05 Detail mapping

Steve Marschner

CS5625 Spring 2016

Hierarchy of scales

macroscopic

mesoscopic

microscopic

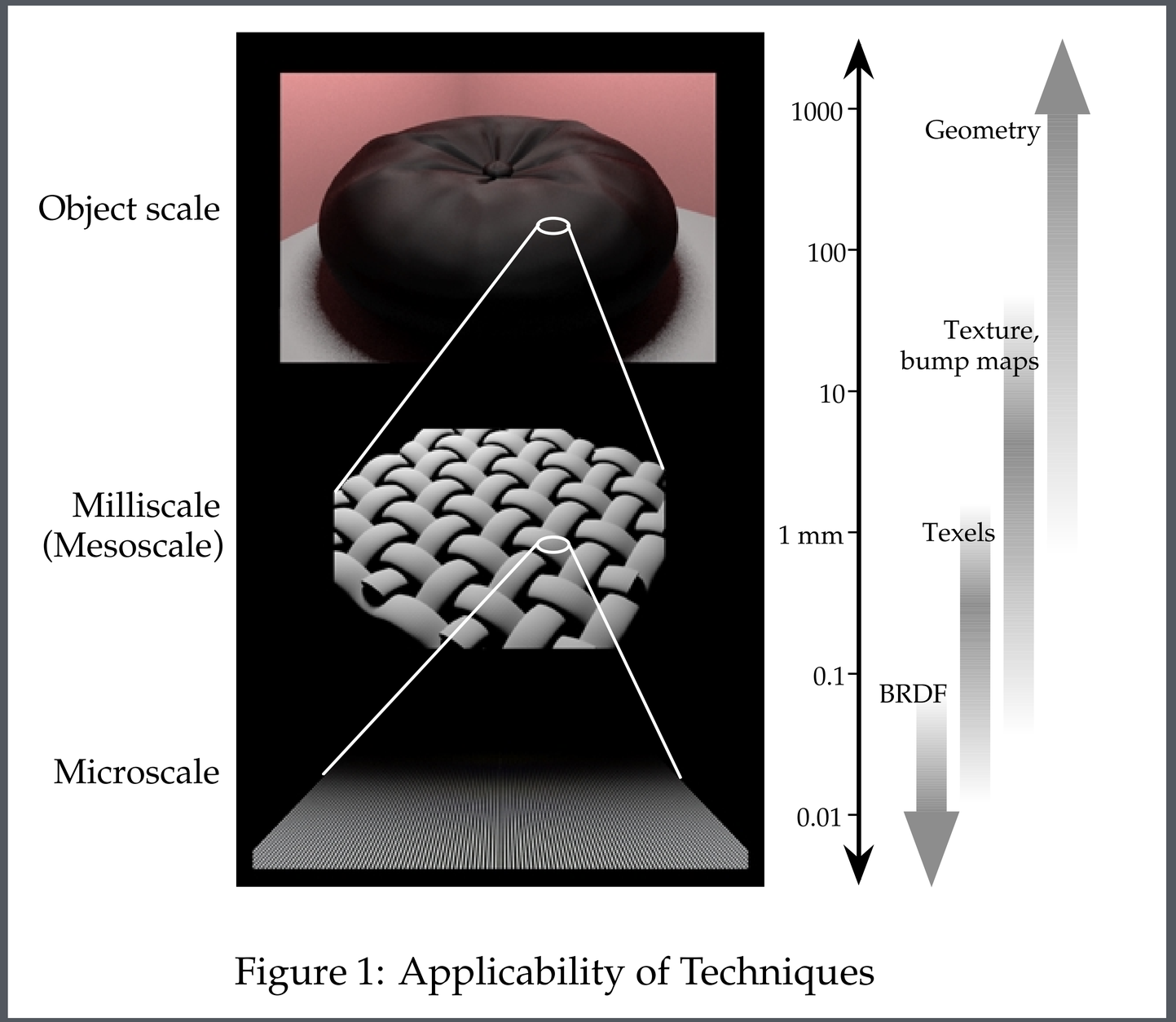


Figure 1: Applicability of Techniques

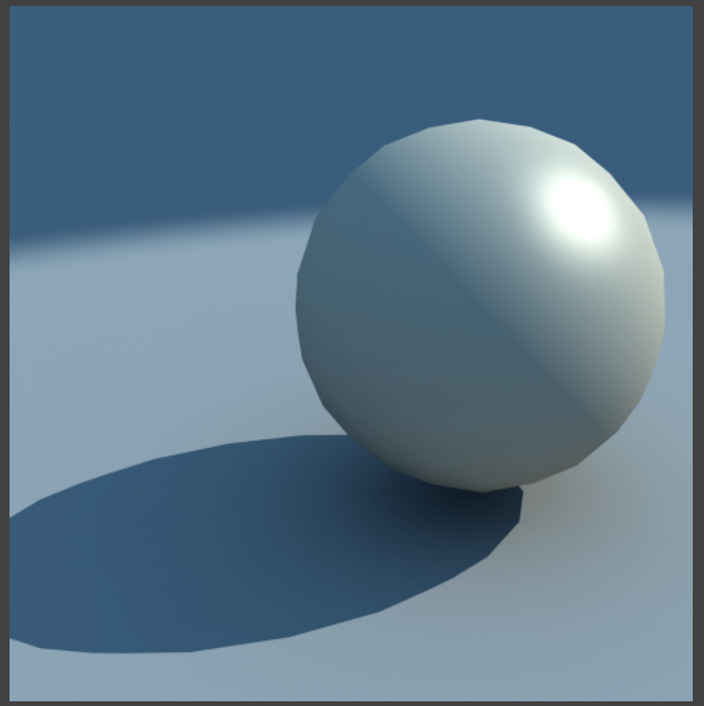
Texture Maps

- Most flexible part of graphics hardware
- Textures can modulate
  - Material
    - Diffuse, Specular/roughness (gloss maps)
  - Geometry
    - Positions
      - displacement mapping
    - Normals
      - bump mapping, normal mapping
  - Lighting
    - Environment mapping
    - Reflection mapping
    - Shadow mapping

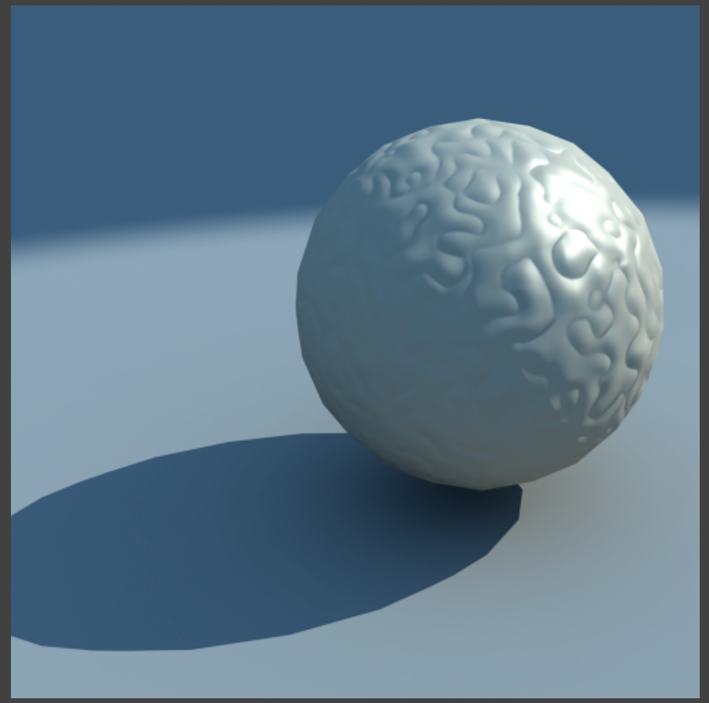
slide courtesy of Kavita Bala, Cornell University

Displacement and Bump/Normal Mapping

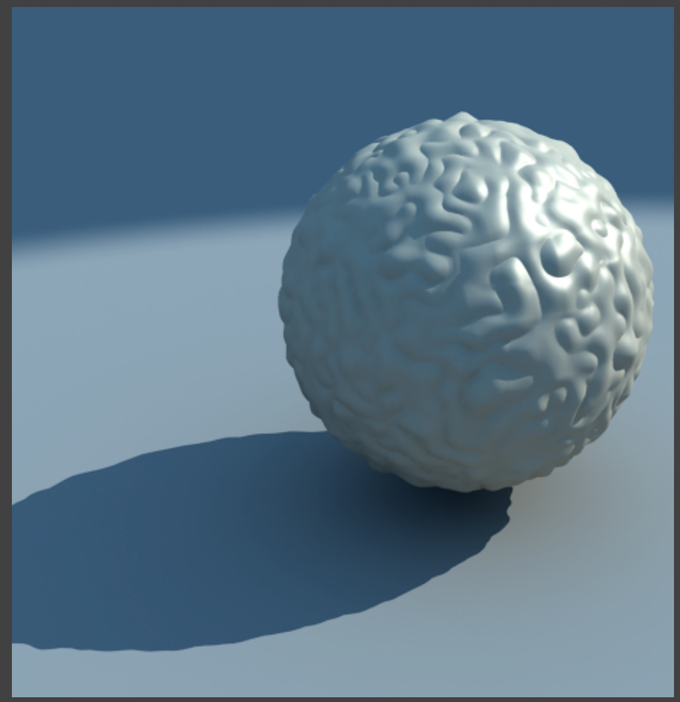
- Mimic effect of geometric detail/meso geometry
  - Also detail mapping



