Dual-Paraboloid Shadow Mapping

A paper by

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Presented By

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Introduction and Background

- An improved perspective shadow mapping technique
- Less memory and render passes required
- Paper was written in 2002

Shadow Mapping

- Very fast to compute
- Acceptable quality
- Requires multiple passes for hemispherical and omnidirectional light sources

Simple Shadow Mapping

- Most basic form of shadow mapping
- Draw scene from light’s perspective
- Store depth buffer
- Compare when drawing shadows

Mapping for hemispherical and omnidirectional lights

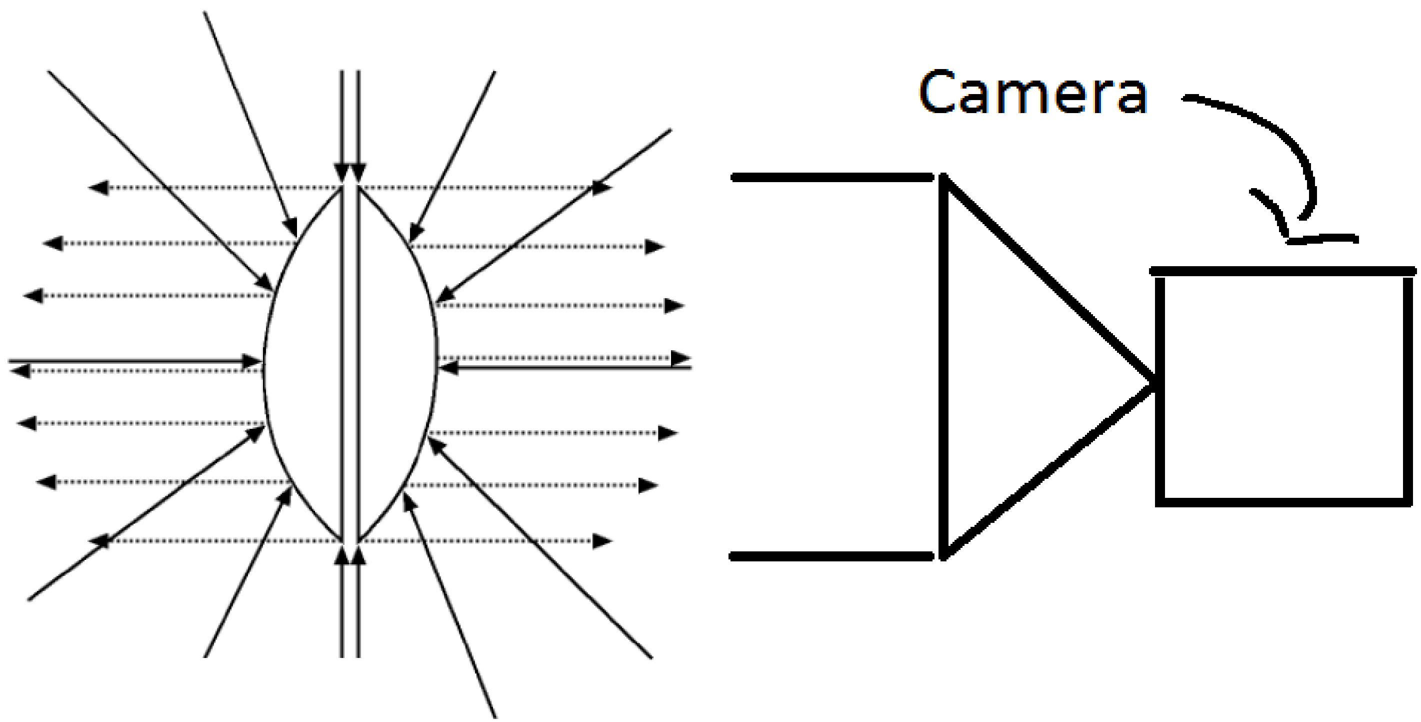
- Spherical mapping
  - Single map, but heavy distortion
- Blinn/Newell Mapping
  - Different parameterization, but expensive
- Cube Mapping
  - Six maps, very expensive
- Dual-Paraboloid Mapping
  - Two maps, little distortion

