



HW3

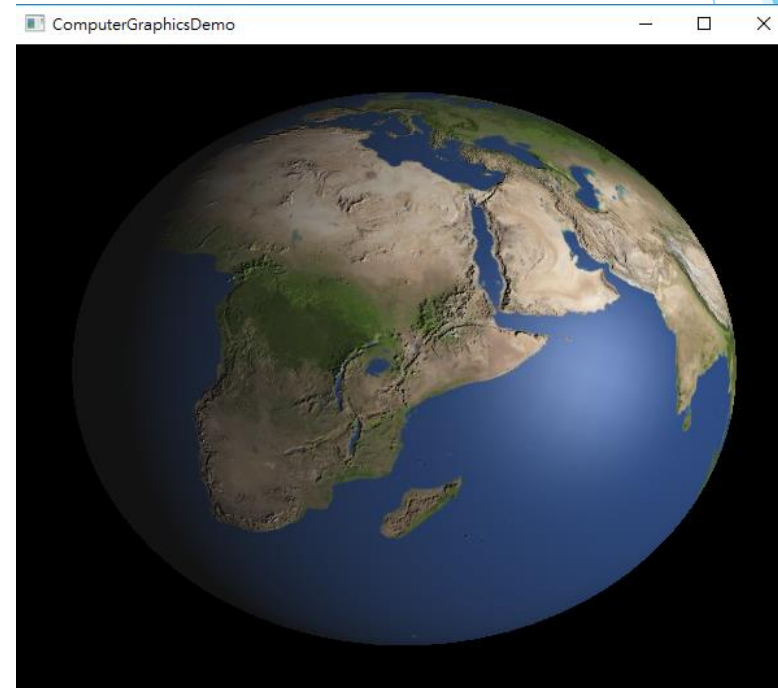
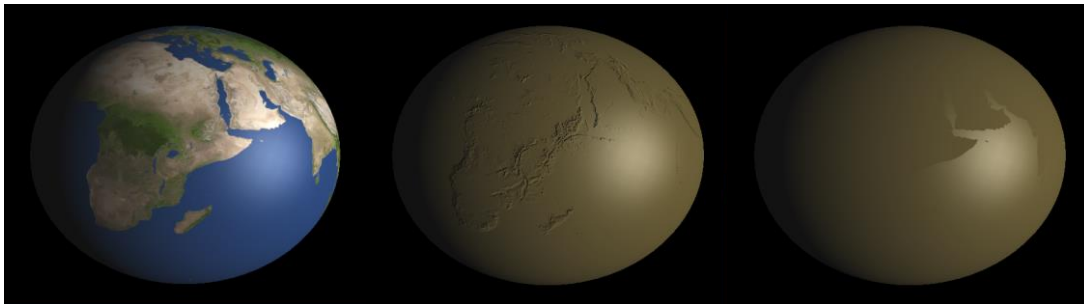
# Introduction

- ▶ Draw a sphere - Earth, and apply Phong shading
- ▶ Map texture map, normal map & specular map
  - ▶ Press '1' to turn on or turn off the texture map
  - ▶ Press '2' to turn on or turn off the normal map
  - ▶ Press '3' to turn on or turn off the specular map
  - ▶ Press 'P' to start and stop
- ▶ Earth rotation
- ▶ Light revolute around the Earth