Geometry



Bump mapping



Displacement mapping

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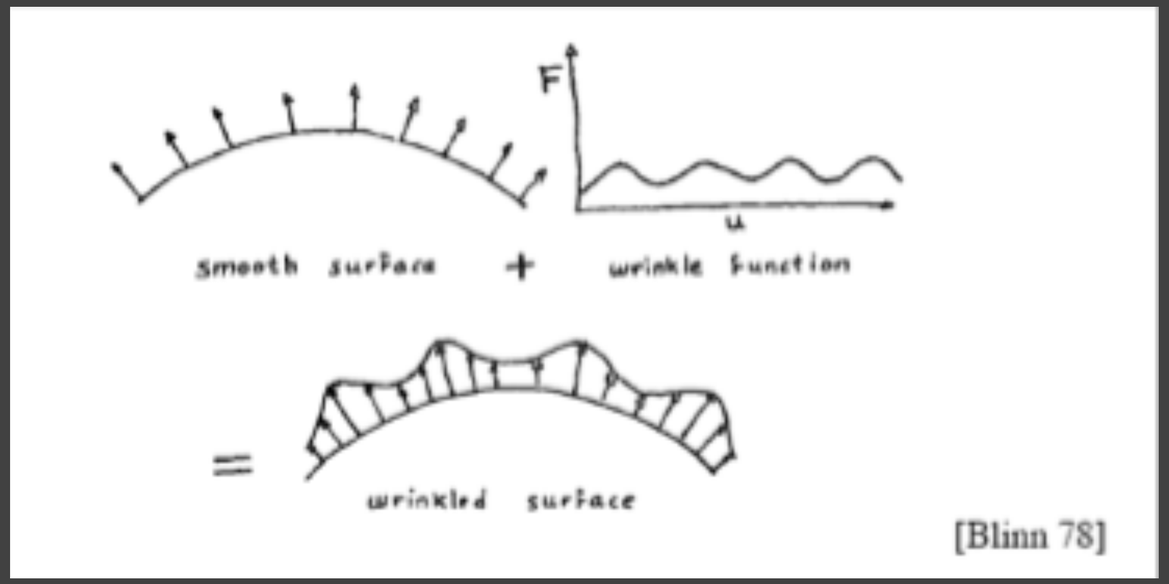
Displacement Mapping



$$\mathbf{p}'(u,v) = \mathbf{p}(u,v) + h(u,v)\mathbf{n}(u,v)$$

slide courtesy of Kavita Bala, Cornell University

Displacement Maps: where?

slide courtesy of Kavita Bala, Cornell University

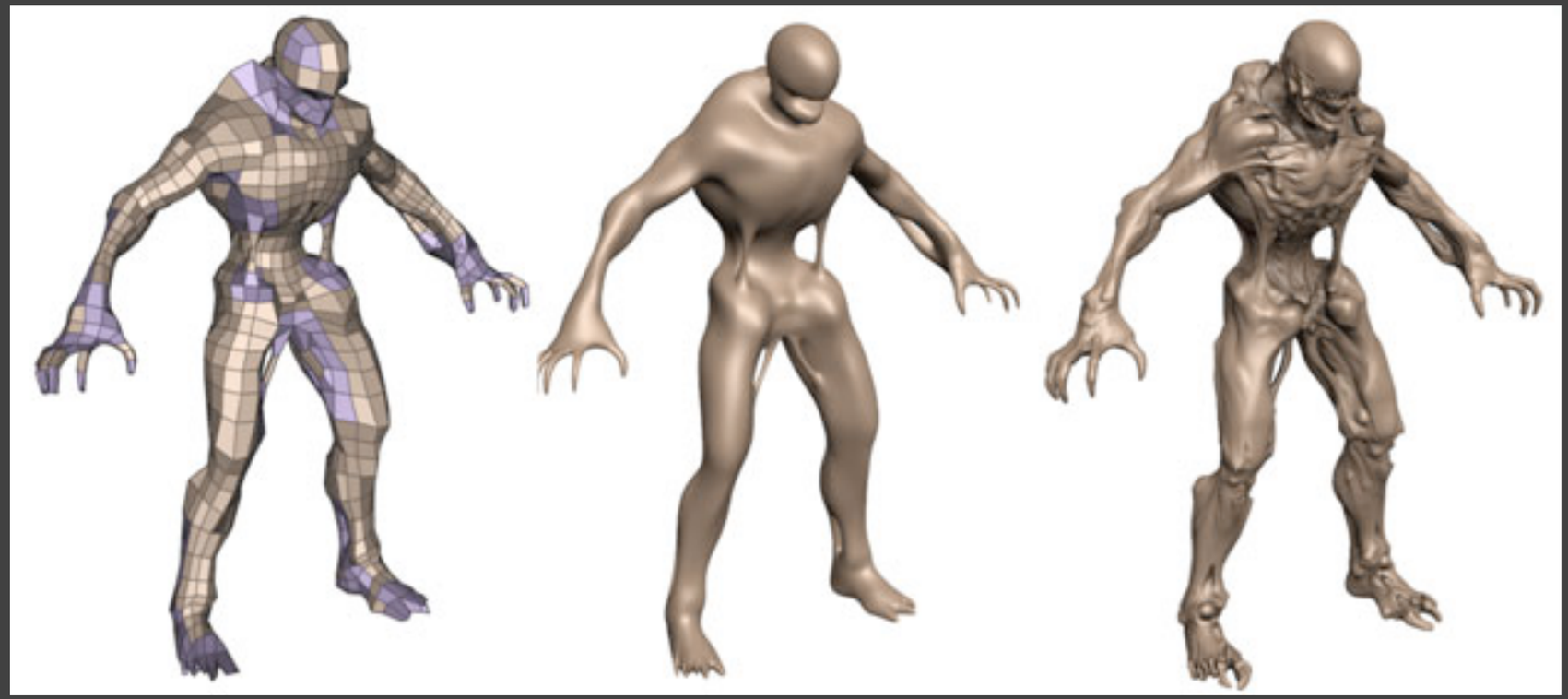
Displacement Maps: vertex map

slide courtesy of Kavita Bala, Cornell University

Displacement Maps

- Pros
  - Gives you very complex surfaces
- Cons
  - Gives you very complex surfaces
  - Or boring with small numbers of vertices
- Relationship with tesselation shaders

