Lecture8 Surface Mapping

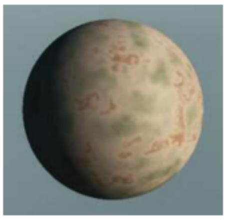
1. Introduction

The appearance of real life surfaces may not be just colored but also have **textures**, **patterns**, **displacements**, or **bumps**

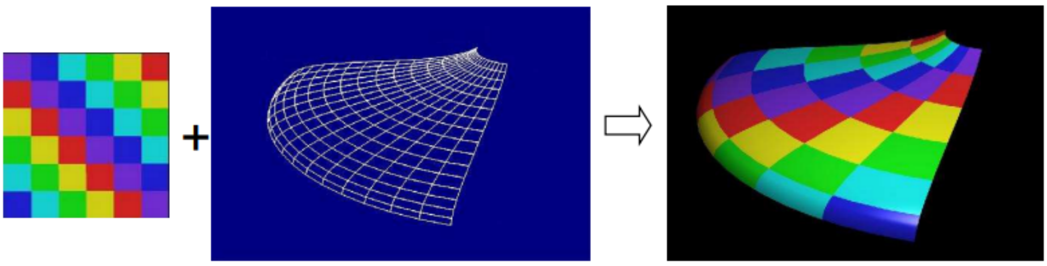
To enrich the appearance, add surface details and achieve the impression of natural colors, textures, or other visual effects, various **surface mapping techniques** have been used in computer graphics

2. Texture Mapping

The addition of a separately defined texture or pattern to a surface, which changes the **color patterns** of the surface



Associate 2D texture with 3D surface

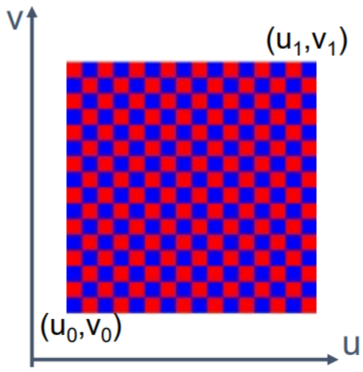


- **Forward mapping**: how to paste the texture onto the surface, i.e., where on the geometry should each color in the texture go?
- **Inverse mapping**: for each point on the geometry, where do we have to look in the texture to find the color?

Steps

Parameterize the texture

A texture is specified as a 2D image, which is called a **texture map**



The texture is parameterized by texture coordinates (u, v) with $u \in [u_0, u_1], v \in [v_0, v_1]$, so that any position in the texture space can be referenced with (u, v)

In practice, it is often to choose $u_0 = v_0 = 0, u_1 = v_1 = 1$

Parameterize the surface

Parameterize the surface in (s, t)

$$x = x(s,t), y = y(s,t), z = z(s,t), s \in [s_0, s_1], t \in [t_0, t_1]$$

Define mapping functions

Map the two pairs

- $u \in [u_0, u_1] \leftrightarrow s \in [s_0, s_1]$
- $v \in [v_0, v_1] \leftrightarrow t \in [t_0, t_1]$

Convert all the parameters to range $[0, 1]$, $\frac{u-u_0}{u_1-u_0}$ and $\frac{s-s_0}{s_1-s_0}$

Make one equal to other $\frac{u-u_0}{u_1-u_0} = \frac{s-s_0}{s_1-s_0}$

Use u to substitute s, v to substitute t, find the mapping between them

Find (s, t) from (x, y, z)

From the parametric equations of the surface

- $x = x(s, t)$
- $y = y(s, t)$
- $z = z(s, t)$

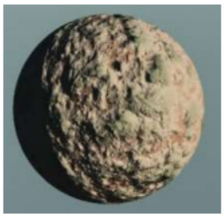
Solve for $(s, t) = f(x, y, z)$ and substitute s, t with the mapping function of u, v

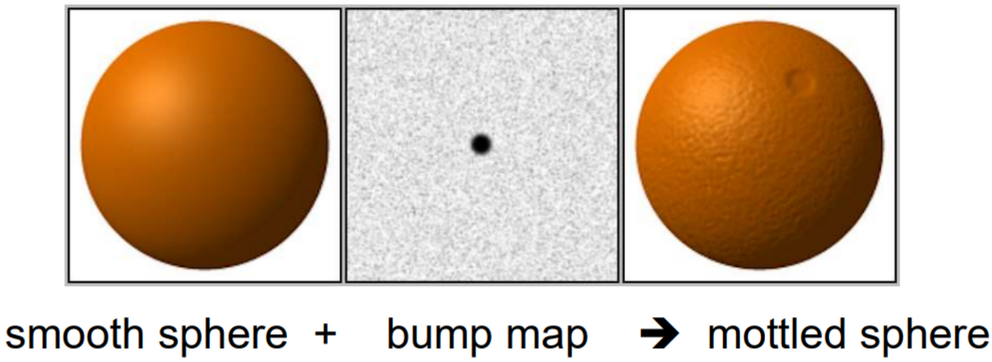
- $u = f(x, y, z)$
- $v = f(x, y, z)$

Use the function to check the specific point (x_0, y_0, z_0) on the surface

3. Bump Mapping

Roughening the surface of an object without actually changing the surface, which just makes the surface look as if it has bumps



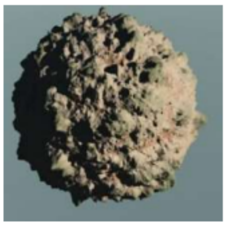


Steps

- Look up the values in the bump map that corresponds to the position on the surface
- Compute two partial derivatives of the bump map
- Use the two **partial derivatives** to perturb the true ("geometric") surface **normal**
- Calculate the intensity of the surface using, for example, Phong illumination model, with the perturbed normal

4. Displacement Mapping

Displacing the surface, which actually changes the geometry of the surface.



Steps

- Inputs: original surface, 3D displacement map
- Step1: find the correspondence between the surface and the map
- Step2: displace the position of each point on the surface by amount according to the values in the corresponding position in the map
- Output: displaced surface