texture

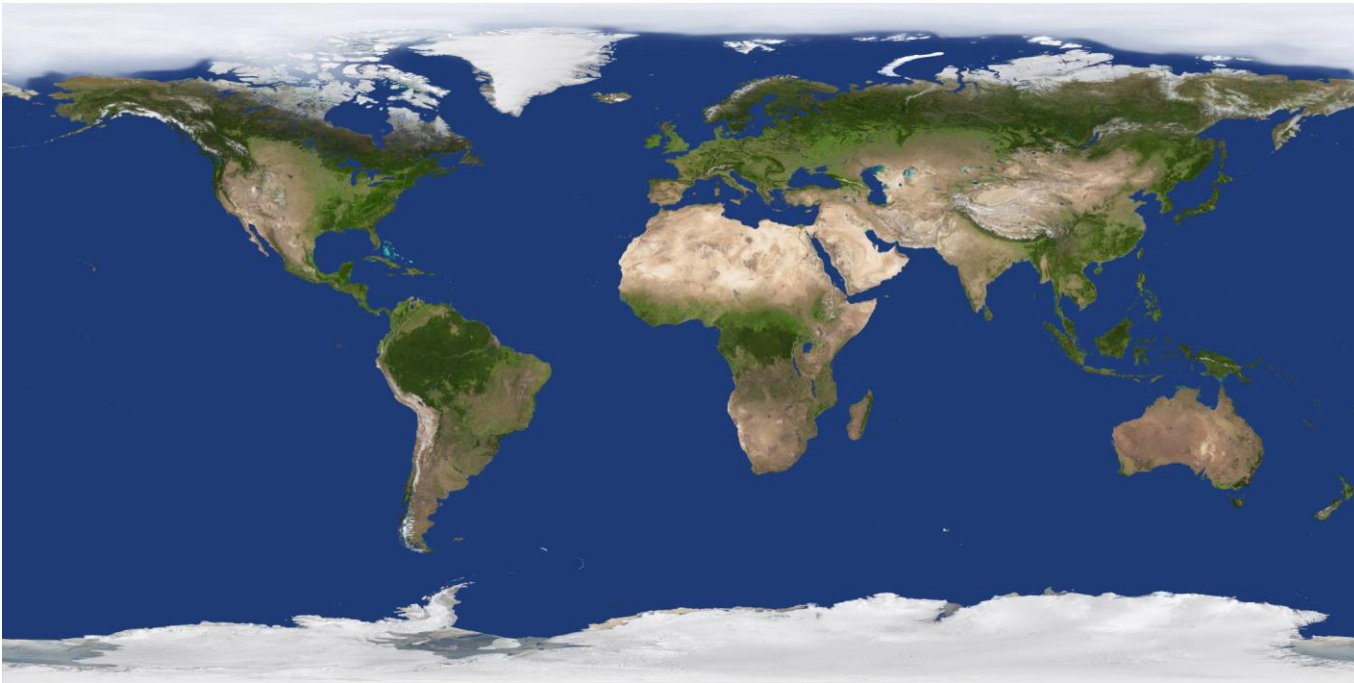
normal

specular



# Texture Map

- ▶ Same as HW2, use FreeImage to load texture
- ▶ Following the instruction in lecture note to implement in shader



