VGP352 – Week 9

- Agenda:
  - Interior mapping
  - Parallax textures
  - Displacement mapping

9-March-2010

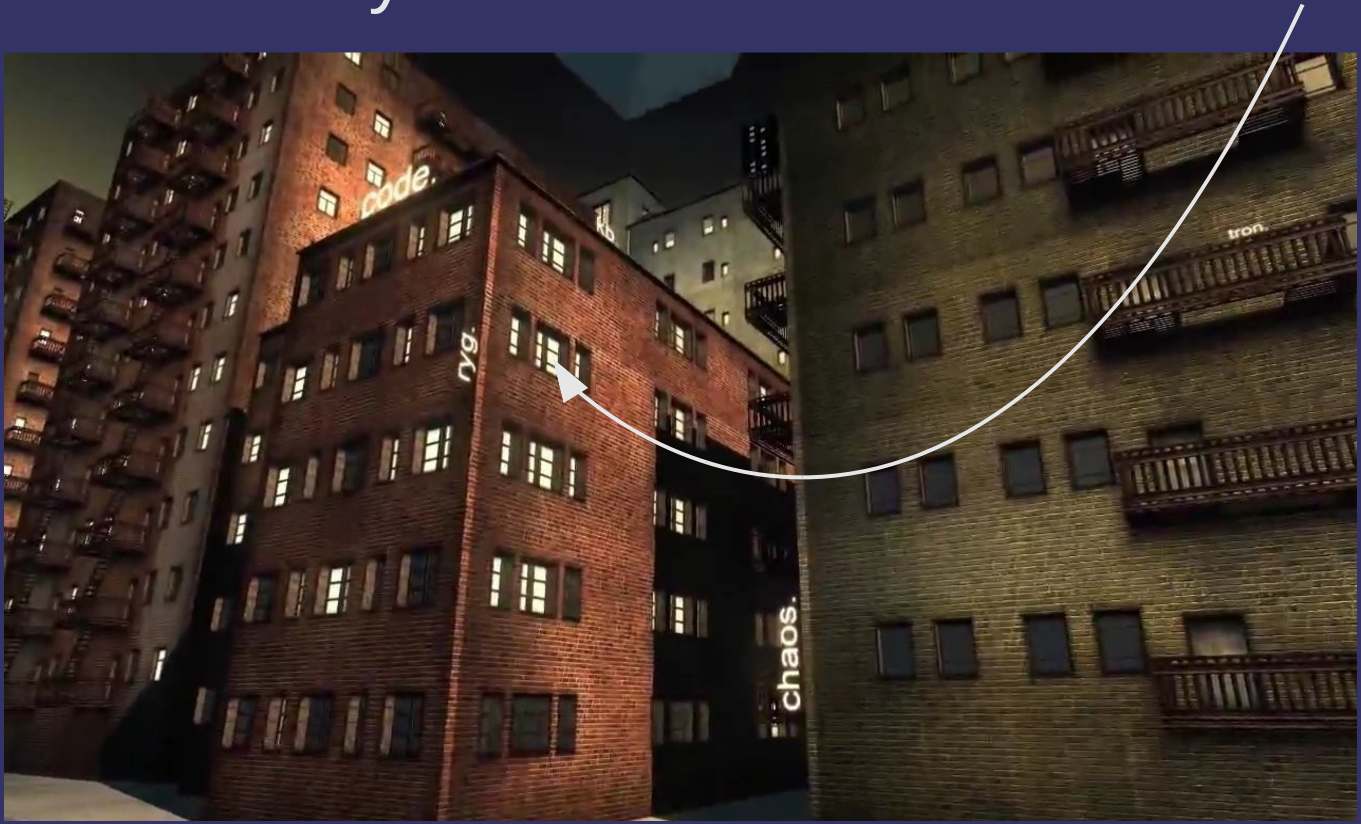
Interior Mapping

- Remember the excellent “debris” demo by Farbrausch?

code.
kb
ryg.
chaos.
tron.