Dual-Paraboloid Shadow Mapping

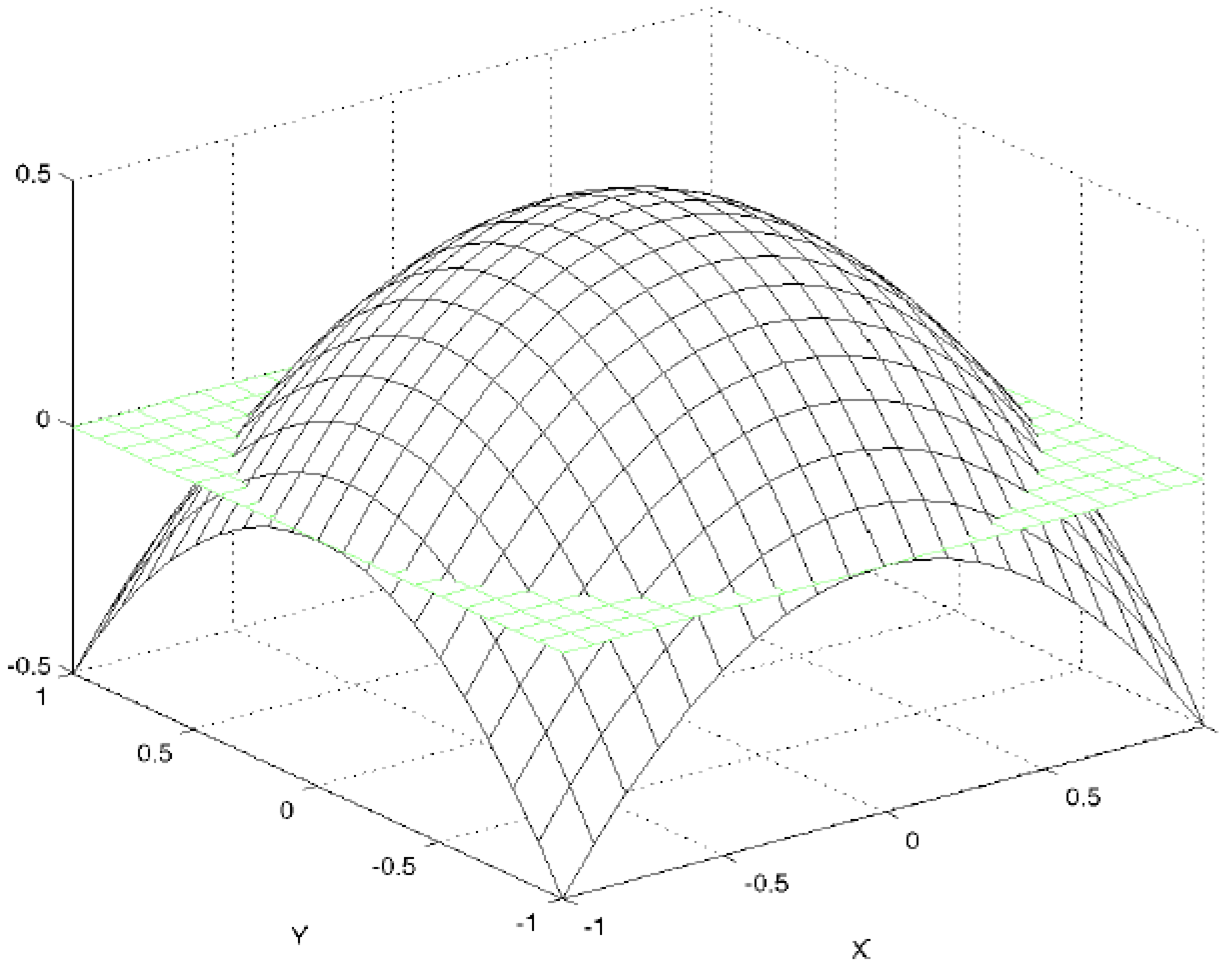
- Similar to traditional shadow mapping
- Needs only one pass per hemisphere

Dual-Paraboloid Shadow Mapping

- Analogy: the image obtained by an orthographic camera viewing a perfectly reflecting paraboloid.



