Computer Graphics (CS 543)
Lecture 10: Bump Mapping, Parallax, Relief, Alpha, Specular Mapping

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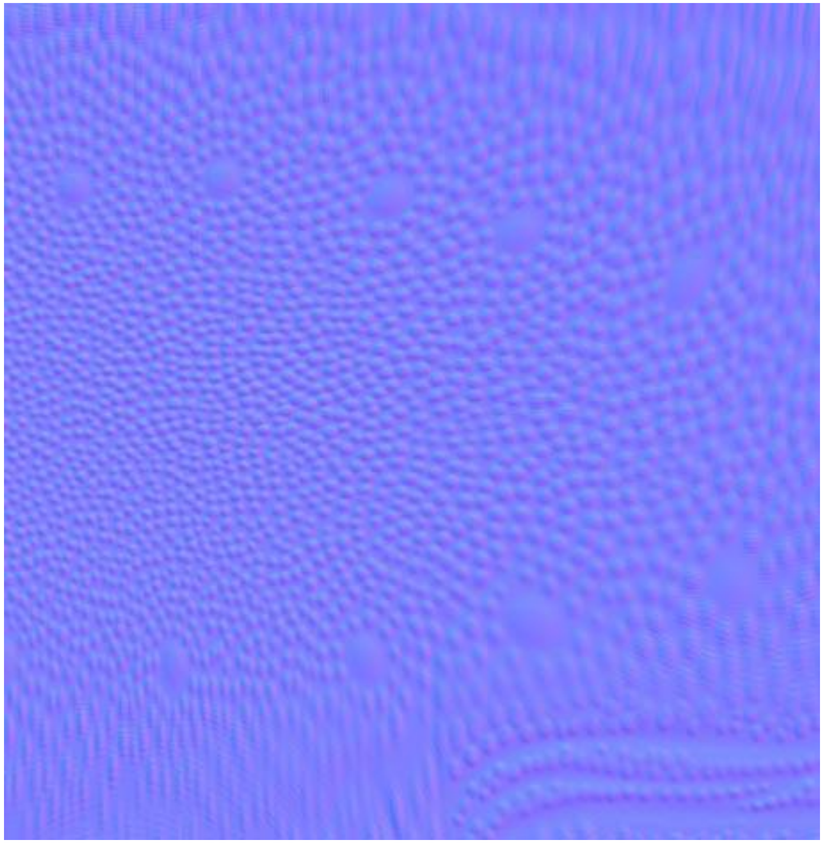
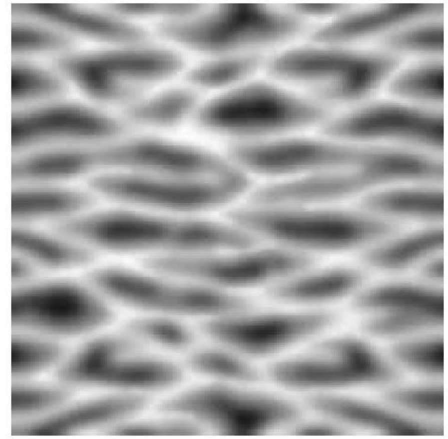
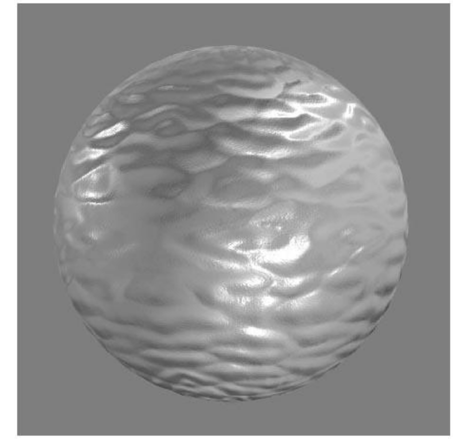
Bump Mapping