slide courtesy of Kavita Bala,



Original

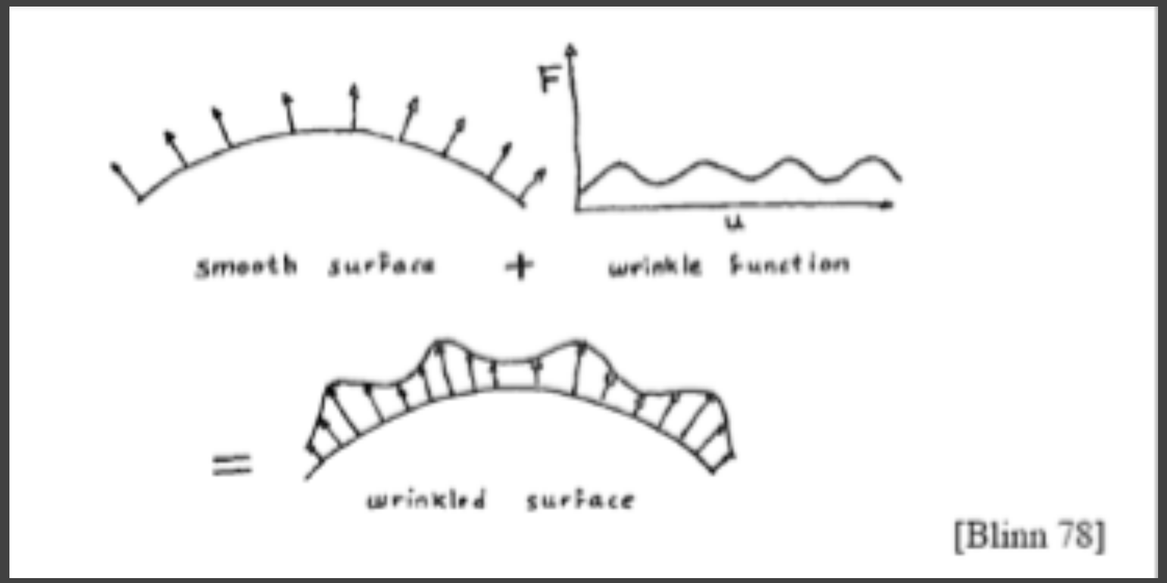
Tesselated

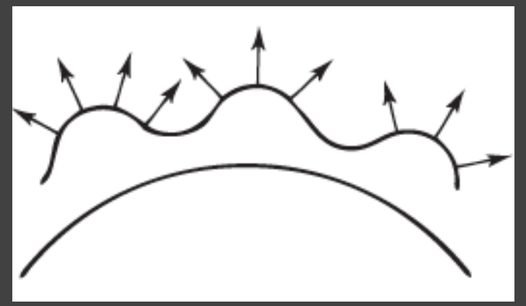
Displacement Mapped

slide courtesy of Kavita Bala, Cornell University

Bump mapping

- “Simulation of Wrinkled Surfaces” Blinn 78





- Blinn: keep surface, use new normals

slide courtesy of Kavita Bala, Cornell University

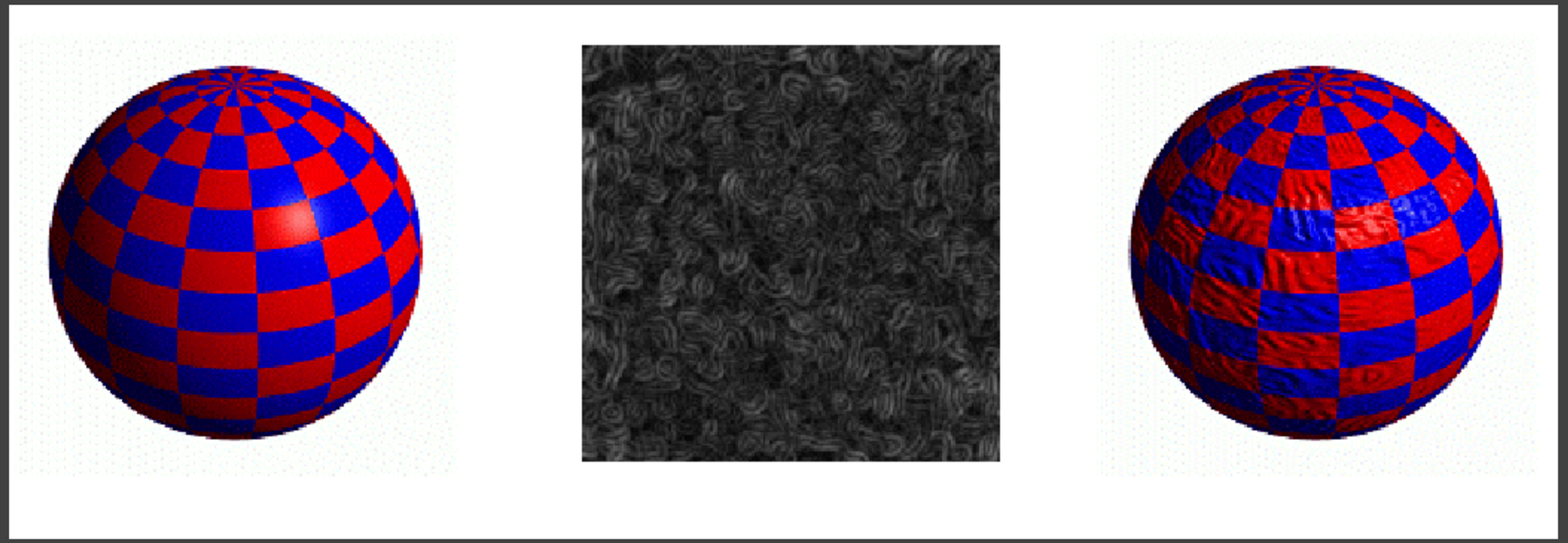
Bump Mapping

- Alter normals of surface
  - Only affects shading normals

- Also, mimics effect of small scale geometry
  - Detail map
  - Except at silhouette
  - Adds perceived bumps, wrinkles

slide courtesy of Kavita Bala, Cornell University

Bump Mapping



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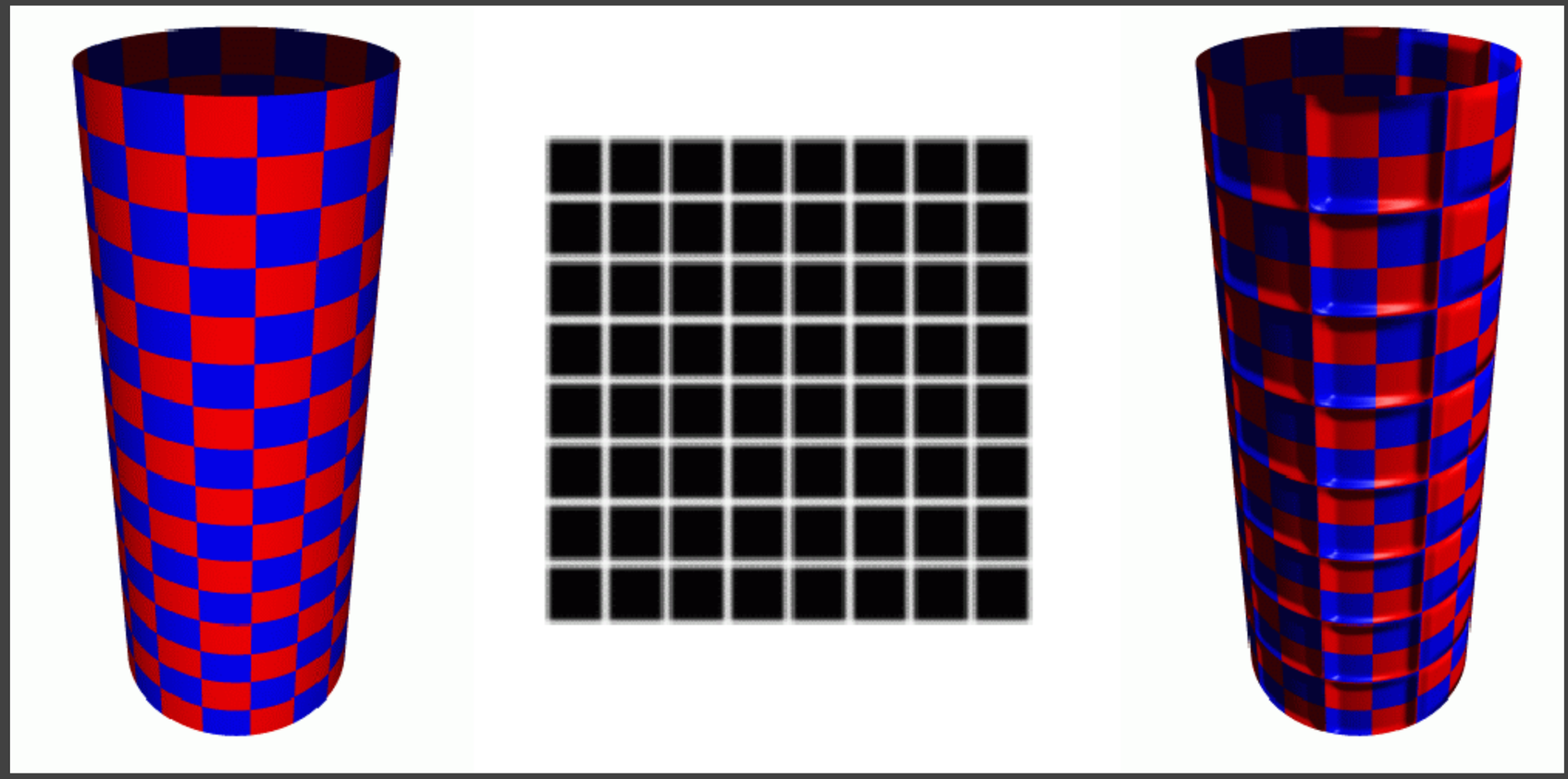
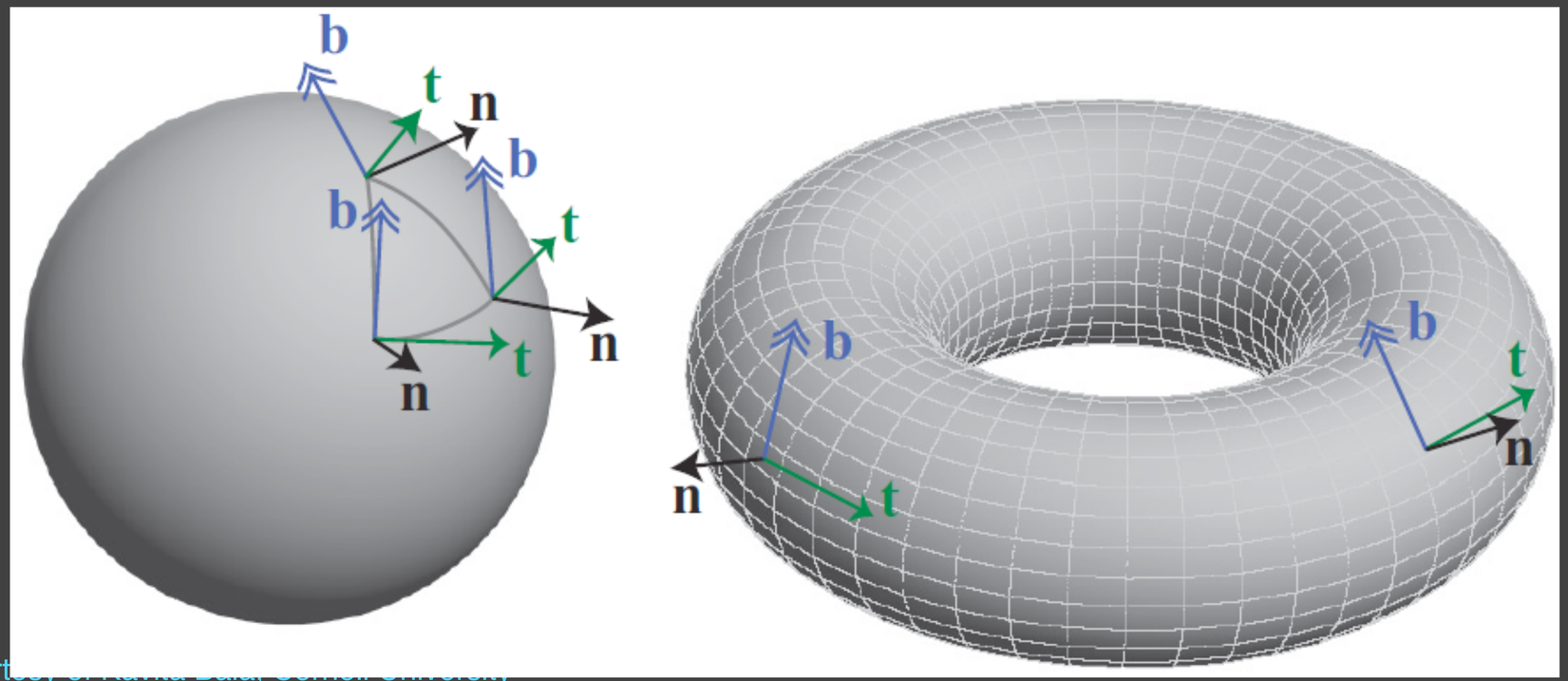
Bump Mapping