Dual-Paraboloid Shadow Mapping

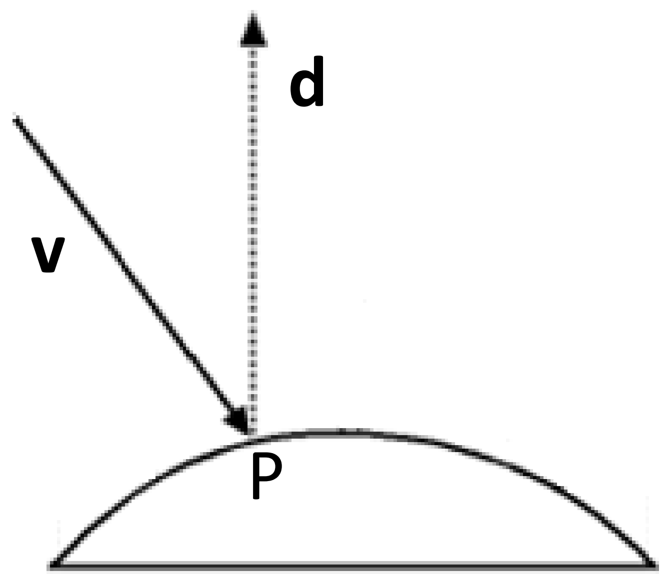


$$f(x, y) = \frac{1}{2} - \frac{1}{2}(x^2 + y^2)$$

Dual-Paraboloid Shadow Mapping

Generating the Shadow Map.

- From 3D to texture coordinates:
  - we need the point P on the paraboloid that reflects a given direction **v** towards the direction **d**.

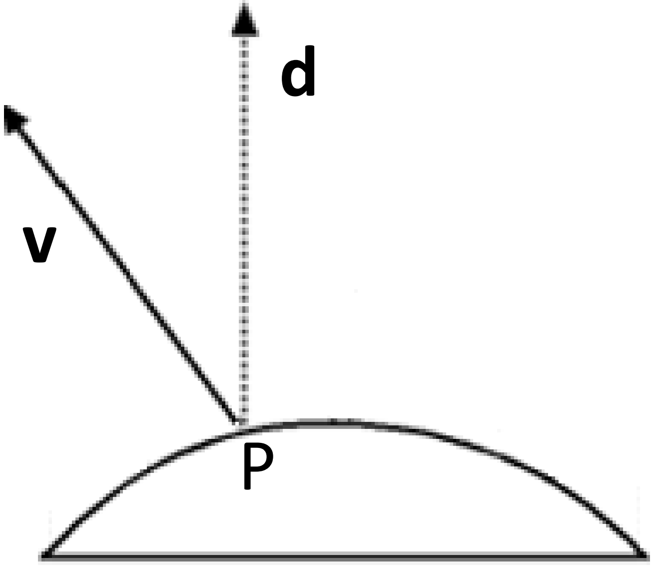


Dual-Paraboloid Shadow Mapping

Generating the Shadow Map.

- From 3D to texture coordinates:
  - we need the point P on the paraboloid that reflects a given direction **v** towards the direction **d**.

For convenience we use the inverted direction.



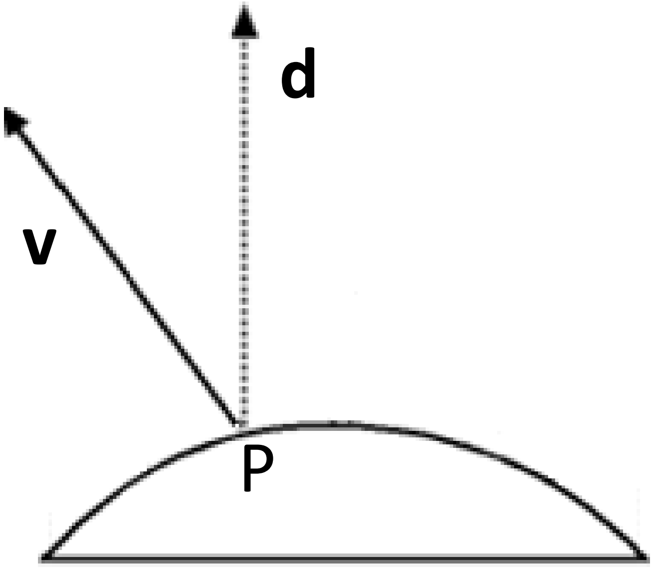
Dual-Paraboloid Shadow Mapping

Generating the Shadow Map.

- From 3D to texture coordinates:
  - we need the point P on the paraboloid that reflects a given direction **v** towards the direction **d**.

For convenience we use the inverted direction.

And transform everything to light coordinate space.