Bump mapping: examples

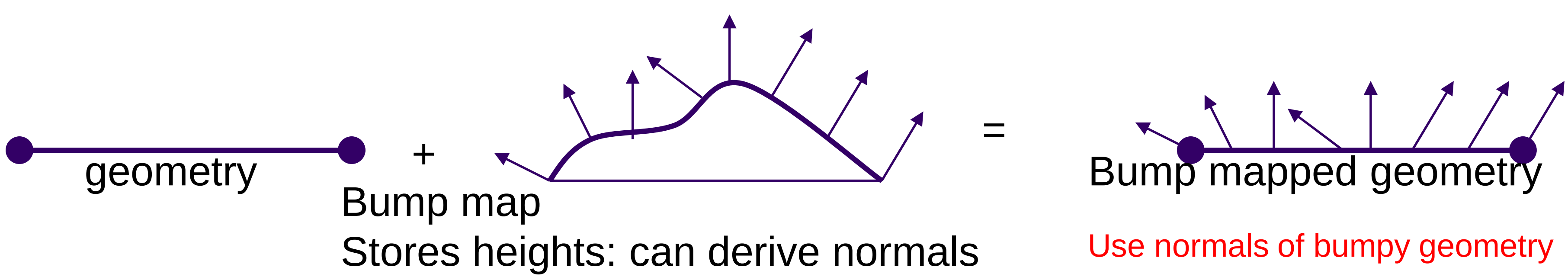


Bump mapping





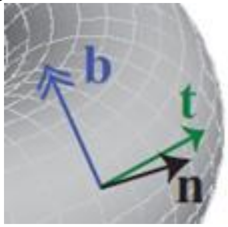
- by Blinn in 1978
- Inexpensive way of simulating wrinkles and bumps on geometry
  - Too expensive to model these geometrically
- Instead let a texture modify the normal at each pixel, and then use this normal to compute lighting

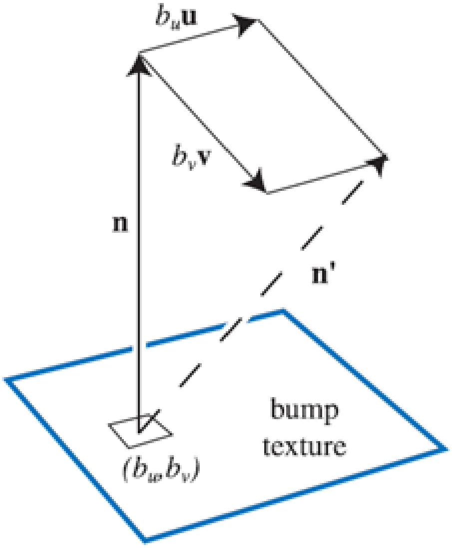


Bump mapping: Blinn's method

- **Idea:** Distort the surface normal at point to be rendered
- **Option a:** Modify normal **n** along u, v axes to give **n'**
  - In texture map, store how much to perturb **n** ($\mathbf{b_u}$ and $\mathbf{b_v}$)
- Using bumpmap
  - Look up $\mathbf{b_u}$ and $\mathbf{b_v}$
  - $\mathbf{n'} = \mathbf{n} + \mathbf{b_u T} + \mathbf{b_v B}$

  (T and B are tangent and bi-tangent vectors)

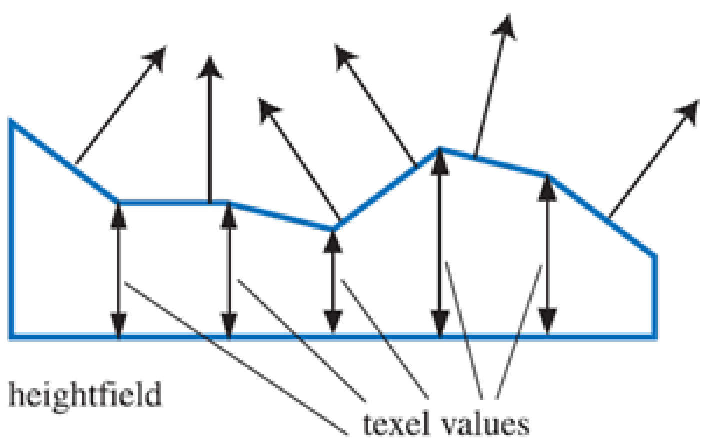




  - **Note:** N' is not normalized
- Bump map code similar to normal map code.
- Just compute, use **n'** instead of **n**