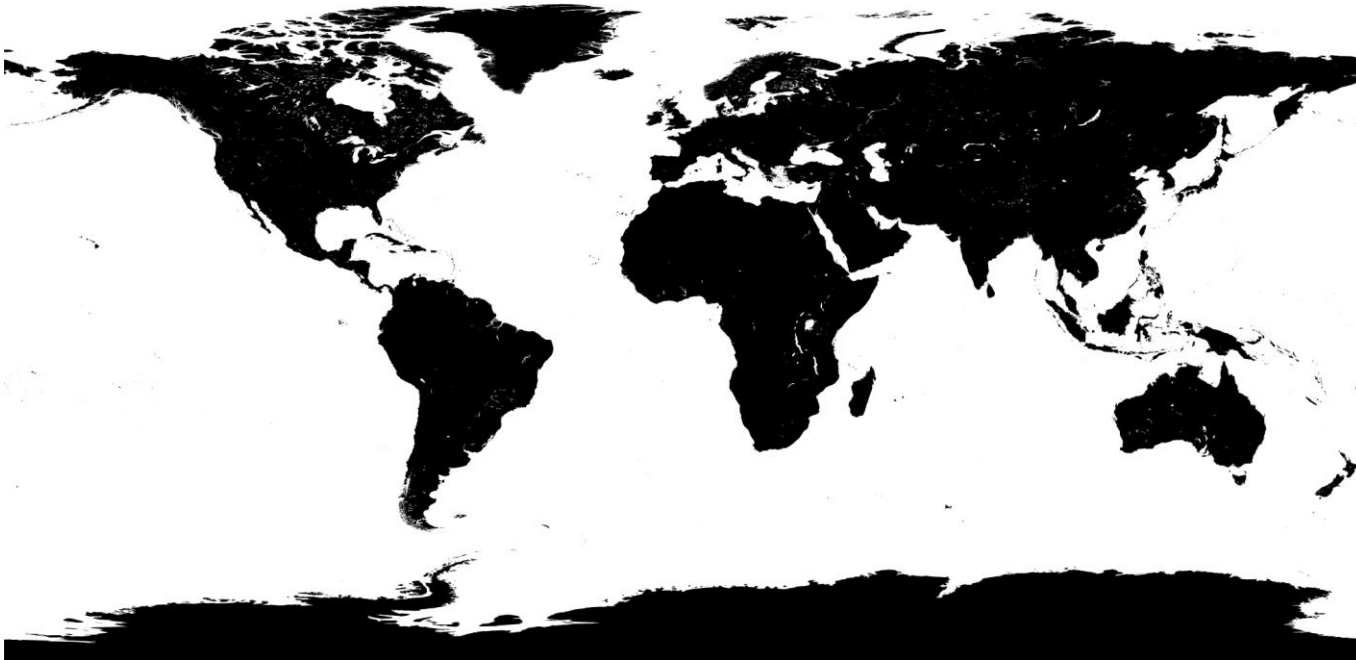
# Normal Map

- ▶ Compute 'tangent' and 'bitangent' by vertex position and texture coordinate
- ▶ Fetch normal map color and computer pixel normal



# Specular Map

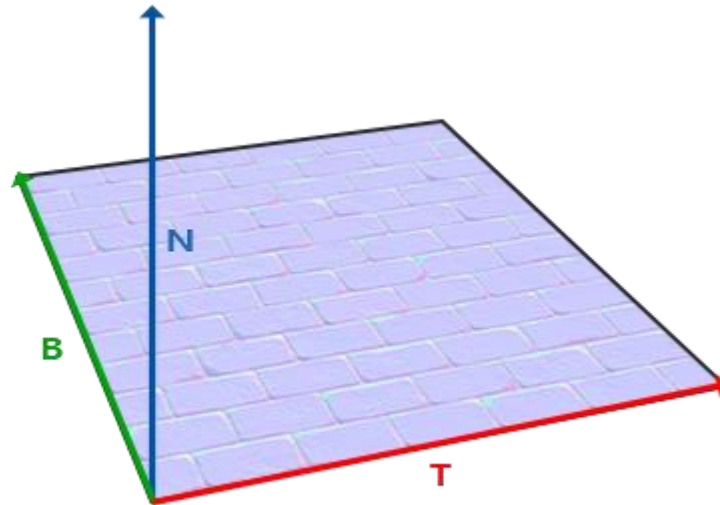
- ▶ Like stencil buffer of specular term in Phong shading
- ▶ Multiply specular term and texture color of specular map



# Normal Map

# Tangent Space

- ▶  $\vec{N} = r\vec{T} + g\vec{B} + b\vec{N}$ 
  - ▶  $\vec{T}$ : Tangent
  - ▶  $\vec{B}$ : Bitangent
  - ▶  $\vec{N}$ : Normal
  - ▶  $r$ : red(0 ~ 255)  $\rightarrow$  (-1 ~ 1)
  - ▶  $g$ : green(0 ~ 255)  $\rightarrow$  (-1 ~ 1)
  - ▶  $b$ : blue(128 ~ 255)  $\rightarrow$  (0 ~ -1)