slide courtesy of Kavita Bala, Cornell University

How to change the normal?

- First, need some frame of reference
  - Normal is modified with respect to that
  - Have tangent space basis: t and b
  - Normal, tangent and bitangent vectors



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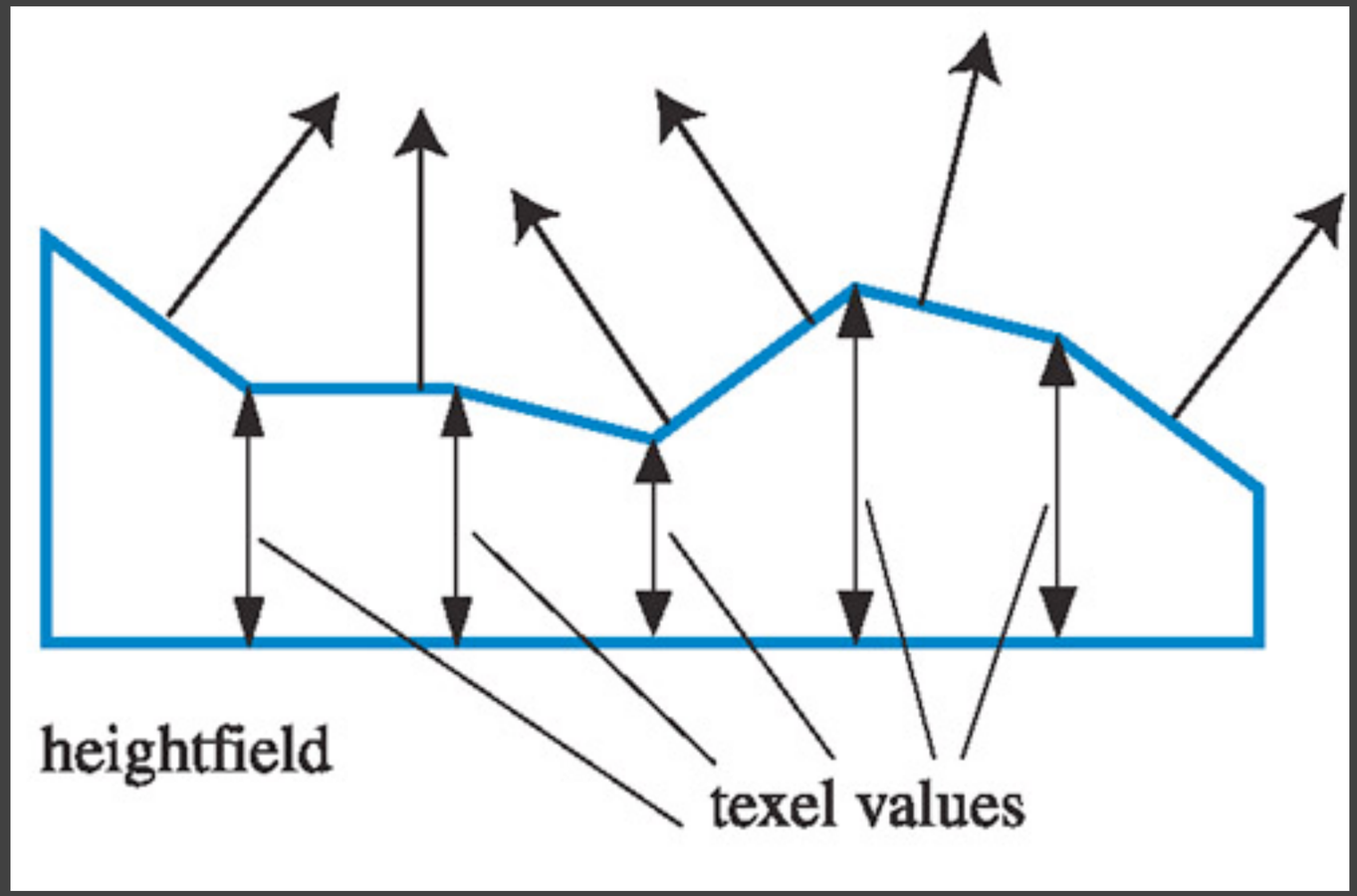
Heightfield: Blinn's original idea

- Single scalar, more computation to infer N'



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Perturbed normal given height map

Normal is determined by partial derivatives of height

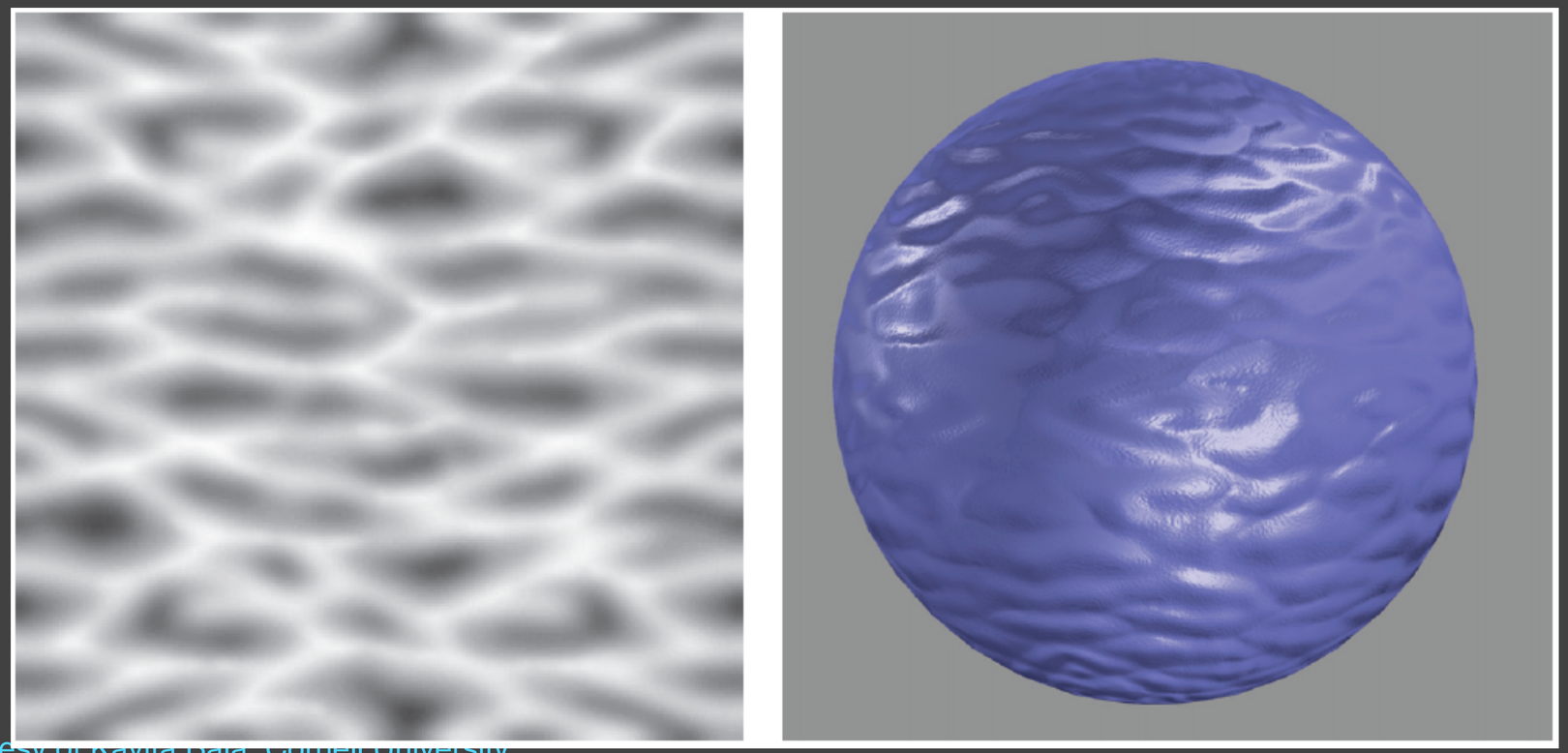
- in the local frame of the displacement map:

