Lecture 22: Texture Mapping

November 27, 2018

Now to Texture mapping

Image from http://www.minecraftercamp.com

Adding surface detail

- Surfaces in the world have appearance
  - They are seldom one flat color.
  - They have true texture – repeating patterns.
  - They have structured markings.
  - They have tiny changes in surface height.
- Purists view (don't try this!)
  - Use ever more even smaller uniform triangles.
- Pragmatists view
  - Paint surfaces with images – texture mapping.

Texture Mapping

- Use projective geometry to compute where vertices appear in the image
- Apply shading to determine the color of pixels
  - -- or –
- Map an existing texture onto a surface
  - Textures supercede/augment the specification of surface material
  - Leaves room for distinction diffuse vs. specular

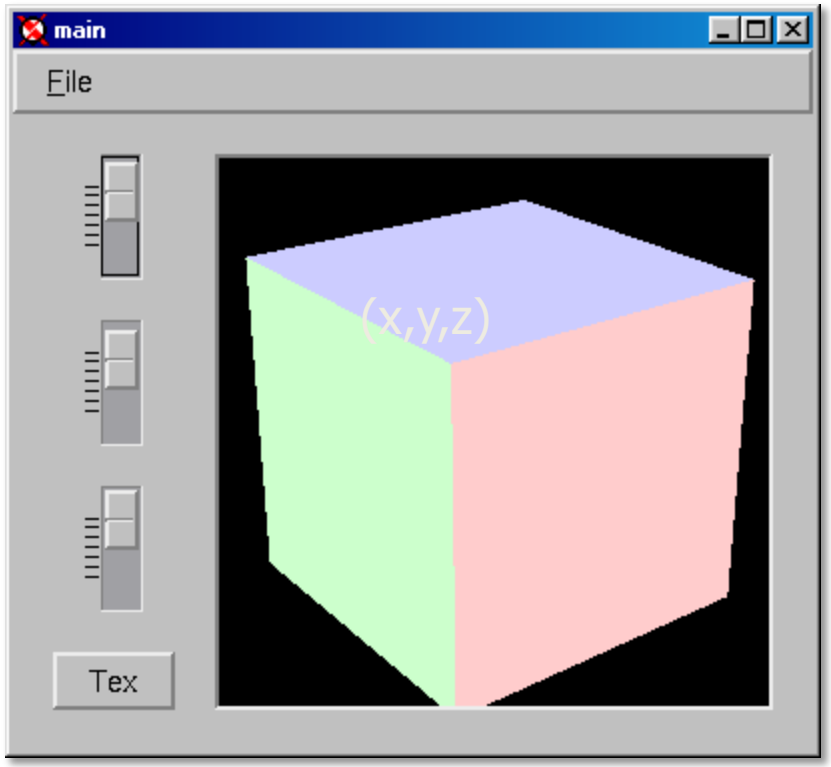
Mapping

- Guess what? The underlying problem is to apply a geometric transformation

(0,0)

(1,1)

t,s coordinates



Mapping (II)

- Textures are color images
  - Logical texture coords run from (0,0) to (1,1)
  - Coordinates fixed regardless of image size
- Polygons are 2D surfaces in a 3D space
- The transformation from texture coordinates to surface coordinates is expressed as – you guessed it – a matrix

Texture Matrices

- Given vertices and the corresponding texture coordinates…

$$\begin{bmatrix} t \\ s \end{bmatrix} = \begin{bmatrix} a & b & c \\ d & e & f \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix}$$

- How many correspondences are needed?
- Maps from surface to texture

Worked Example - Before

- Consider point correspondences
  - Pairs of points in texture and 3-D coordinates
  - Three such pairs of points yield six constraints
  - Constraints match free variables – six.
- Specifically
  - Point (0,0) matches point (1,2,3)
  - Point (1,1) matches point (2,2,2)
  - Point (0,1) matches point (3,2,2)

Worked Example

Match #1 $\begin{vmatrix} 0 \\ 0 \end{vmatrix} = \begin{vmatrix} a & b & c \\ d & e & f \end{vmatrix} \begin{vmatrix} 1 \\ 2 \\ 3 \end{vmatrix}$

$\begin{vmatrix} 0 \\ 1 \end{vmatrix} = \begin{vmatrix} a & b & c \\ d & e & f \end{vmatrix} \begin{vmatrix} 3 \\ 2 \\ 3 \end{vmatrix}$

Match #3

Match #2 $\begin{vmatrix} 1 \\ 1 \end{vmatrix} = \begin{vmatrix} a & b & c \\ d & e & f \end{vmatrix} \begin{vmatrix} 2 \\ 2 \\ 2 \end{vmatrix}$

$0 = a + b + c$

$1 = 2a + 2b + 2c$

$0 = 3a + 2b + 3c$

3 equations for first texture coords

Linear Alg. Setup

$\begin{vmatrix} 0 \\ 1 \\ 0 \end{vmatrix} = \begin{vmatrix} 1 & 2 & 3 \\ 2 & 2 & 2 \\ 3 & 2 & 3 \end{vmatrix} \begin{vmatrix} a \\ b \\ c \end{vmatrix}$

$\begin{vmatrix} 0 \\ 1 \\ 1 \end{vmatrix} = \begin{vmatrix} 1 & 2 & 3 \\ 2 & 2 & 2 \\ 3 & 2 & 3 \end{vmatrix} \begin{vmatrix} d \\ e \\ f \end{vmatrix}$