Dual-Paraboloid Shadow Mapping

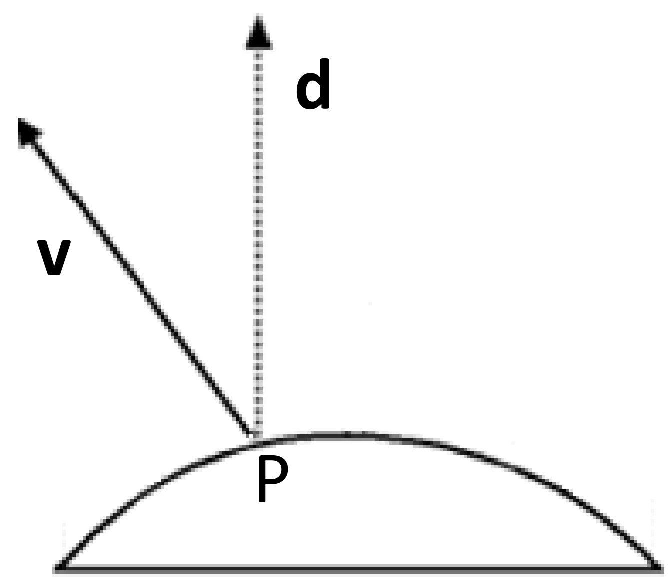
Generating the Shadow Map.

Using the formula for the paraboloid:

Normal vector at P(x, y, z): $\vec{n} = \frac{1}{z}\begin{pmatrix} x \\ y \\ 1 \end{pmatrix}$

Halfway vector at P(x, y, z):

$$\vec{h} = \vec{d_0} + \vec{v} = k \cdot \begin{pmatrix} x \\ y \\ 1 \end{pmatrix} \quad v_z \geq 0$$



Dual-Paraboloid Shadow Mapping

Generating the Shadow Map.

- Halfway vectors for two connected paraboloids

  $\mathbf{h} = \mathbf{d_0} + \mathbf{v}$ $\qquad \mathbf{v_z} \geq 0$

  $\mathbf{h} = \mathbf{d_1} + \mathbf{v}$ $\qquad \mathbf{v_z} < 0$

  where **v** is the direction from the light to the point in light coordinate space

  and

  $\mathbf{d_0} = (0, 0, 1)$

  $\mathbf{d_1} = (0, 0, -1)$

Dual-Paraboloid Shadow Mapping

Generating the Shadow Map.

- To get texture coordinates from halfway vector:
    - Divide x and y by the z-component
    - Map from [-1, 1] to [0, 1]

- Store distance [0,1] using near and far distances

Dual-Paraboloid Shadow Mapping

Shadow Test

- Do the same calculations for shadow testing
- Sample correct paraboloid texture using z comparison
- Compare point depth to stored value

What does it offer?

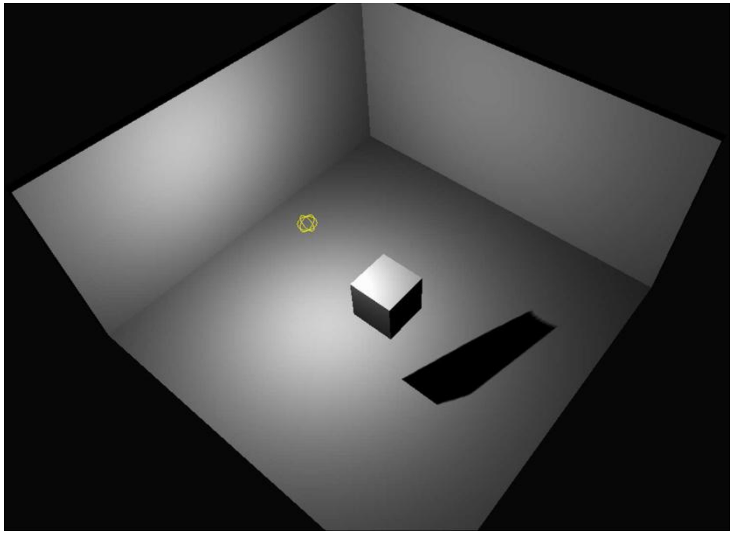
- Advantages:
  - Less artifacts due to parabolic map
  - One map covers one hemisphere
  - Easy to implement
  - Low computational cost
  - Easily combined with usual shadow mapping techniques
- Disadvantages:
  - Still reduced precision around perimeter
  - Fails for very large polygons because of rasterization