Interior Mapping

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



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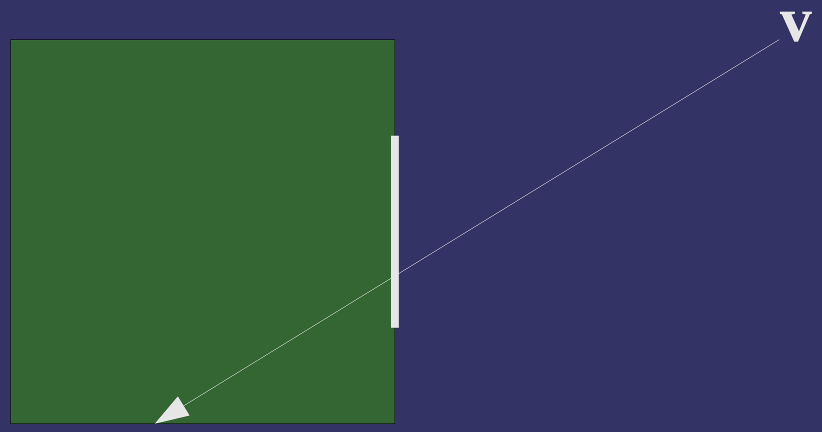
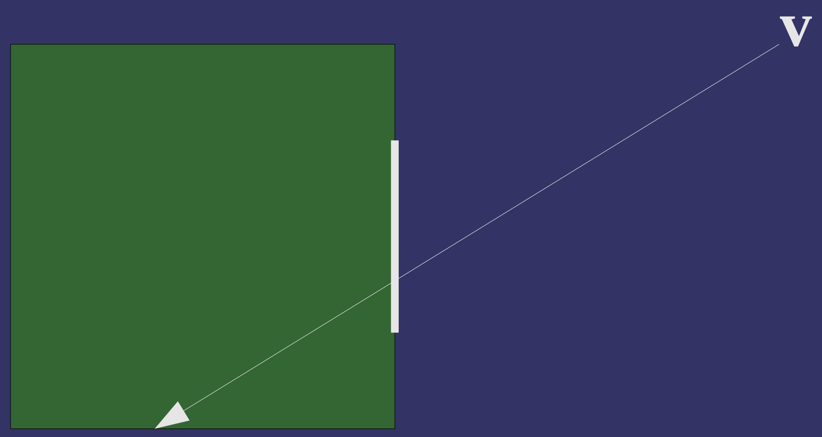
Interior Mapping

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



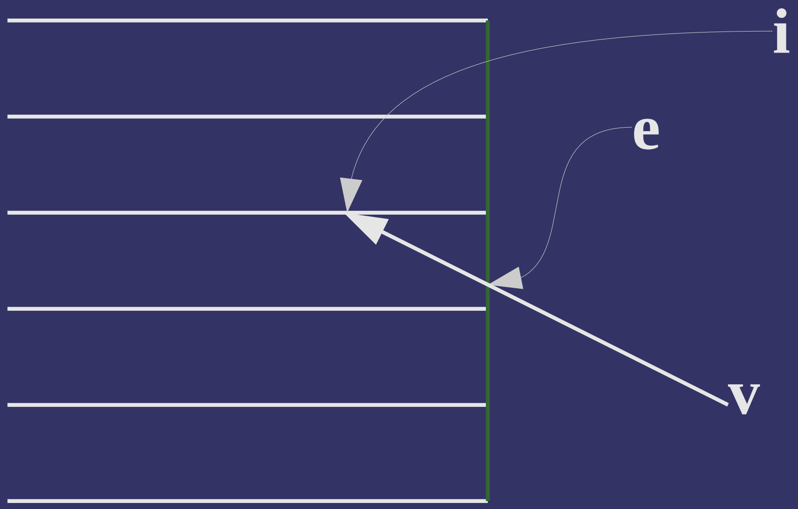
Interior Mapping

- 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



$$\mathbf{i}_y = \left\lceil \mathbf{e}_y / h \right\rceil \times h$$

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Interior Mapping

- Parametric equation of V:

$$\mathbf{p} = \mathbf{v} + \hat{\mathbf{v}}\, t$$
$$\text{where } \hat{\mathbf{v}} = \mathbf{e} - \mathbf{v}$$