Solved in Maple

$a = 0 \quad b = 3/2 \quad c = -1$

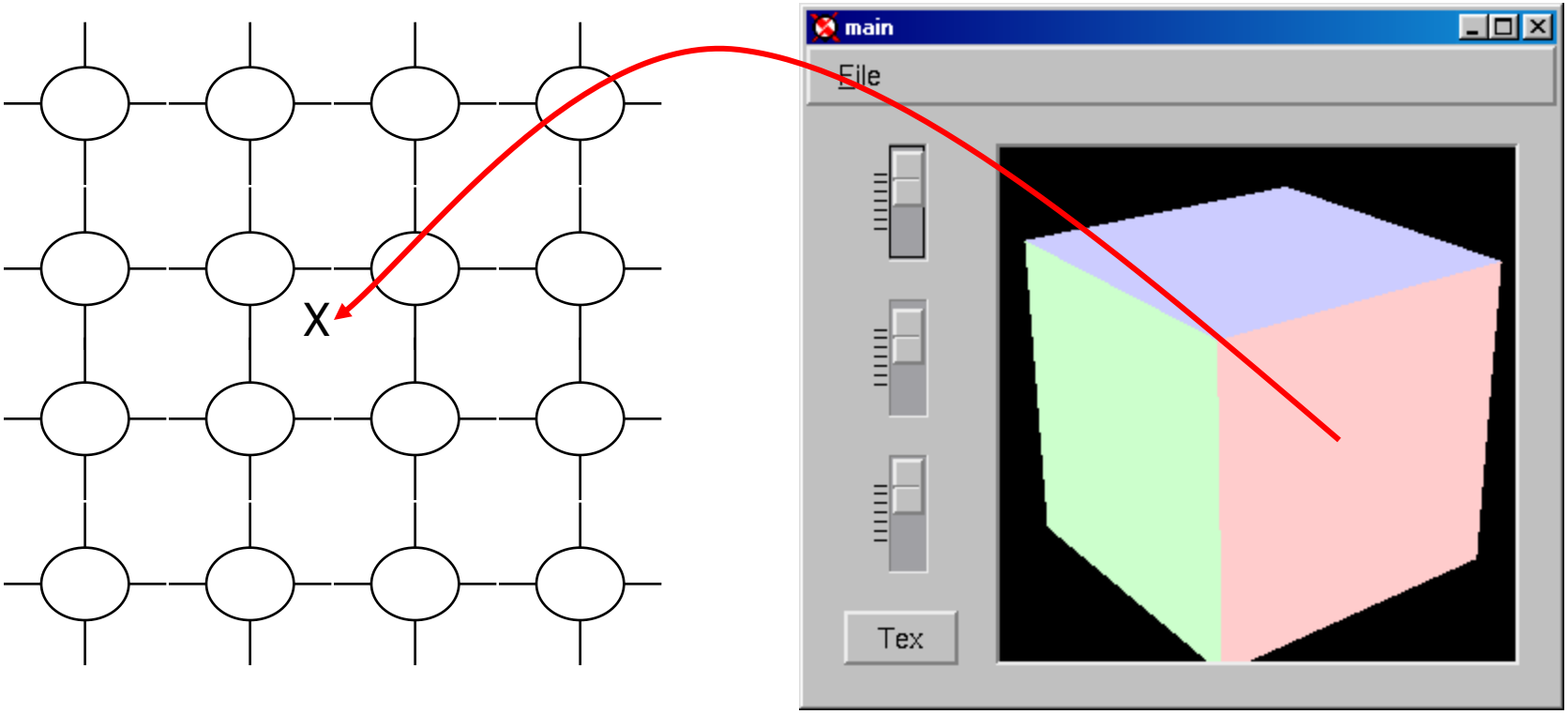
$d = \frac{1}{2} \quad e = \frac{1}{2} \quad f = -\frac{1}{2}$

Texture Mapping (II)

- The fragment processor computes a reflectance color for every pixel
- When textures are enabled,
  - The fragment processor also computes a texture value for every pixel
  - Using the pixel to do texture mapping
- These values are multiplied together to produce the final value

Issue #1: Sampling

- The mapping from surface points to texture coordinates produces real values



Sampling

- Nearest-neighbor:
  - pick the closest texture pixel
- Bilinear:
  - linearly interpolate in both dimensions
- Bicubic:
  - fit a 3rd order surface to 16 surrounding points
  - Not as expensive as it sounds

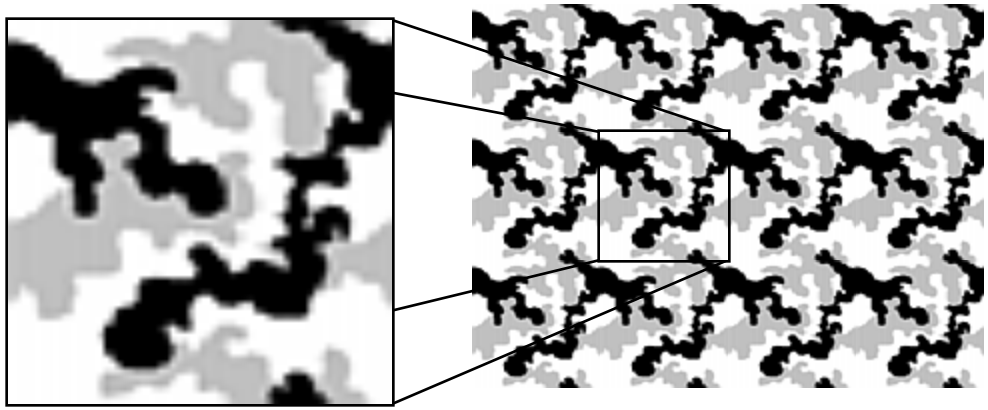
Sampling (III)

- A better solution is for the texture map to be roughly the same size as the surface projection.

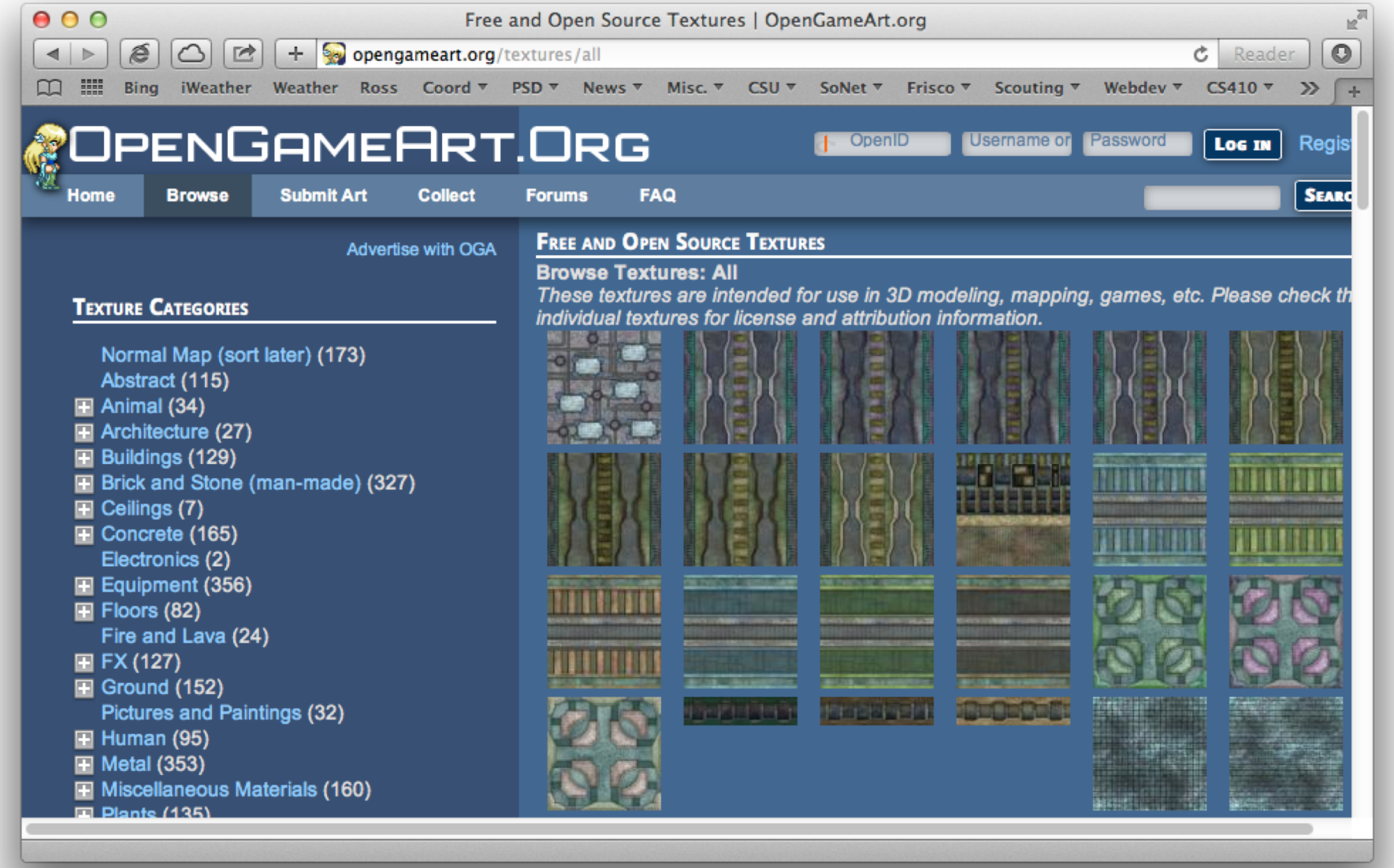
- A MipMap is an image pyramid built from a texture map
  - Example: if the texture is 64x64, the pyramid also includes 32x32, 16x16, etc.