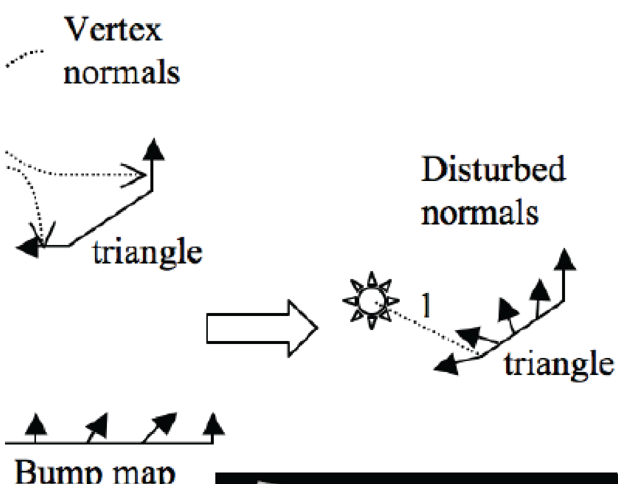
Bump mapping: Blinn’s method

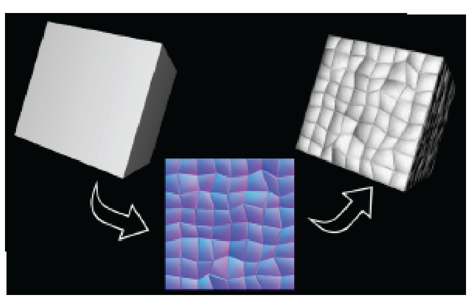
- **Option b:** Store values of u, v as a heightfield
  - Slope of consecutive columns determines how much changes **n** along u
  - Slope of consecutive rows determines how much changes **n** along v
- **Option c (Angel textbook):** Encode using differential equations



Bump Mapping Vs Normal Mapping

- **Bump mapping**
- (Normals $\mathbf{n}=(n_x, n_y, n_z)$ stored as *local distortion of face orientation*. Same bump map can be tiled/repeated and reused for many faces)





- **Normal mapping**
- Coordinates of normal (relative to tangent space) are encoded in color channels
- Normals stored combines face orientation + plus distortion.

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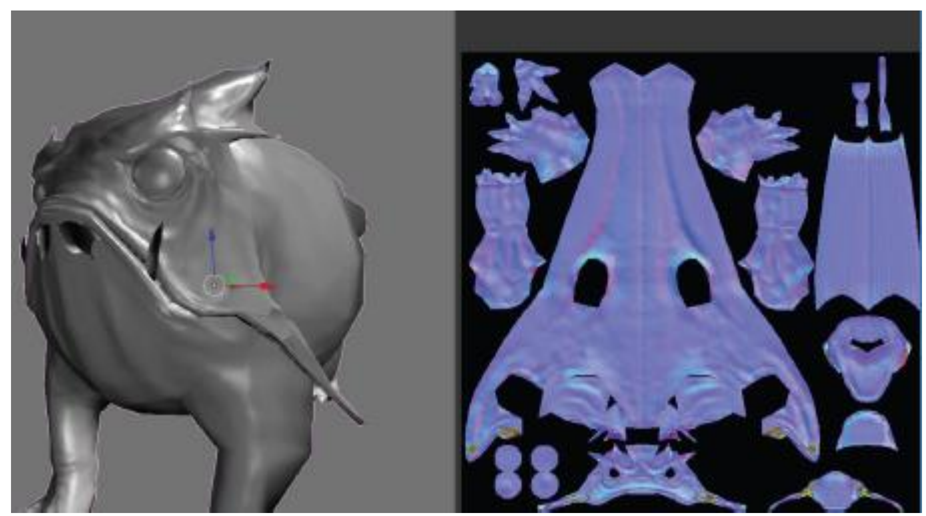
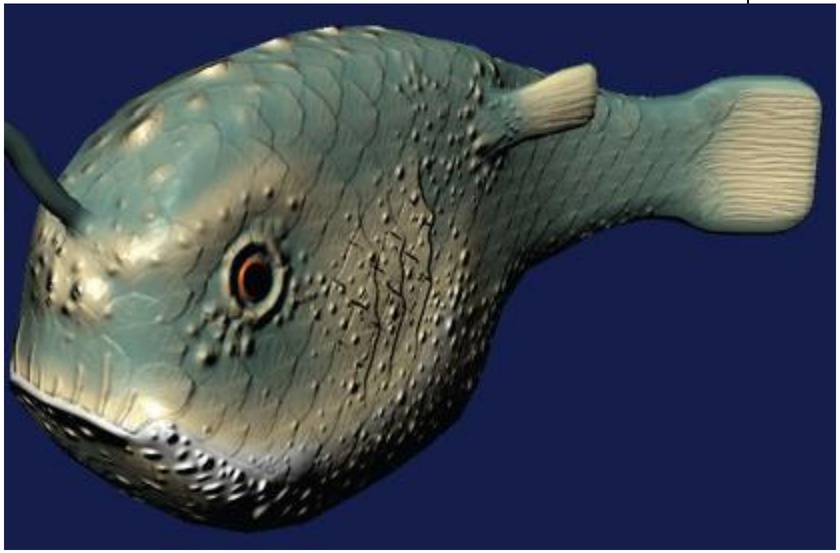
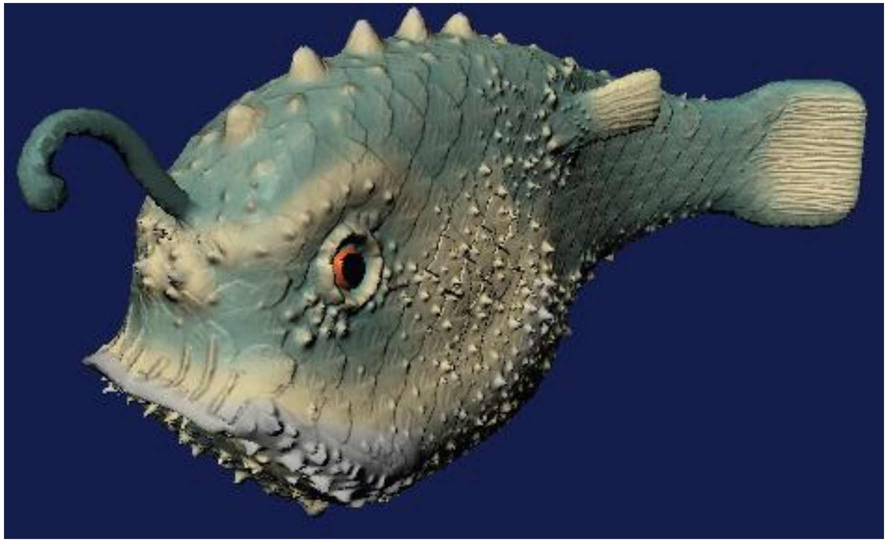