# Tangent & Bitangent

►  $\Delta P = \Delta U \times T + \Delta V \times B$

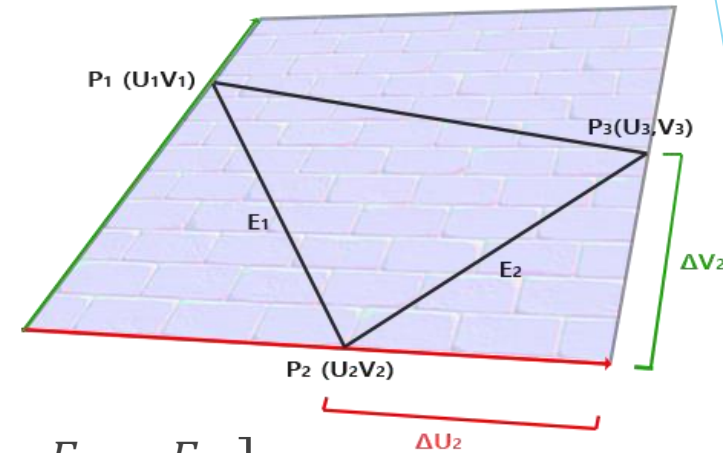
► We can formulate following matrix equation

$$\begin{bmatrix} E_{1x} & E_{1y} & E_{1z} \\ E_{2x} & E_{2y} & E_{2z} \end{bmatrix} = \begin{bmatrix} \Delta U_1 & \Delta V_1 \\ \Delta U_2 & \Delta V_2 \end{bmatrix} \begin{bmatrix} T_x & T_y & T_z \\ B_x & B_y & B_z \end{bmatrix}$$

$$\Rightarrow \begin{bmatrix} \Delta U_1 & \Delta V_1 \\ \Delta U_2 & \Delta V_2 \end{bmatrix}^{-1} \begin{bmatrix} E_{1x} & E_{1y} & E_{1z} \\ E_{2x} & E_{2y} & E_{2z} \end{bmatrix} = \begin{bmatrix} T_x & T_y & T_z \\ B_x & B_y & B_z \end{bmatrix}$$

$$\Rightarrow \begin{bmatrix} T_x & T_y & T_z \\ B_x & B_y & B_z \end{bmatrix} = \frac{1}{\Delta U_1 \Delta V_2 - \Delta U_2 \Delta V_1} \begin{bmatrix} \Delta V_2 & -\Delta V_1 \\ -\Delta U_2 & \Delta U_1 \end{bmatrix} \begin{bmatrix} E_{1x} & E_{1y} & E_{1z} \\ E_{2x} & E_{2y} & E_{2z} \end{bmatrix}$$

► Hint: You can compute these in geometry shader





# Spec

- ▶ Global value:
  - ▶ Speed:  $X$ (any value)
- ▶ Camera:
  - ▶ Position:  $(0, 0, 3)$
  - ▶ Center:  $(0, 0, 0)$
  - ▶ Up vector:  $(0, 1, 0)$
- ▶ Light:
  - ▶ Radius: 3
  - ▶ Revolution:  $X / 10$

# Spec

- ▶ Earth:
  - ▶ Slice: 360
  - ▶ Stack: 180
  - ▶ Rotation: X
  - ▶ Radius: 1
  - ▶ Obliquity: 23.5
  - ▶ Texture Map: earth\_texture\_map.jpg
  - ▶ Normal Map: earth\_normal\_map.tif
  - ▶ Specular Map: earth\_specular\_map.tif

# Spec

- ▶ Phong Shading Parameter: (You can modify them as beautiful as possible)
  - ▶ Ambient Color: (0.7, 0.7, 0.7, 1.0)
  - ▶ Ambient Coefficient: 0.1
  - ▶ Diffuse Color:
    - ▶ With Texture: Texture Color
    - ▶ Origin Color: (0.35, 0.3, 0.15, 1.0)
  - ▶ Diffuse Coefficient: 1
  - ▶ Specular Color: (1.0, 1.0, 1.0, 1.0)
  - ▶ Specular Coefficient: 0.3

# Reference

- ▶ <https://learnopengl.com/Advanced-Lighting/Normal-Mapping>