Issue #2: Getting Textures

- WEB!
  - **millions** of textures – people use them for backgrounds of web pages a lot! You can download them in bulk packages, etc..
- Build your own
  - Make them "seamless"
    - When tiled, you cannot see the edges of the tiles.



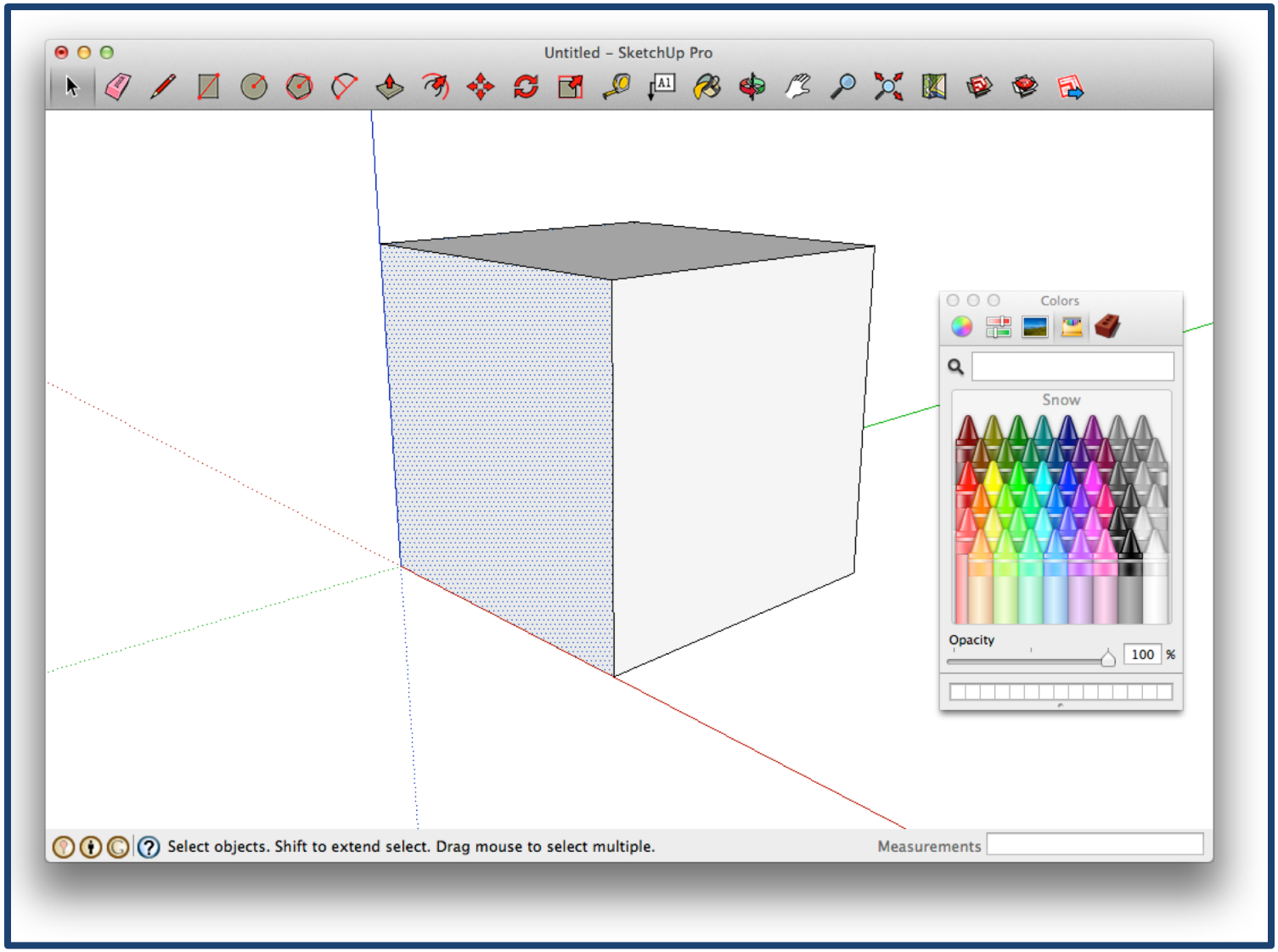
Just for example …



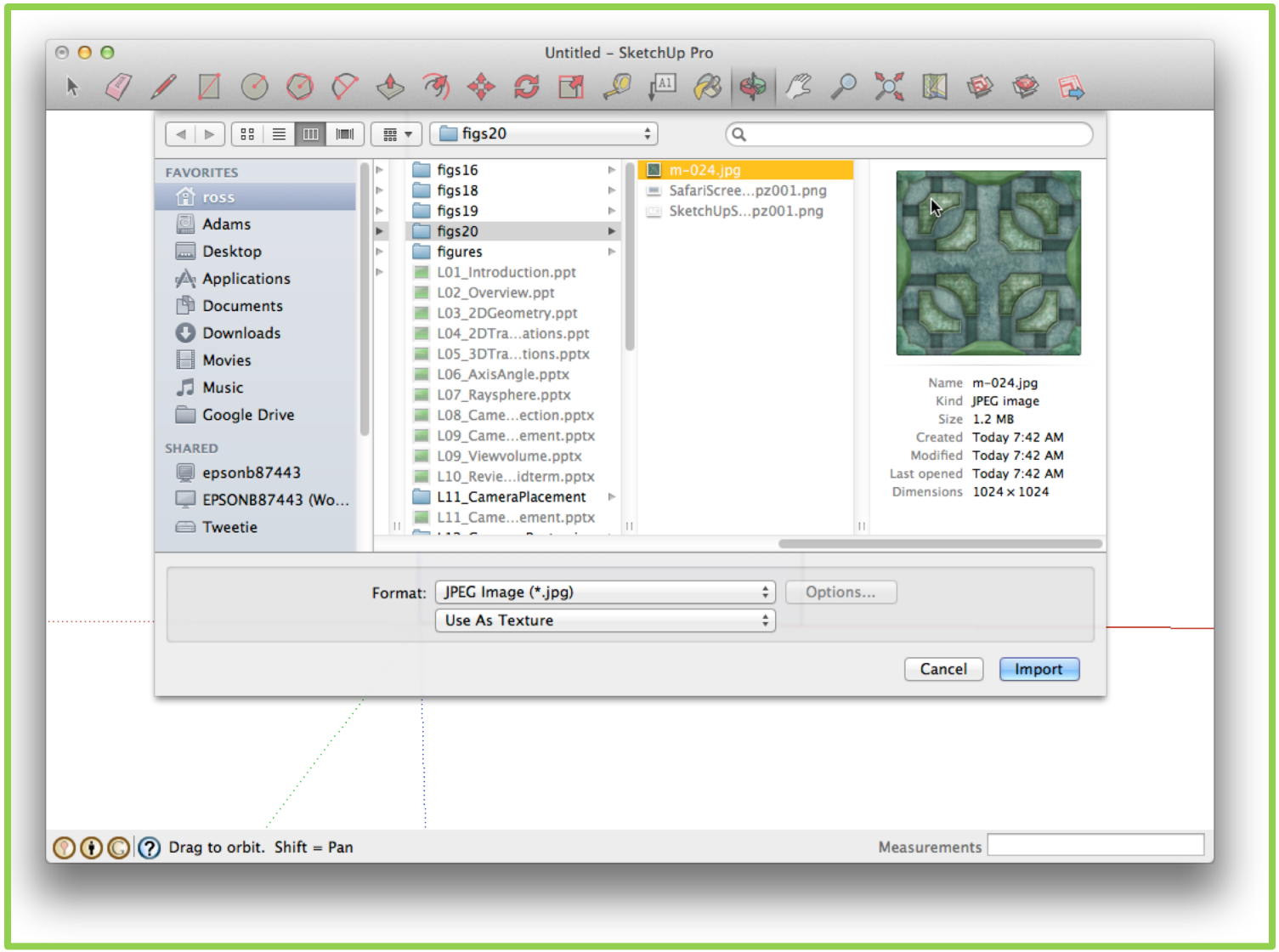
Texture Makers

- There are tons of them.. Some examples:
  - ftp://zdftp.zdnet.com/pub/private/sWIIB/graphics_multimedia_tools/graphics_tools/terltx32.zip
  - http://www.backgroundmagic.com/software/BGM.zip
  - http://www.metaworkshop.com/ftp/twinst.zip
  - http://216.156.212.112/photoseam.exe