Displacement Mapping

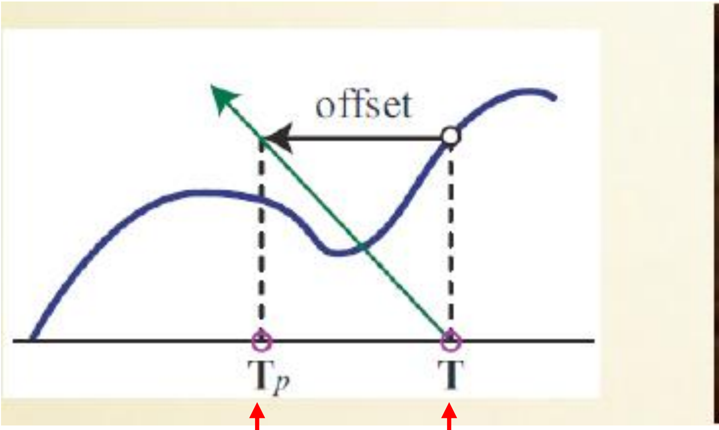
- Uses a map to displace the surface at each position
- Offsets the position per pixel or per vertex
  - Offsetting per vertex is easy in vertex shader
  - Offsetting per pixel is architecturally hard





Parallax Mapping

- Bump and normal maps increase surface detail, but do not simulate:
  - Parallax effects: Slanting of texture with view angle
  - Blockage of one part of surface by another part
- Parallax mapping
  - simulates parallax effects
  - Looks up a texture location offset depending on view angle
  - Different texture returned after offset