$$\mathbf{n}_{\text{disp}} = (h_u, h_v, 1)$$

- approx: heights are small compared to radius of curvature (constant normal)
- then the displaced surface is locally a linear transformation of the height field
- normal transforms by the adjoint matrix (as normals always to)
- perform 4 lookups to get 4 neighboring height values
- subtract to obtain finite difference derivatives

Height Field Bump Maps

- Older technique, less memory
- Texture map value is a height
- Gray scale value: light is +, dark is -



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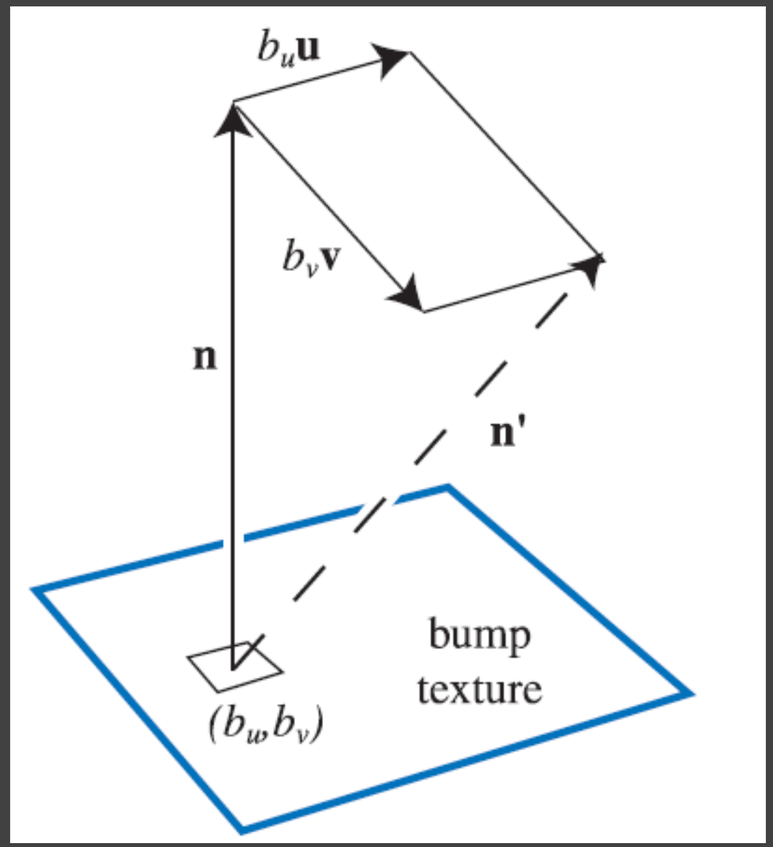
Bump Mapping

- Look up bu and bv
- N’ is not normalized

- N’ = N + bu T + bv B



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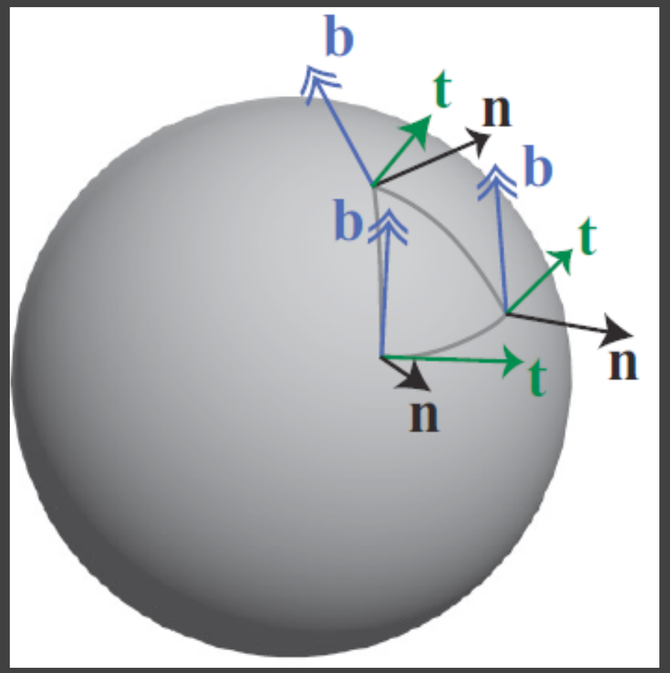
Rendering with Bump Maps

- N'.L
- Perturb N to get N' using bump map
- Transform L to tangent space of surface
  - Have N, T (tangent), bitangent B = T x N



slide courtesy of Kavita Bala, Cornell University

http://www.youtube.com/watch?v=1mdR2imNeZI

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Normal Maps

- Preferred technique for bump mapping for modern graphics cards
- Store new normals in texture map
  - Encodes (x, y, z) mapped to [-1, 1]
- More memory but lower computation

Normal Map

Height Map

slide courtesy of Kavita Bala, Cornell University

- Store

```
colorComponent = 0.5 * normalComponent + 0.5
•
```

- Use

```
normalComponent = 2* colorComponent -1
```

slide courtesy of Kavita Bala, Cornell University

Normal Map

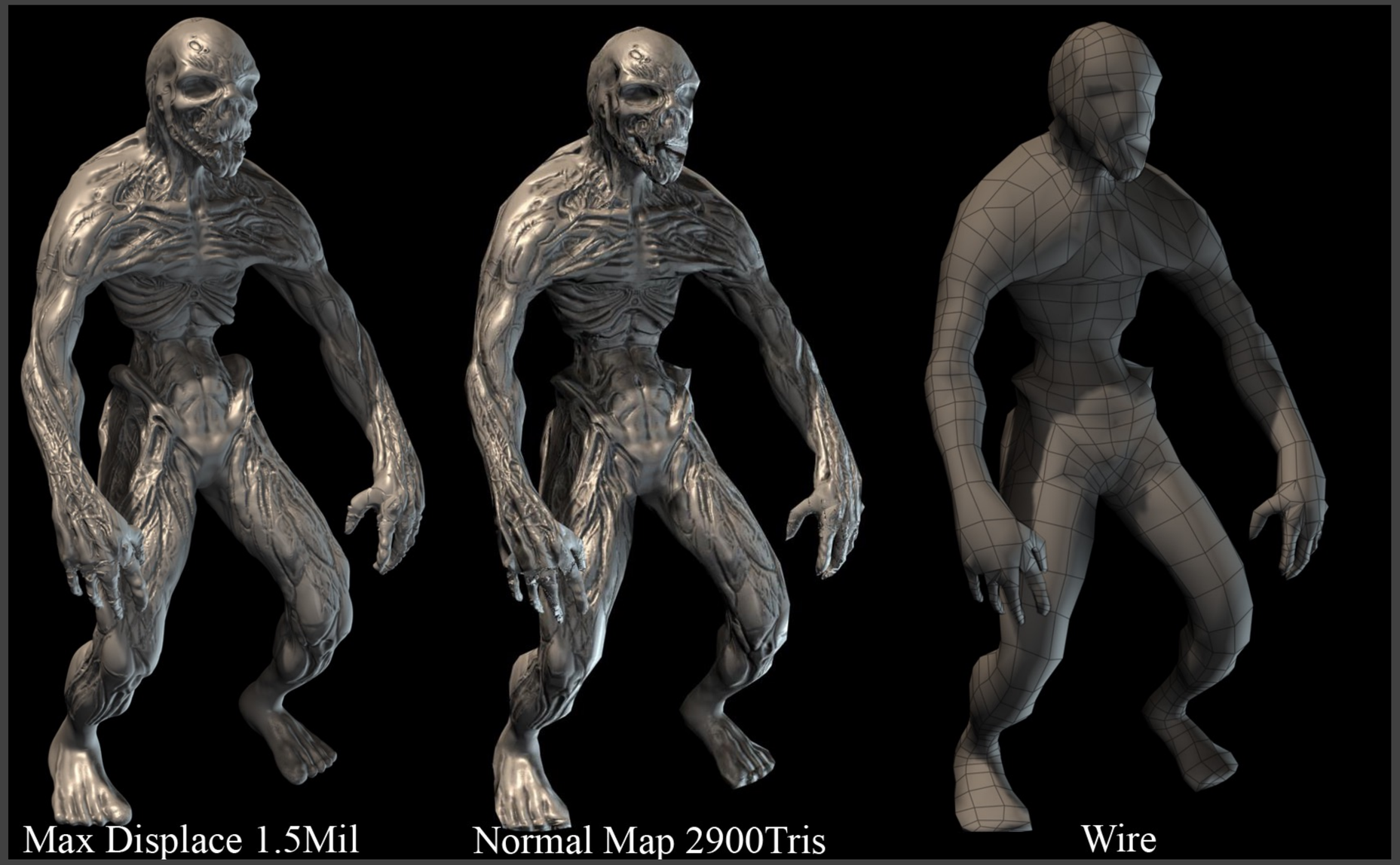
slide courtesy of Kavita Bala, Cornell University