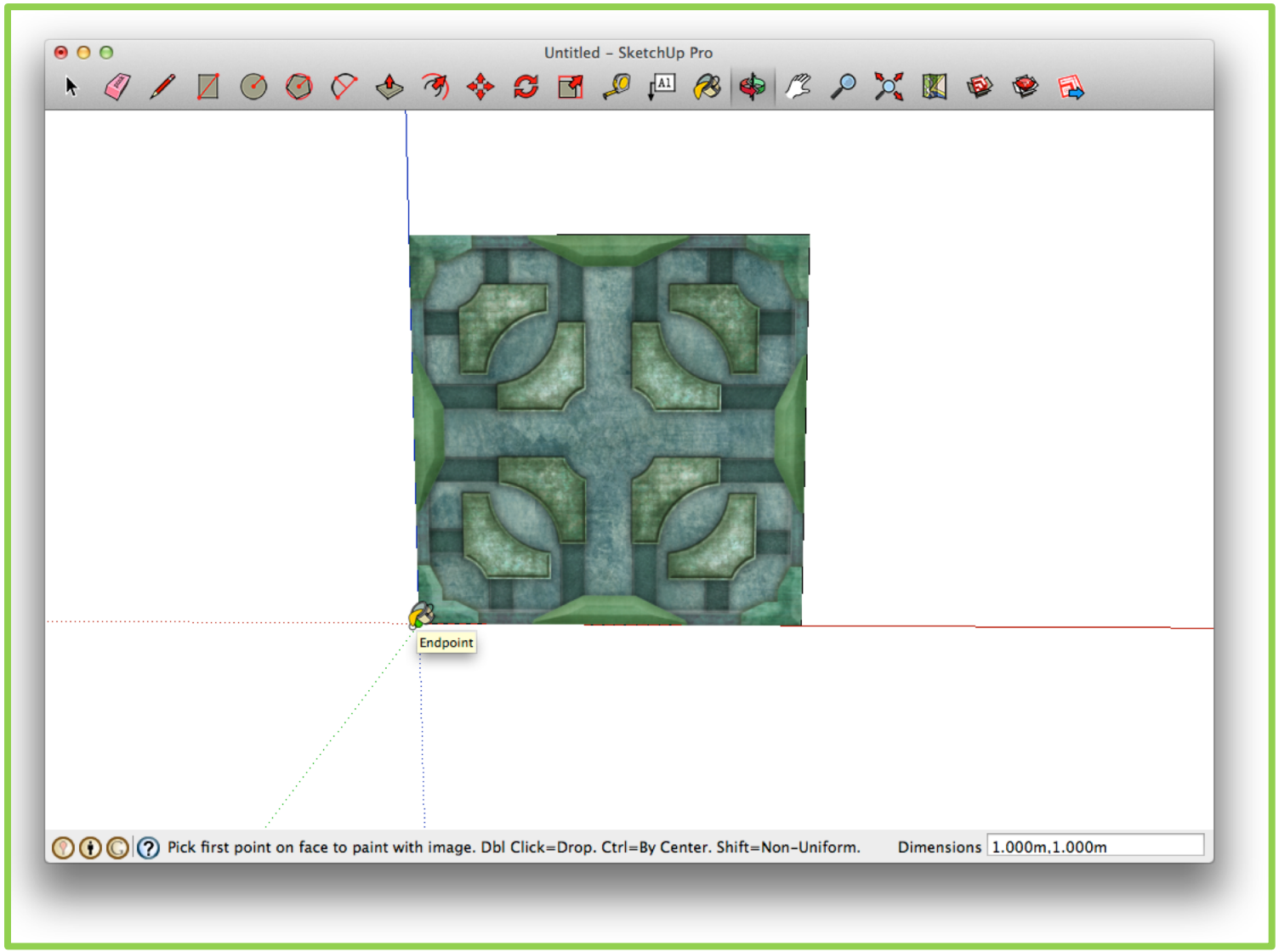
Example in SketchUp - Cube



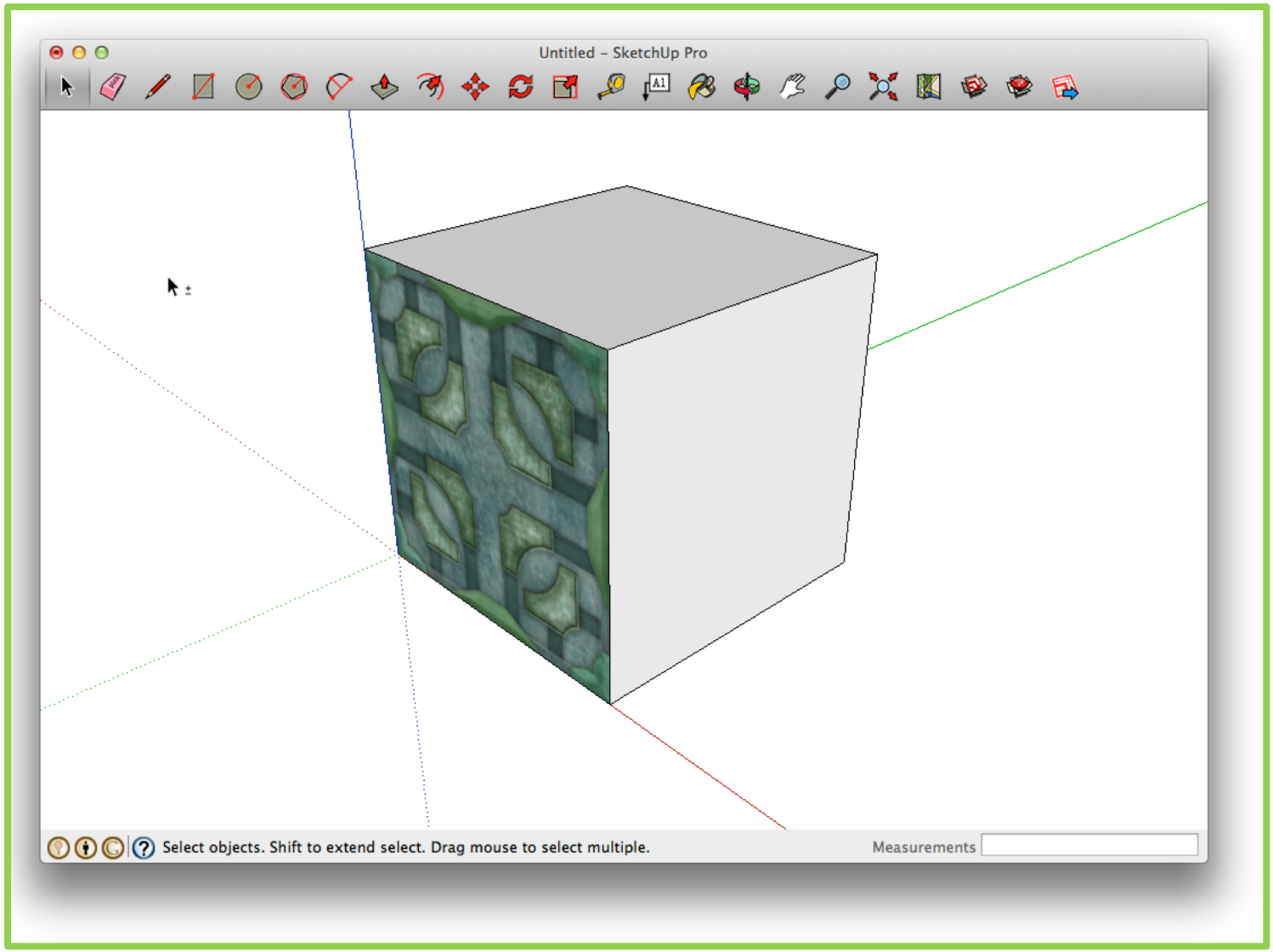
Import a Texture Image