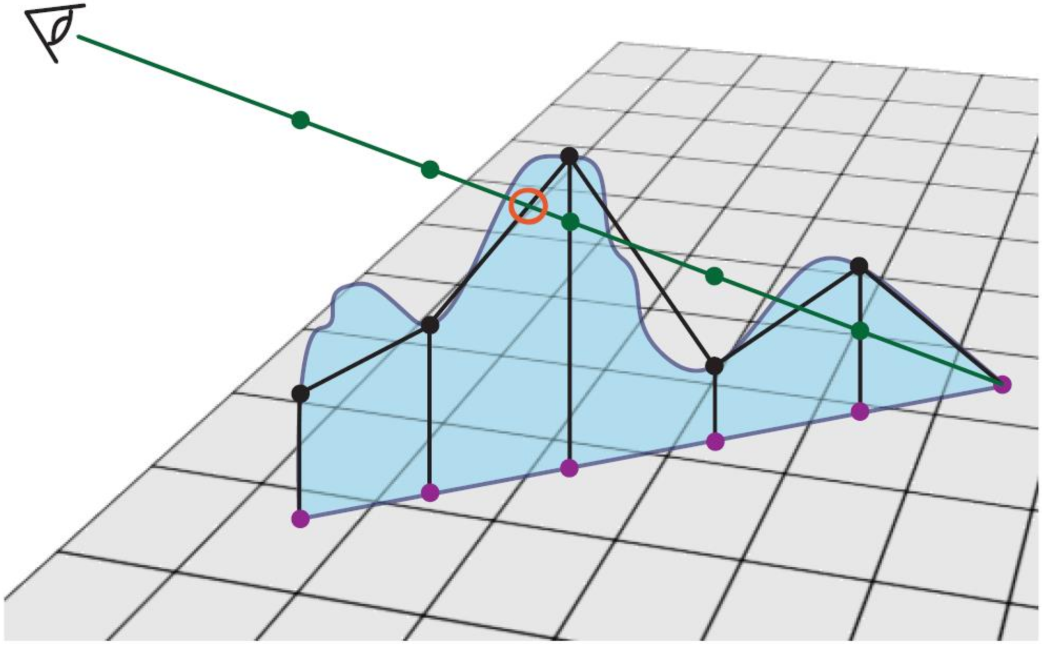


Parallax map
Looks up here

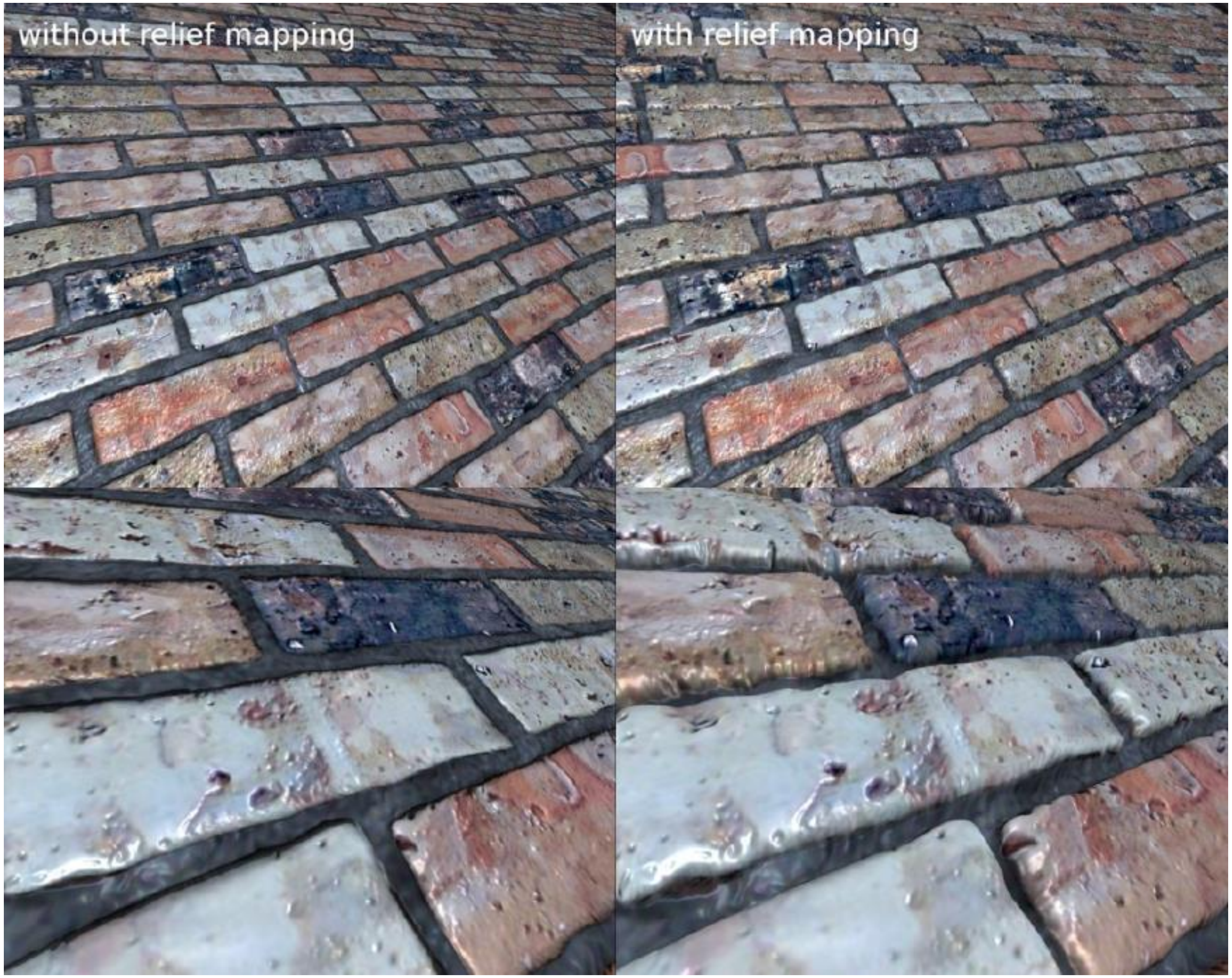
Normal map
Looks up here

Relief (or Parallax Occlusion) Mapping

- Parallax mapping approximates parallax
- Sometimes doesn't work well for occlusion effects
- Implement a heightfield raytracer in a shader, detect blockage
- Pretty expensive, but looks amazing



Relief Mapping Example

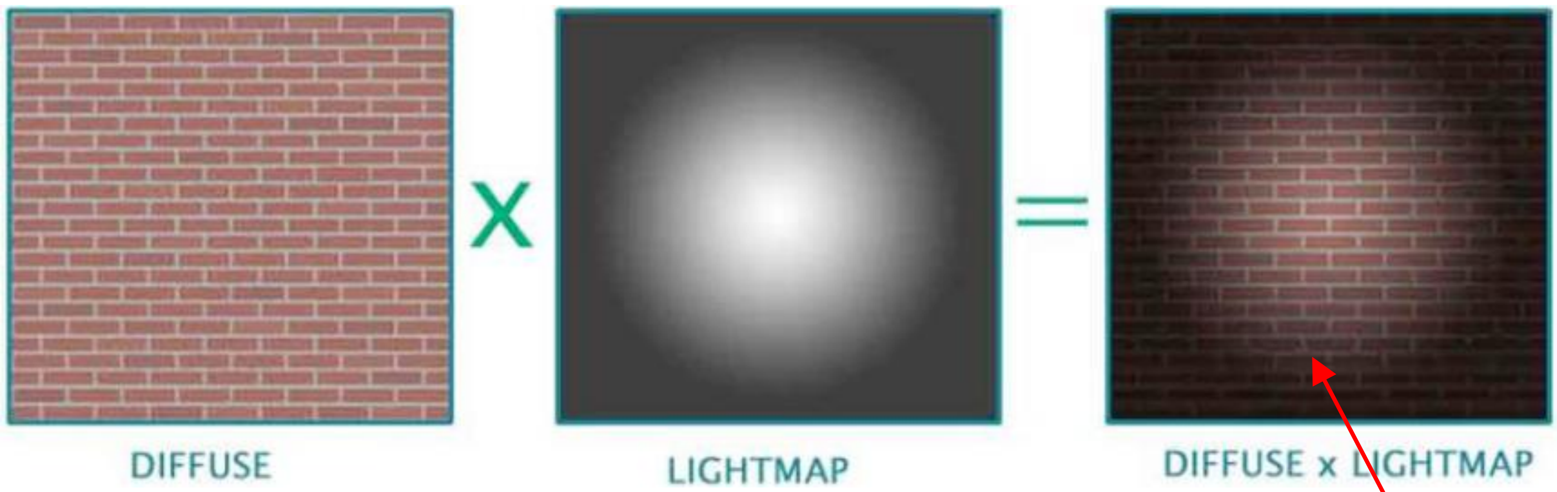


Cool YouTube Video: https://youtu.be/EkLKhsRzE-g

Light Mapping

Light Maps

- Good shadows are complicated and expensive
- If light and object positions do not change, shadows do not change
- Can “bake” the shadows into a texture map as a preprocess step
- During lighting, lightmap values are multiplied into resulting pixel



Apply this in fragment shader

Specular Mapping

- Store specular in a map
- Use greyscale texture to store specular component

Alpha Mapping

- RGBA: A or alpha is how transparent material is
  - 0 transparent, 1 opaque
- Represent the alpha channel with a texture
- Can give complex outlines, used for plants