  - Calculate the value of t where $\mathbf{p}_{\mathrm{y}} = \mathbf{i}_{\mathrm{y}}$

$$\begin{aligned} \mathbf{i}_{\mathrm{y}} &= \mathbf{v}_{\mathrm{y}} + \hat{\mathbf{v}}_{\mathrm{y}}\, t \\ \mathbf{i}_{\mathrm{y}} - \mathbf{v}_{\mathrm{y}} &= \hat{\mathbf{v}}_{\mathrm{y}}\, t \\ \frac{\mathbf{i}_{\mathrm{y}} - \mathbf{v}_{\mathrm{y}}}{\hat{\mathbf{v}}_{\mathrm{y}}} &= t \end{aligned}$$

  - Use t to calculate the rest of $\mathbf{i}$

Interior Mapping

- Perform similar calculations for walls
  - The intersection with the smallest t is used
  - Use resulting $\mathbf{i}_{xy}$ 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

References

van Dongen, Joost, "Interior Mapping - A new technique for rendering realistic buildings." In *Computer Graphics International Conference* (CGI). 2008. http://interiormapping.oogst3d.net

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

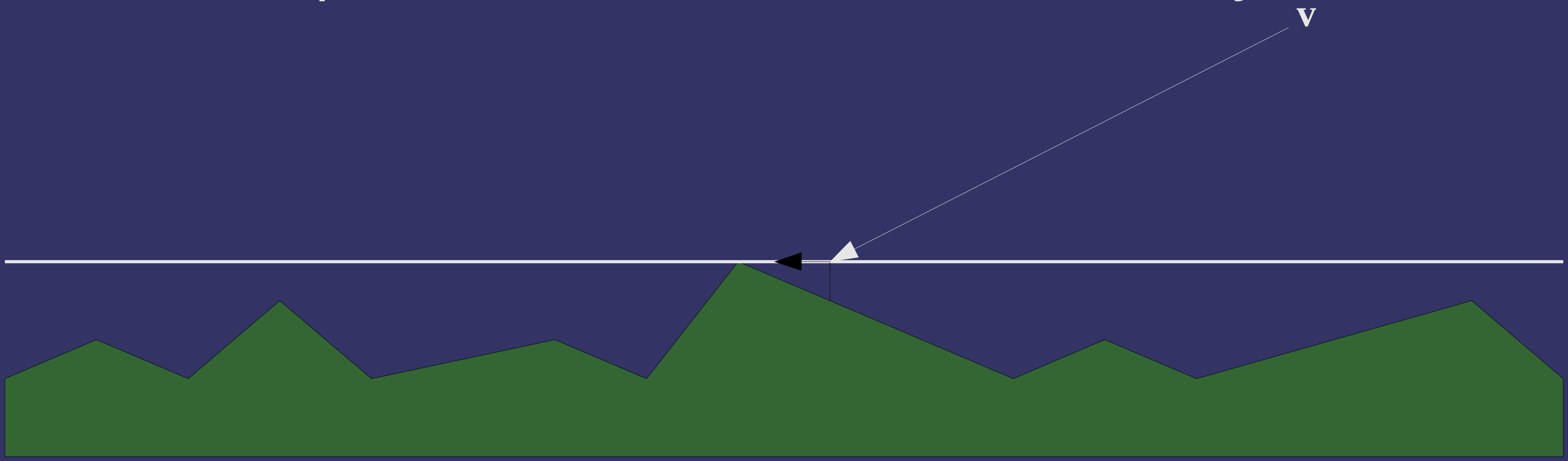
- From wikipedia:

  > 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”