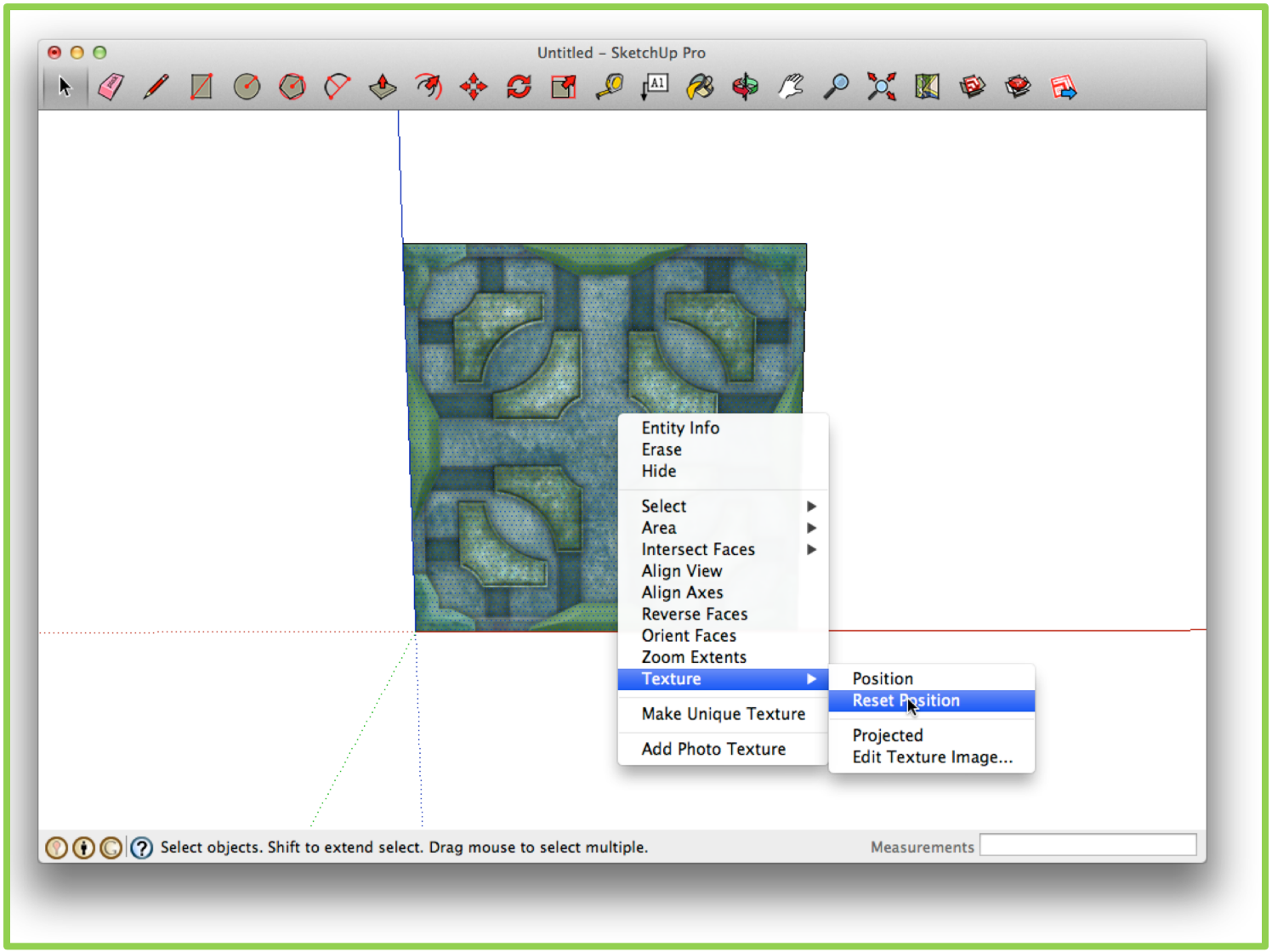
Place Texture on Face



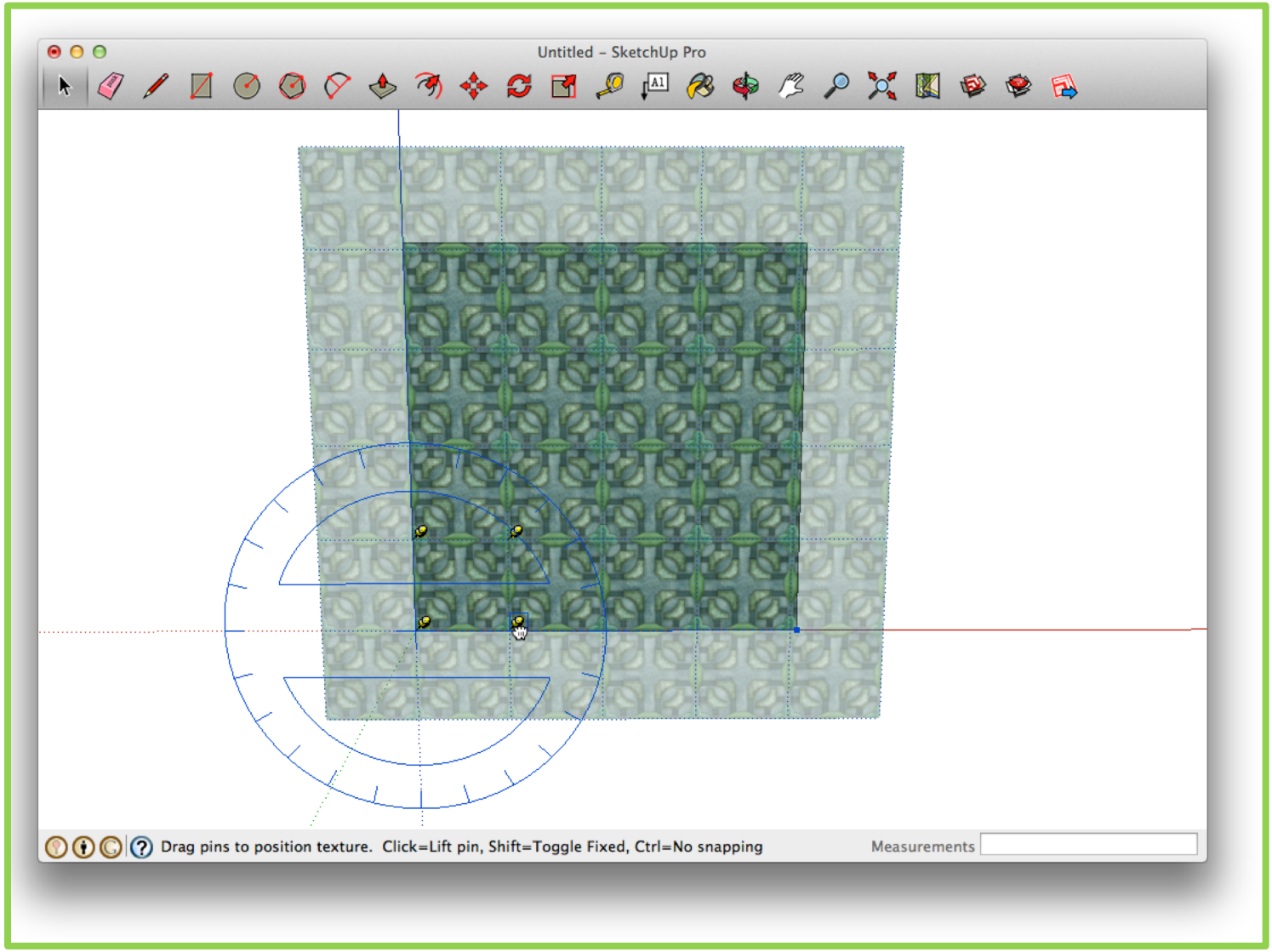