Creating Normal Maps

- First create complex geometry
- Simplify (in modeling time) to simple mesh with normal map

slide courtesy of Kavita Bala, Cornell University

Displacement Maps vs. Normal Maps



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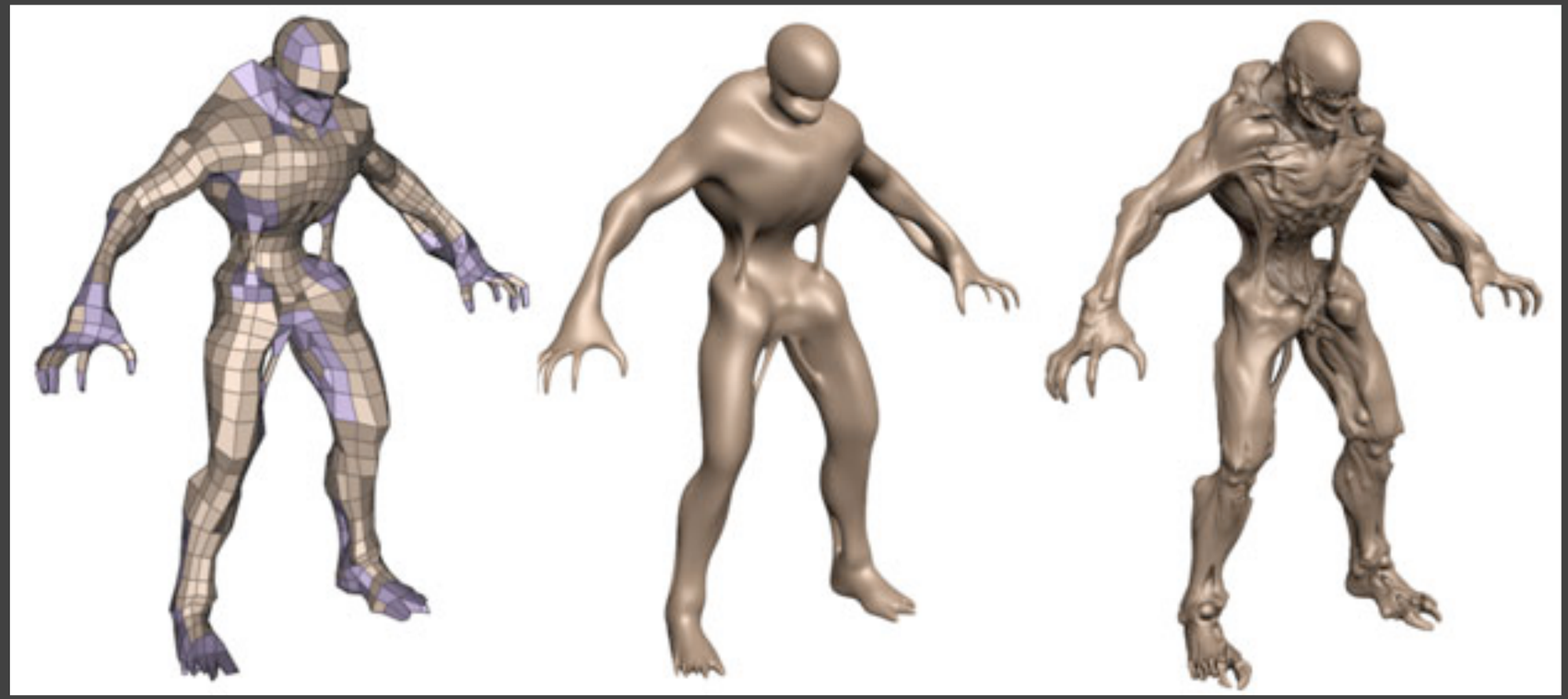
Compare with the opposite view



Original

Tesselated

Displacement Mapped

slide courtesy of Kavita Bala, Cornell University

Unreal 3

slide courtesy of Kavita Bala, Cornell University

2M polys

slide courtesy of Kavita Bala, Cornell University

5k

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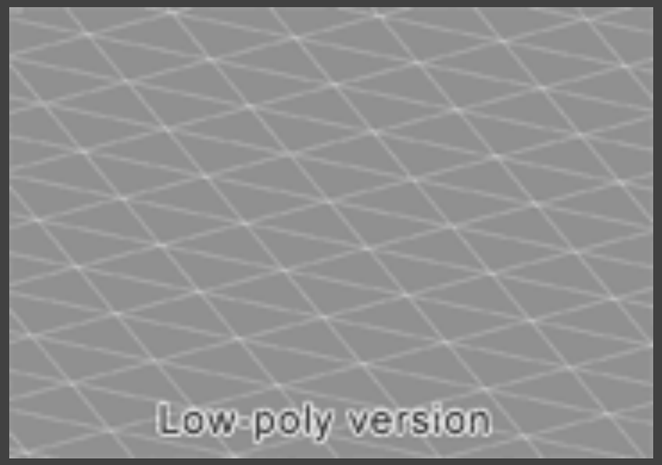
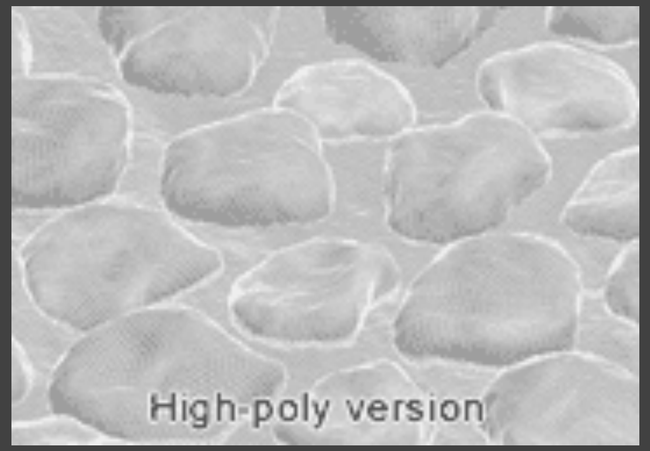
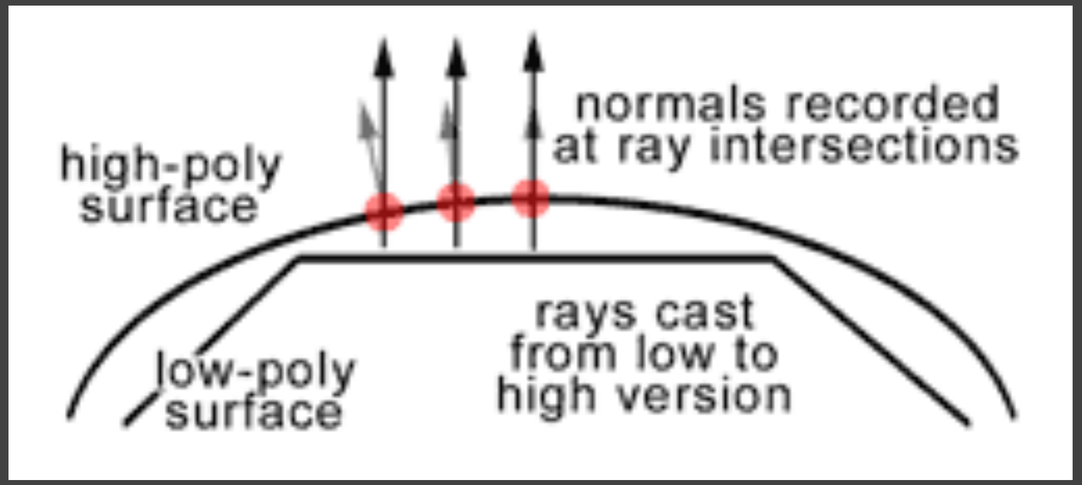
Creating Normal Maps