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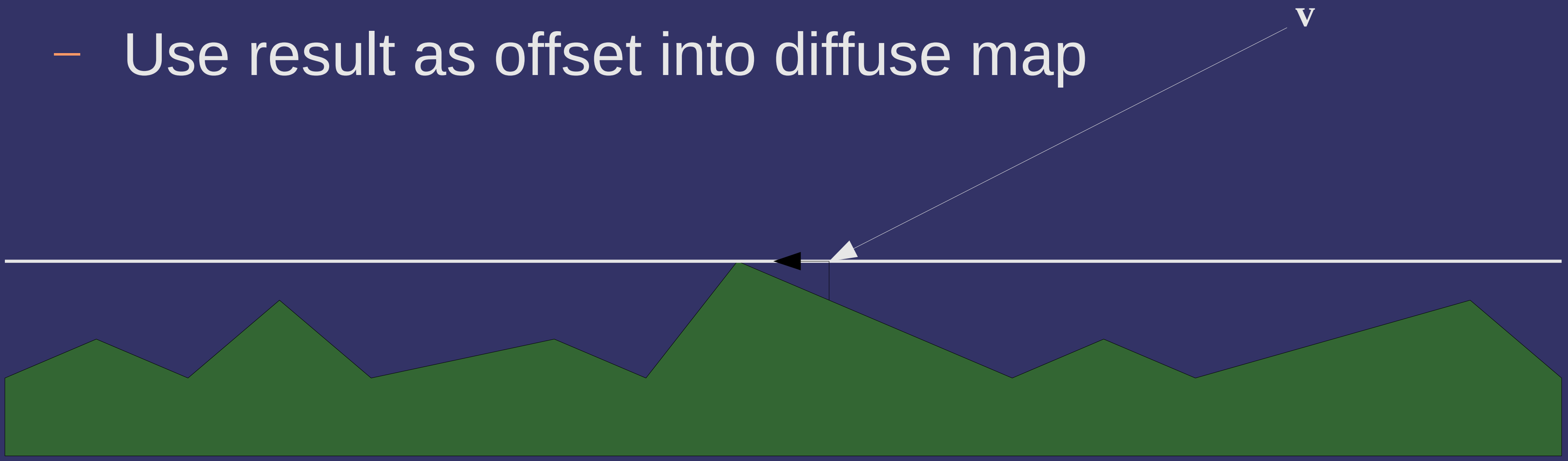
Parallax Textures

- 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 short comings?

Parallax Textures

- What could go wrong? What are the short comings?
  - Assumes a smoothly varying height field
    - Can't handle large displacements
    - Can't handle high-frequency data
  - Doesn't properly handle occlusion