View the Result



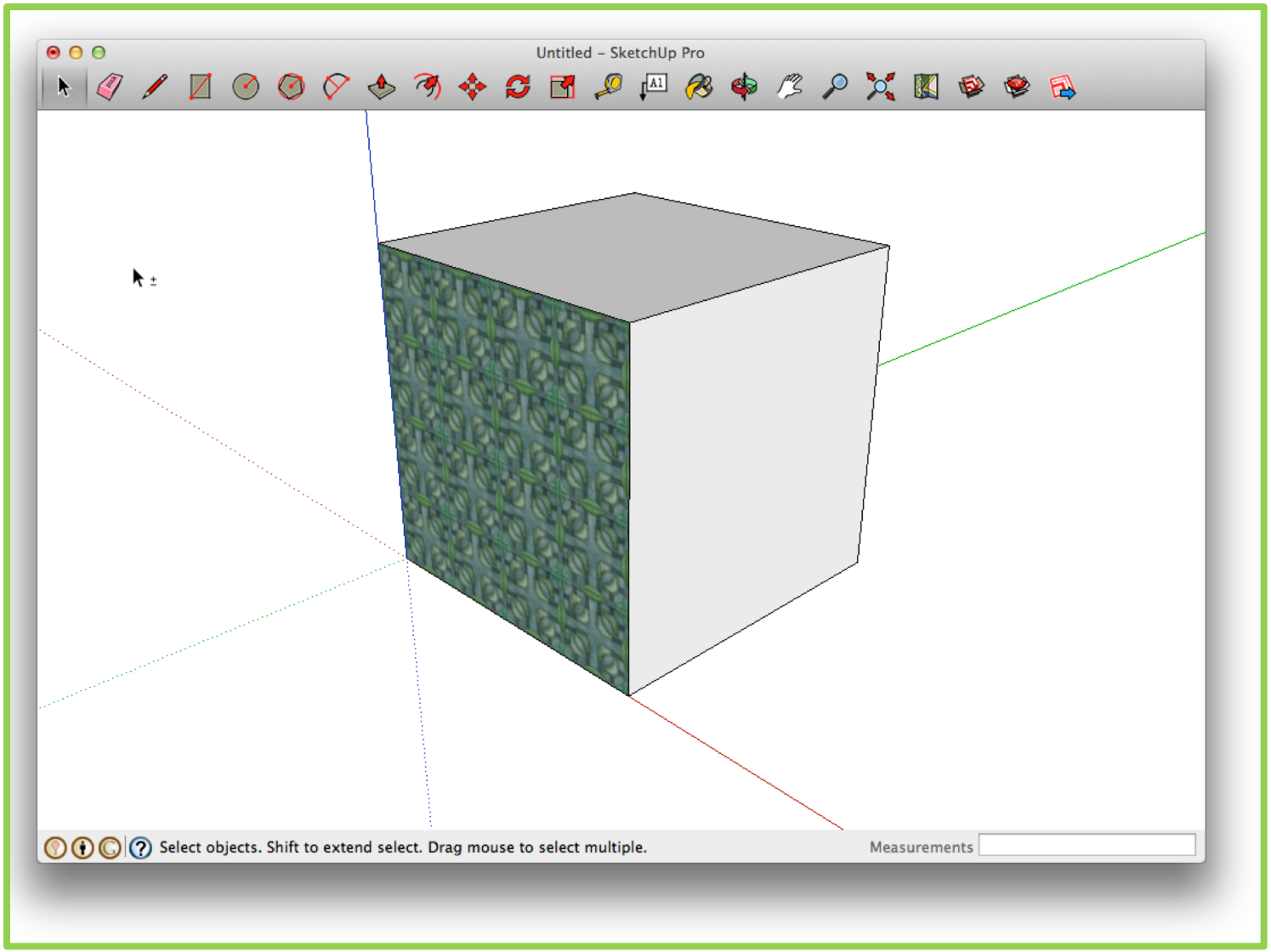
Position/Reset-Position



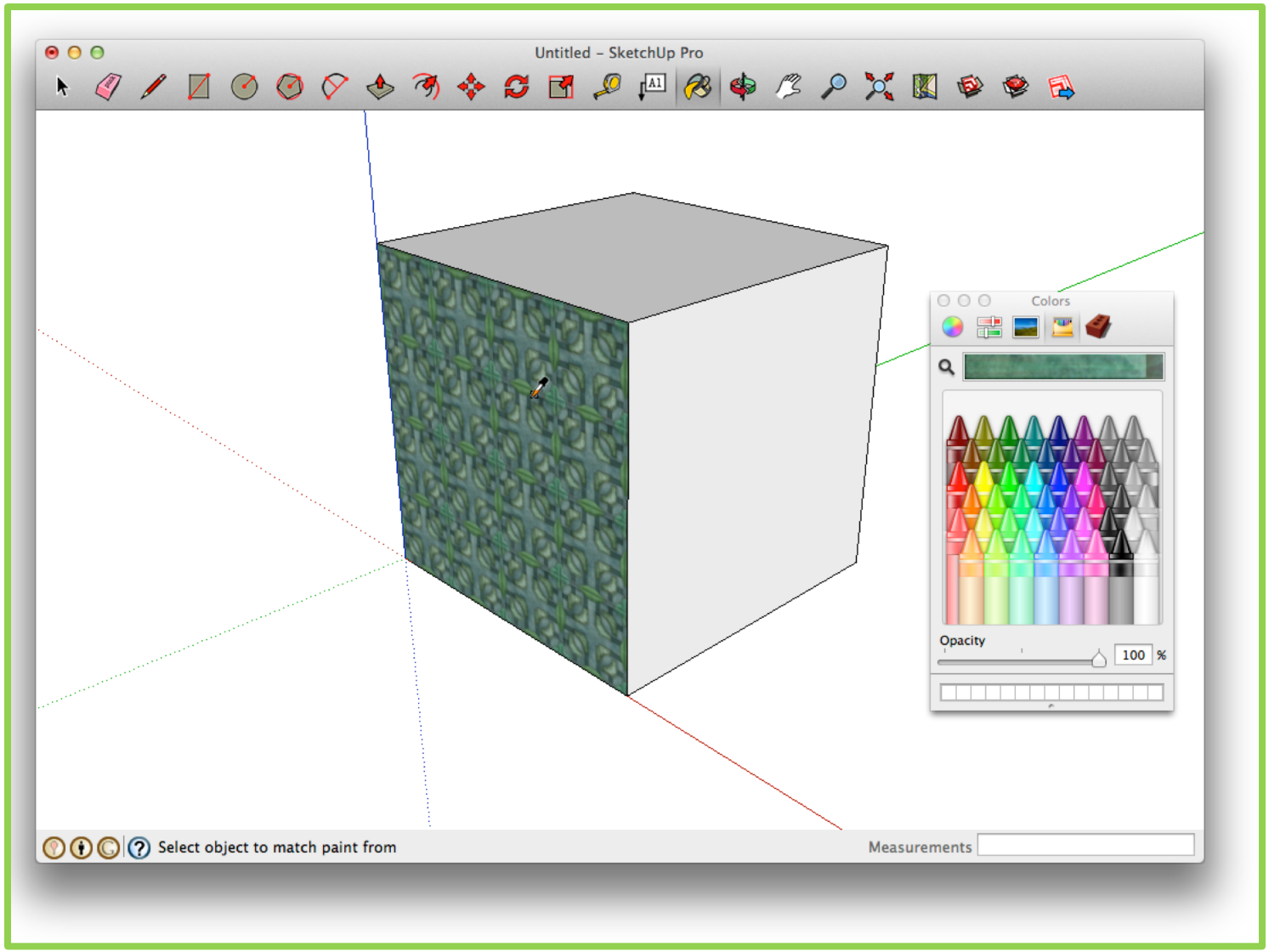