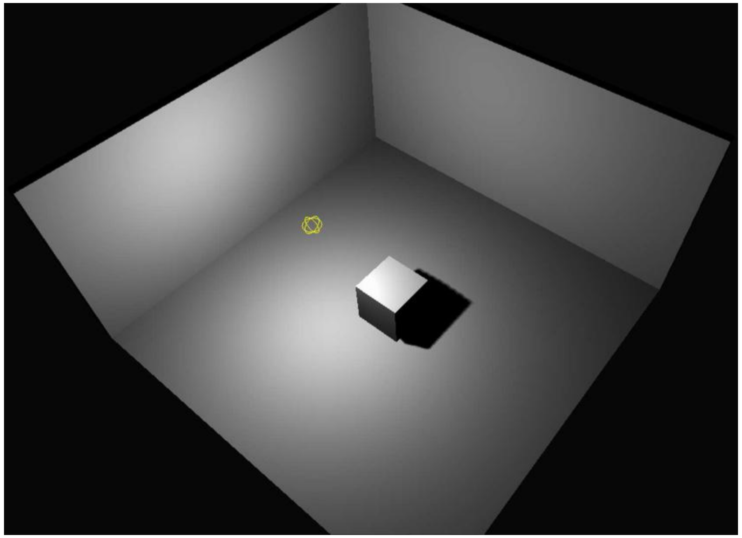
Improvements

- Further improvements have been made:
  - “Practical Implementation of Dual Paraboloid Shadow Maps” – B. Osman et al. (2006)
- Original implementation needs sufficient geometry in both shadow caster and shadow receiver
- Eliminates need for shadow receivers to be tesselated

Improvements

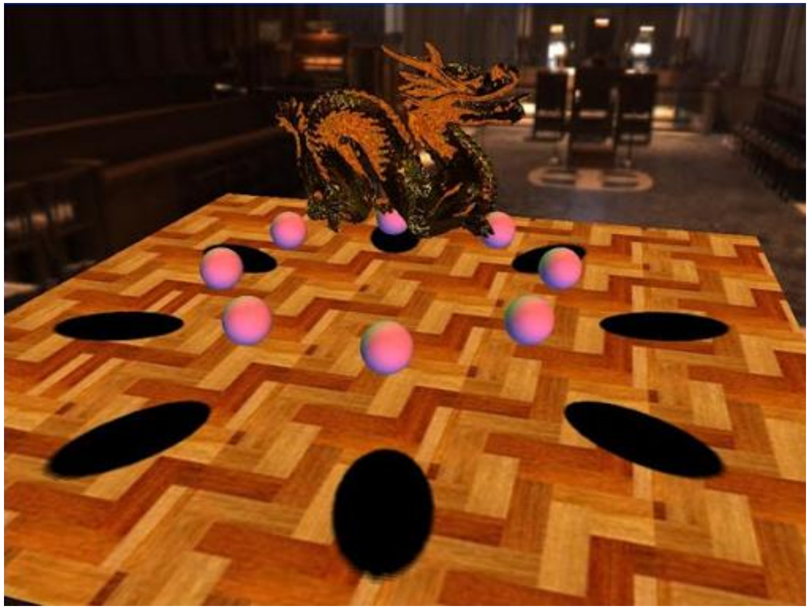
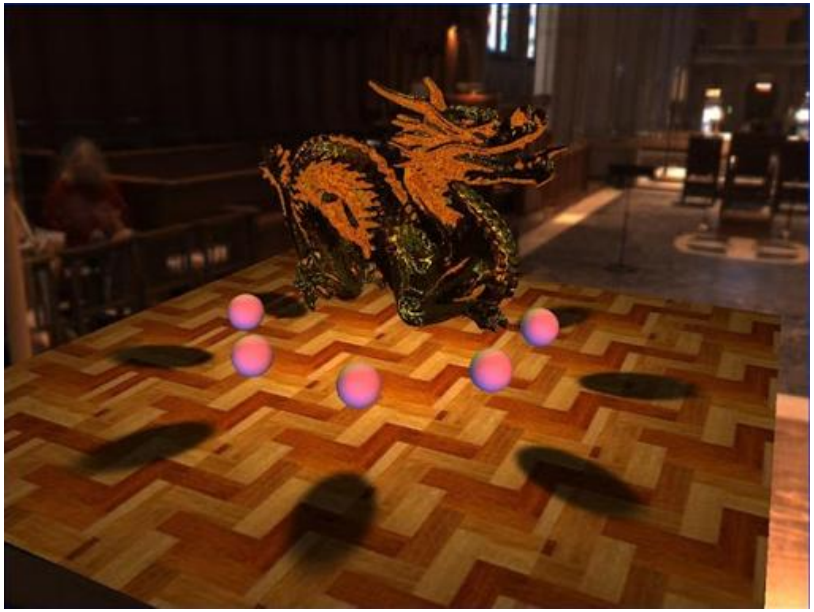
- Original DPSM needs tesselation because vertex shader performs linear interpolation
- Solution suggests sending world-coordinates
    - These interpolate correctly and can be transformed in the pixel shader afterwards





Improvements

- Variance Shadow Mapping (VSM) can be applied to DPSM to achieve soft shadows
- Regular method for VSM can be applied, no difference compared to applying VSM to SSM.

Questions