Does so by exploiting the parallax effect
Parallax Textures

From wikipedia:
Parallax is an apparent displacement or difference of orientation of an object viewed along two different lines of sight, and is measured by the angle or semi-angle of inclination between those two lines. Nearby objects have a larger parallax than more distant objects when observed from different positions, so parallax can be used to determine distances.

- 2D side-scrolling games use this effect all the time
- Nearer background objects scroll by faster than farther background objects
Parallax Textures

- Implement this for a 3D surface:
  - Use a height (bump) map to set per-fragment distance from viewer
  - As the viewer moves side-to-side in surface space, nearer portions of the texture will “scroll by faster”
Parallax Textures

At each fragment:
- Sample the depth from the surface using the bump map
- Use this value to scale projection of the view vector on to the surface
- Use result as offset into diffuse map
Parallax Textures

What could go wrong? What are the shortcomings?
Parallax Textures

What could go wrong? What are the shortcomings?

- Assumes a smoothly varying height field
  - Can't handle large displacements
  - Can't handle high-frequency data
- Doesn't properly handle occlusion
References


Displacement Mapping

- We really want to raytrace into arbitrary volume data representing our surface
  - Would require a linear search through a volume texture *per fragment*
Displacement Mapping

- What if we knew, at every position, the distance to the nearest voxel?
  - As we walk the ray through voxel space, we could step by the distance to the nearest voxel
  - Reduces the search from $n$ to $\log n$
Displacement Mapping

◊ Algorithm:

For some number of steps:

\[
\text{distance} = \text{sample distance texture at position}
\]

\[
\text{position} += \text{distance} \times \text{direction}
\]

- Dynamic branching hardware can end loop early if distance is below some preset threshold
- direction is the normalized viewing direction vector
- Must be rescaled from surface space to texel space
Displacement Mapping

- Result of raytracing is a 3D position
  - Project the 3D position onto the surface
    - i.e., just use the $x$ and $y$ components
  - Use the resulting projection to sample texture and normal maps
Euclidean Distance Map

- Generate distance map using Danielsson's algorithm
  - Initialize a texture with (0, 0) for elements “inside” the surface or (∞, ∞) for elements outside
  - Perform 4 passes over the image propagating distances among neighbors
  - This is the 2D version... it can be trivially extended to 3D
Euclidean Distance Map

◊ Pass 1:
- Move the mask top-to-bottom, left-to-right
- The green element is the pixel being examined, the others are its neighbors
- Add the specified offsets to the pixel distance values, store the minimum in the pixel

```
  (1,0)     (0,1)
(0,0)```

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Euclidean Distance Map

✐ Pass 2:
  - Move the mask top-to-bottom, right-to-left
  - The green element is the pixel being examined, the others are its neighbors
  - Add the specified offsets to the pixel distance values, store the minimum in the pixel

(0,0) (1,0)
Euclidean Distance Map

Pass 3:
- Move the mask bottom-to-top, right-to-left
- The green element is the pixel being examined, the others are its neighbors
- Add the specified offsets to the pixel distance values, store the minimum in the pixel
Euclidean Distance Map

− Pass 4:
  − Move the mask bottom-to-top, left-to-right
  − The green element is the pixel being examined, the others are its neighbors
  − Add the specified offsets to the pixel distance values, store the minimum in the pixel

\[(1,0) \quad (0,0)\]
Euclidean Distance Map

◊ Final pass:
  - Convert the distance vectors to distance scalars
Displacement Mapping

◊ Caveats:

- Take partial derivatives of input texture coordinate and use those when sampling the final texture
- Otherwise the texture filtering will be wrong in weird ways
- Use $\text{ddx}$ and $\text{ddy}$ functions
References


http://distance.sourceforge.net/

- You'll have to Google (with some effort!) for a live link to the actual paper. :(
Next week...

✧ Next class meeting TBD
  - I will be traveling on business all next week
✧ Multiple render targets
✧ Deferred shading
✧ Quiz #4
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