The Essence of Tiling



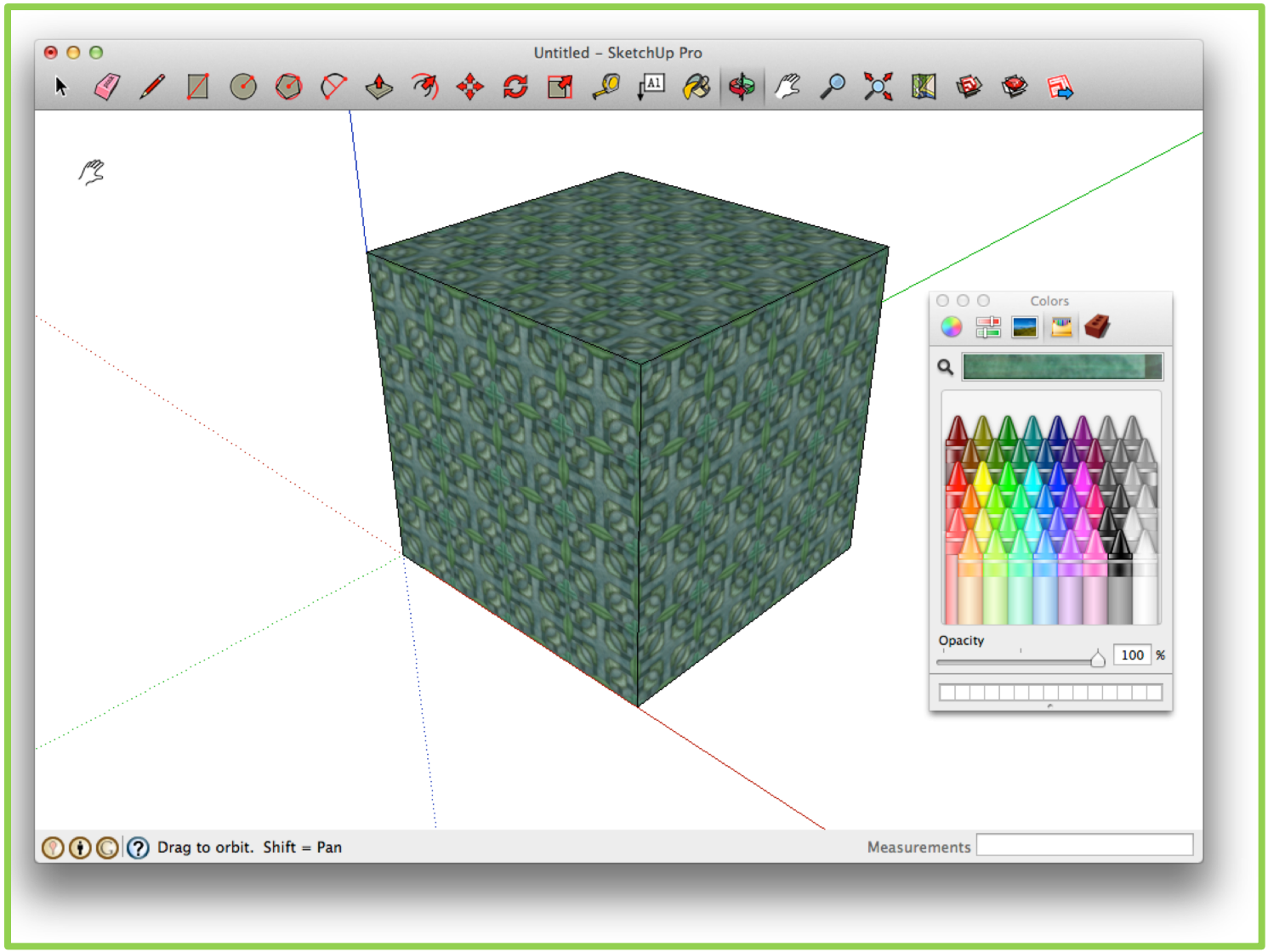
View the Result



Support for ‘Painting’ Textures