RGB

Alpha

Render Bush on 1 polygon

Render Bush on polygon rotated 90 degrees

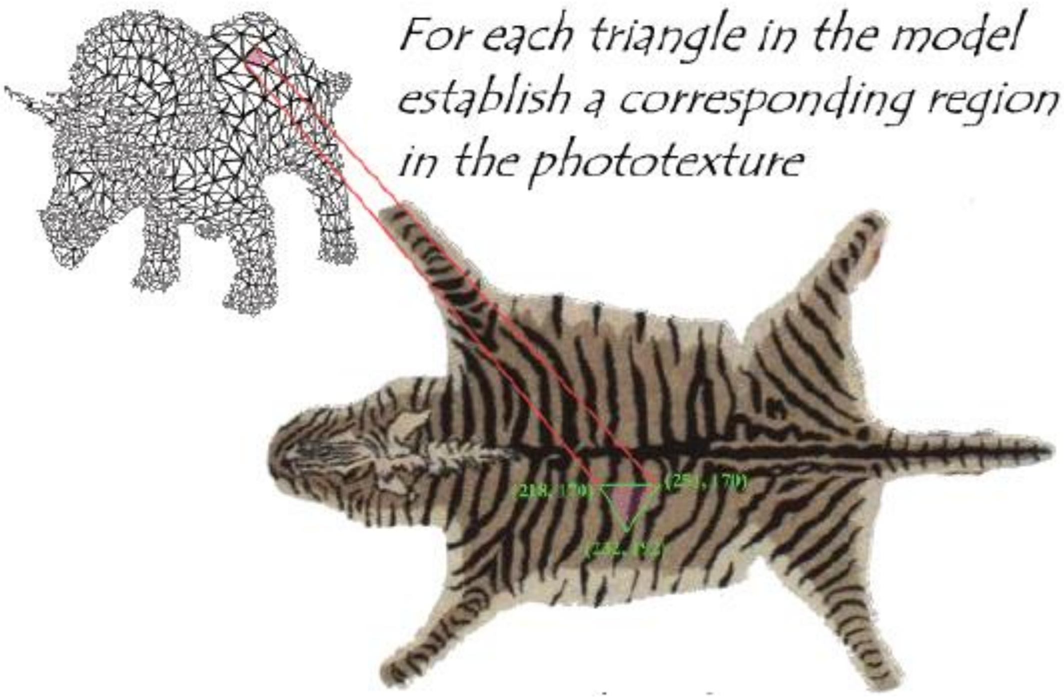
Alpha Mapping

- Rotation trick works at eye level (left image)
- Breaks down from above (right image)