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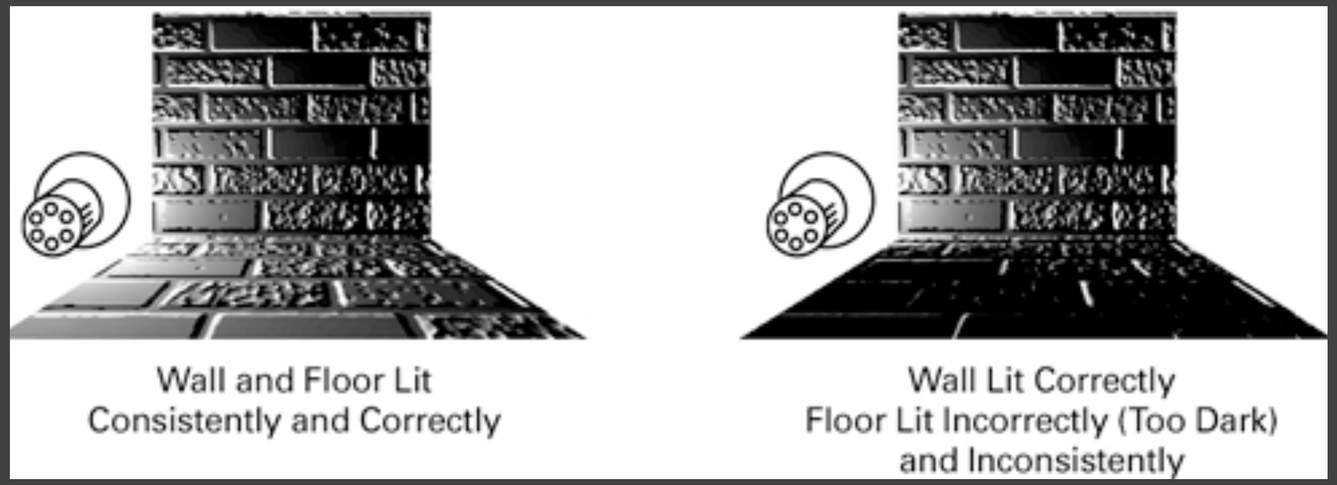
Which space is normal map in?

- World space
  - Easy computation
    - Get normal
    - Get light vector
    - Compute shading
  - Can we use the same normal map for…
    - two walls
    - A rotating object
- Object space
  - Better, but cannot be reused for symmetric parts of object

slide courtesy of Kavita Bala, Cornell University

Which space is normal in?

- Tangent space normals
  - Can reuse for deforming surfaces
  - Transform lighting to this space and shade



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Parallax Mapping

- Problem with normal mapping
  - No self-occlusion
  - Supposed to be a height field but never see this occlusion across different viewing angles

- Parallax mapping
  - Positions of objects move relative to one other as viewpoint changes

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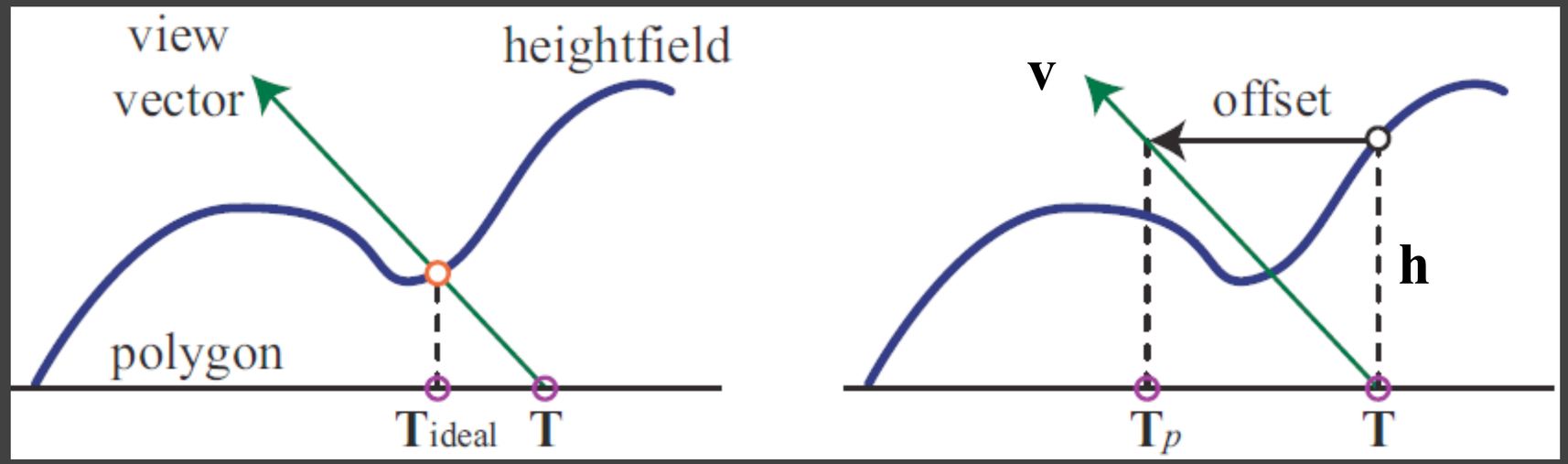
Parallax Mapping

- Want T_{ideal}
- Use T_p to approximate it

$$p_{adj} = p + h\frac{v_{xy}}{v_z}$$



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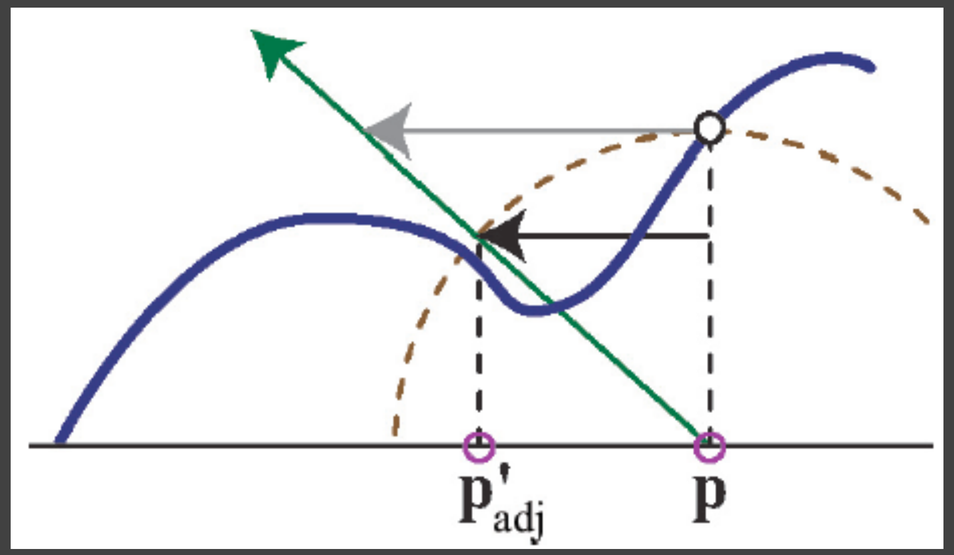
Parallax Offset Limiting

- Problem: at steep viewing, can offset too much
- Limit offset $p_{adj} = p + hv_{xy}$



slide courtesy of Kavita Bala, Cornell University

Parallax Offset Limiting

- Widely used in games
  - the standard in bump mapping

Normal Mapping

Parallax Mapping Offset Limiting

slide courtesy of K[illegible]