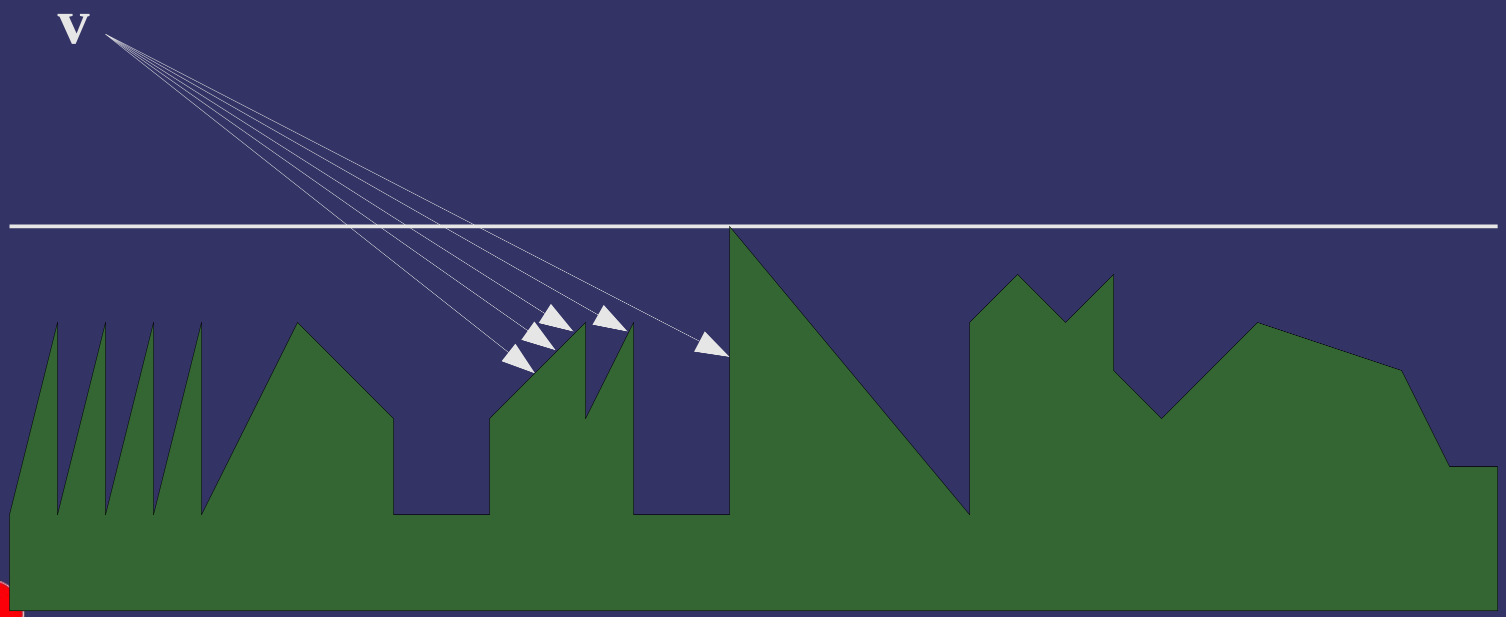
References

Kaneko, Tomomichi, Toshiyuki Takahei, Masahiko Inami, Naoki Kawakami, Yasuyuki Yanagida, Taro Maeda, and Susumu Tachi. 2001. “Detailed Shape Representation with Parallax Mapping.” In *Proceedings of the ICAT 2001 (The 11th International Conferences on Artificial Reality and Telexistence)*, Tokyo, December 2001, pp. 205 – 208. http://vrsj.t.u-tokyo.ac.jp/ic-at/ICAT2003/papers/01205.pdf

West, Mick. “Parallax Mapped Bullet Holes.” Game Developer, May 2006. http://cowboyprogramming.com/2007/01/05/parallax-mapped-bullet-holes/

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:
    distance = sample distance texture at
    position
    position += distance * 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

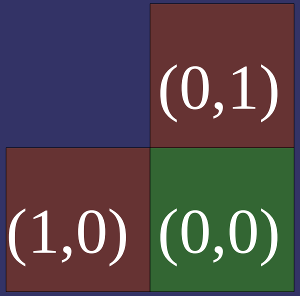
- Result of raytracing is a 3D position
  - Project the 3D position onto the surface
    - i.e., just use the x and y components
  - Use the resulting projection to sample texture and normal maps

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

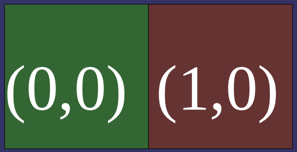


(0,1)

(1,0) (0,0)

Euclidean Distance Map

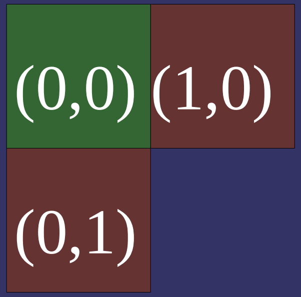
- Pass 2:
  - Move the mask top-to-bottom, right-to-left
  - The green element is the pixel being examined, the others are its neighbors
  - Add the specified offsets to the pixel distance values, store the minimum in the pixel



(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

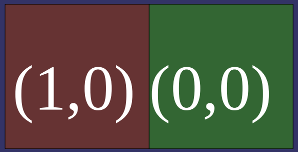


(0,0) (1,0)

(0,1)

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)	(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 `dFdx()` and `dFdy()` functions

References

Donnelly, William. "Per-Pixel Displacement Mapping with Distance Functions" in Fernando, Randima (editor) GPU Gems 2, Addison Wesley, 2005. http://download.nvidia.com/developer/GPU_Gems_2/GPU_Gems2_ch08.pdf

Fabbri, R., Costa, L. F., Torelli, J. C., and Bruno, O. M. 2008. 2D Euclidean distance transform algorithms: A comparative survey. ACM Computing Surveys 40, 1 (Feb. 2008), 1-44. http://distance.sourceforge.net/

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

Next week...

- Multiple render targets
- Deferred shading
- Quiz #4

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