Mesh Parametrization

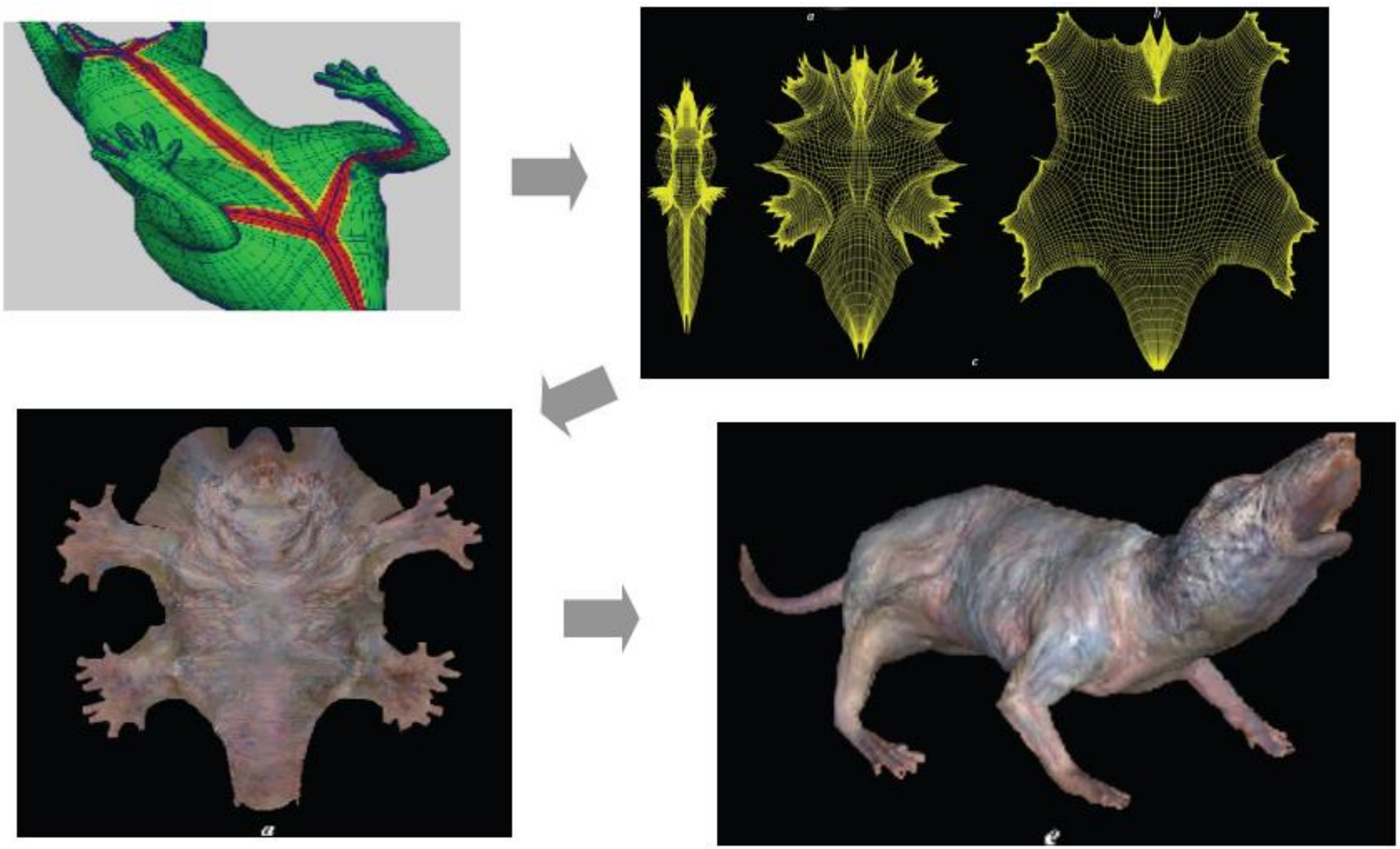
Mesh Parametrization

- The concept is very simple: define a mapping from the surface to the plane



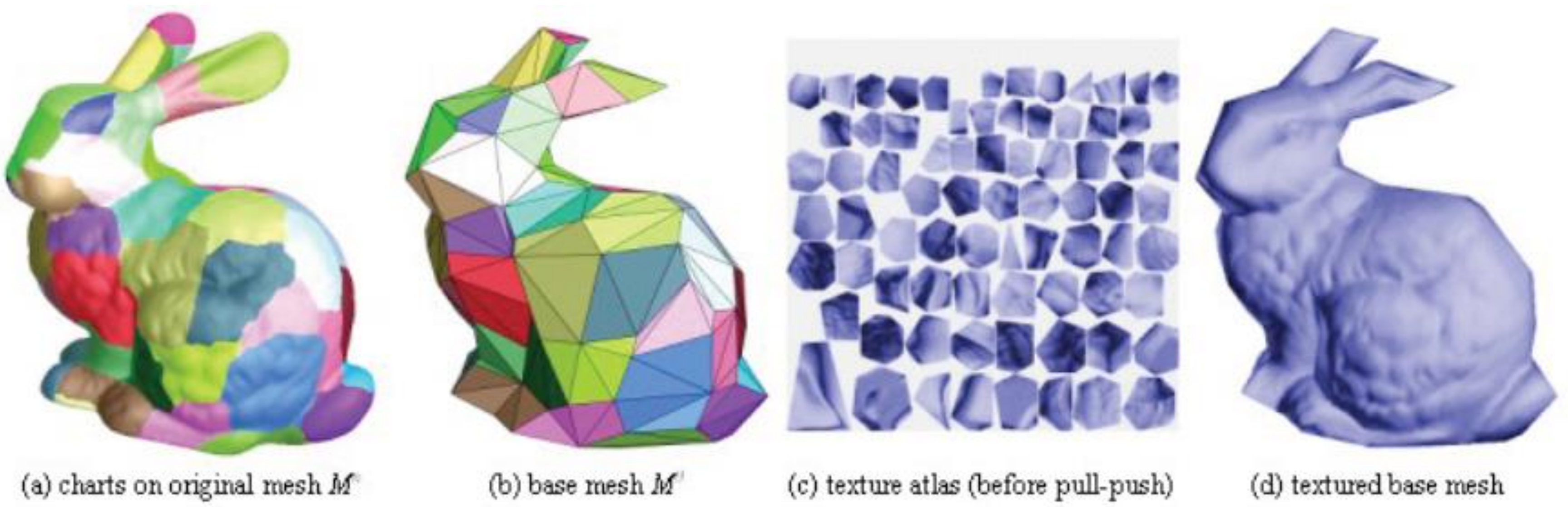
Parametrization in Practice

- Texture creation and parametrization is an art form
- Option: Unfold the surface



Parametrization in Practice

- Option: Create a Texture Atlas
- Break large mesh into smaller pieces



References

- Interactive Computer Graphics (6th edition), Angel and Shreiner
- Computer Graphics using OpenGL (3rd edition), Hill and Kelley
- Real Time Rendering by Akenine-Moller, Haines and Hoffman