1,100 polygon object w/ parallax occlusion mapping

1.5 million polygon

slide courtesy of Kavita Bala, Cornell University

http://www.youtube.com/watch?v=nZPsQtlHthQ

slide courtesy of Kavita Bala, Cornell University

Relief Mapping

- Aka Parallax occlusion mapping, relief mapping, steep parallax mapping

- Tries to find where the view ray intersects the height field
  - Kinda

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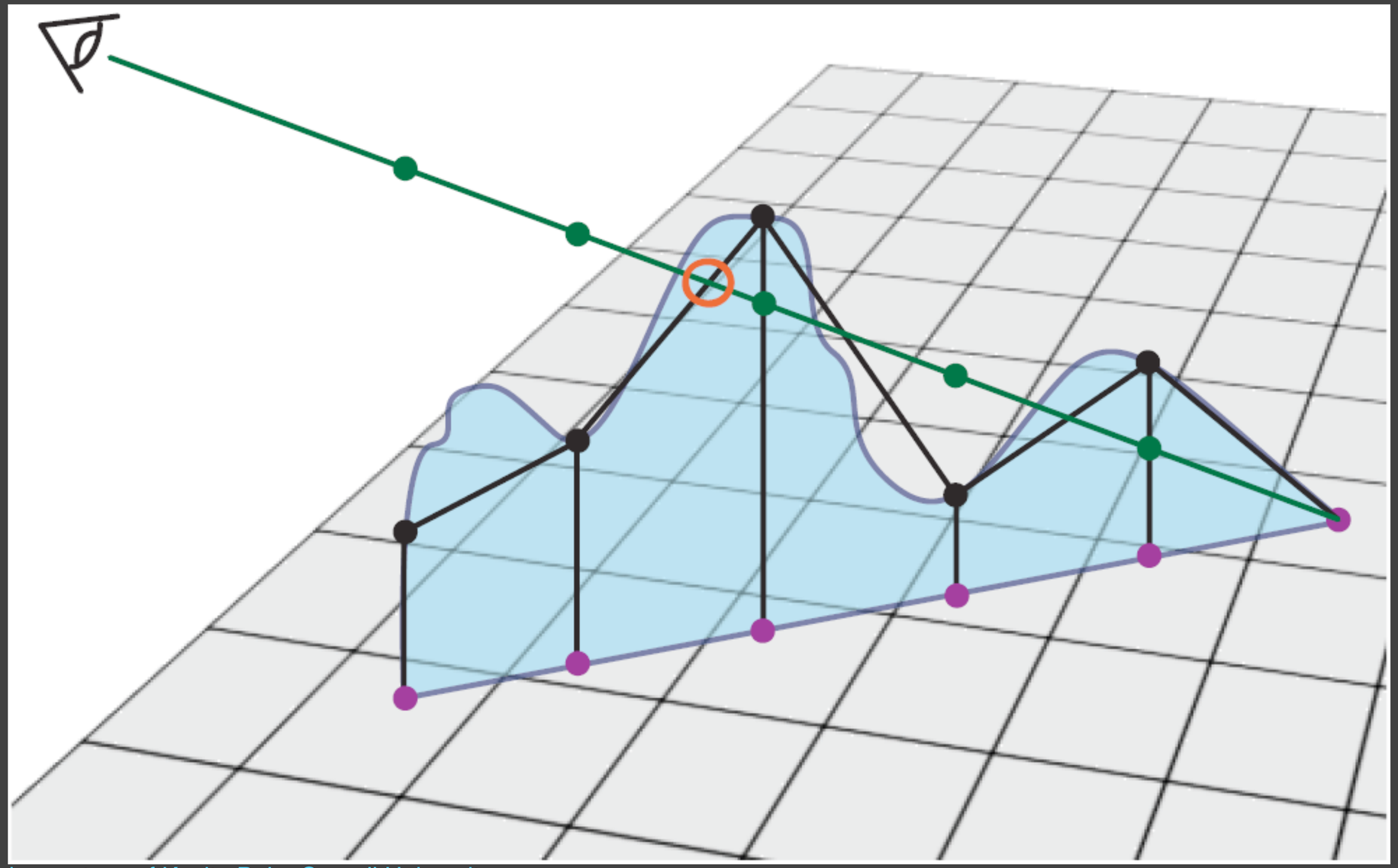
Relief Mapping



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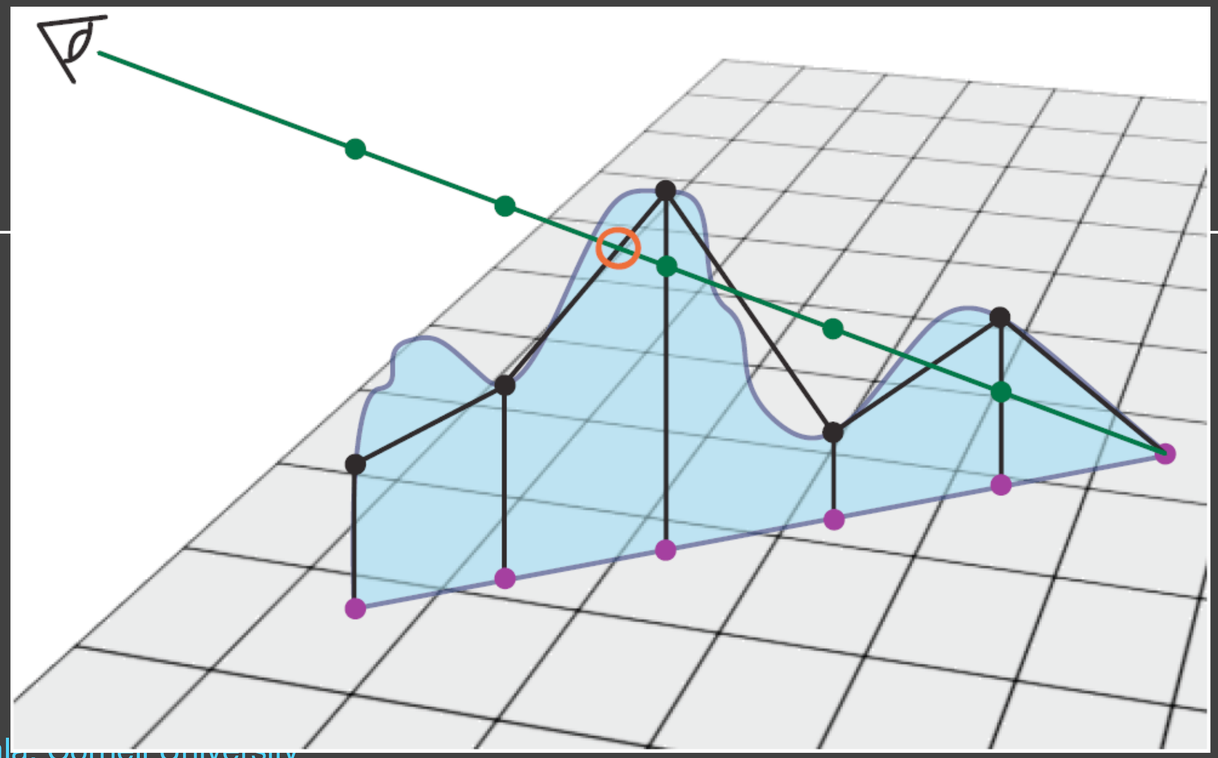
```
Sample along ray (green points)
Lookup violet points (texture values)
   /* Inferthe black line shape */
Compare green points with black points
Find intersect between two conditions
   prev: green above black
   next: green below black
```



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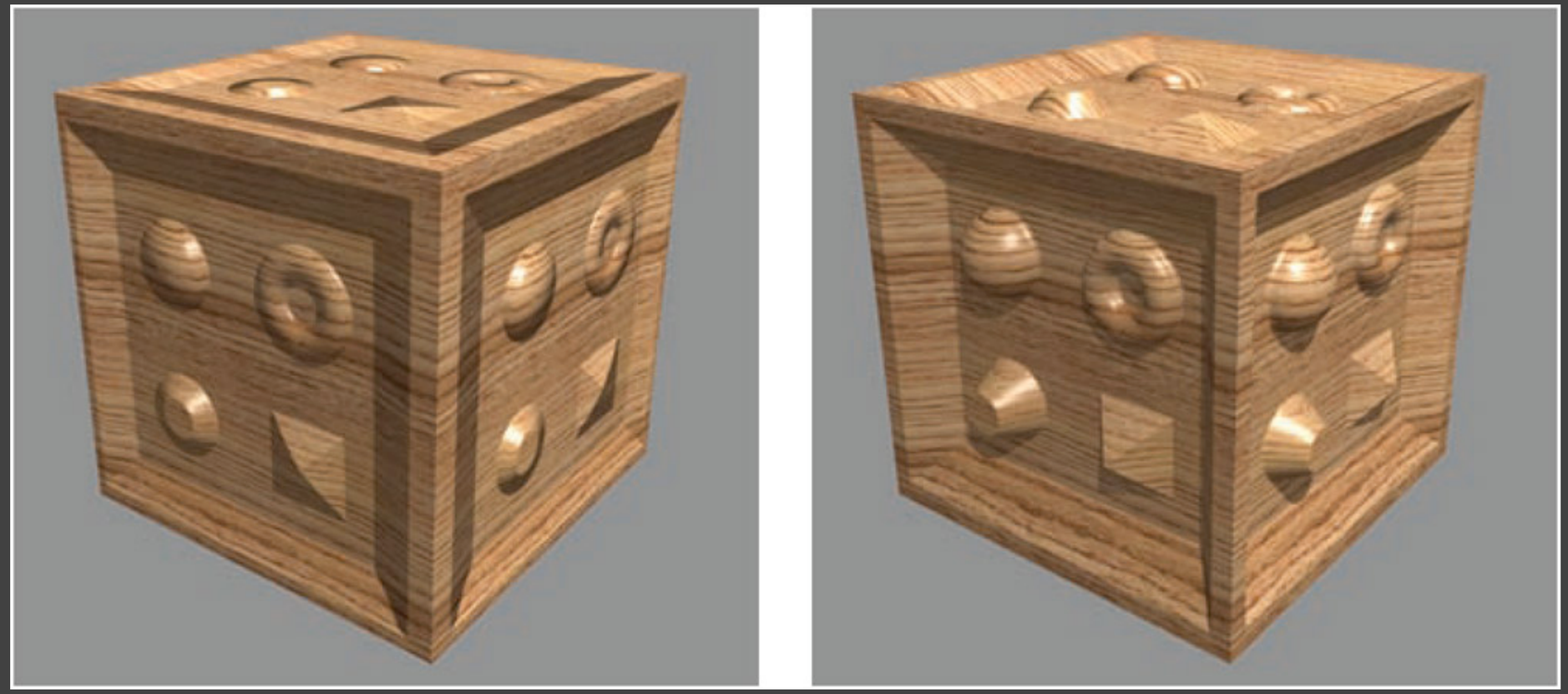

Parallax Mapping

Relief Mapping

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http://www.youtube.com/watch?v=_erYebogWUw

http://www.youtube.com/watch?v=5gorm90TXJM

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Crysis, Crytek

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