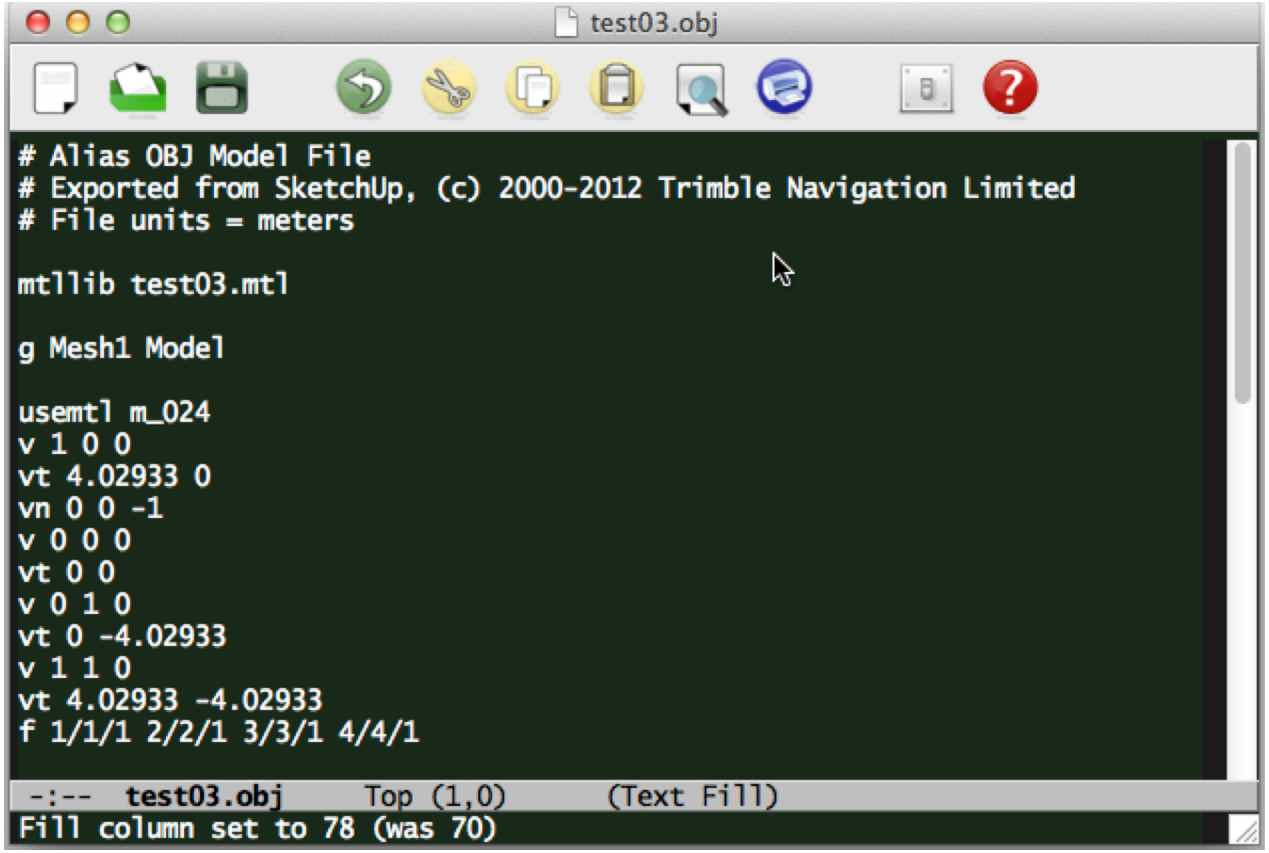


Final Result – Textured Cube

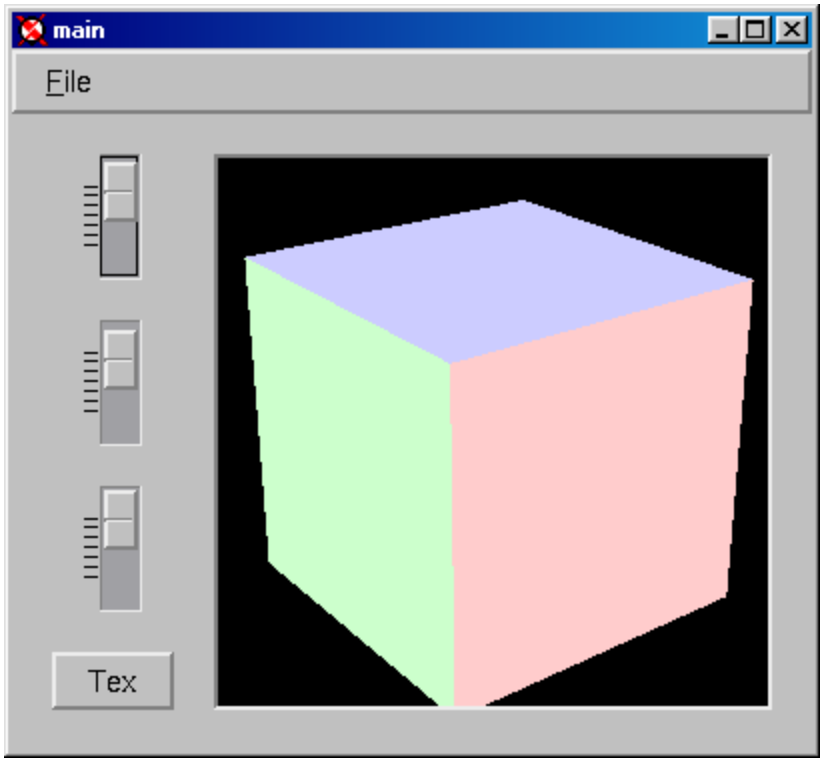


Alas - .obj support marginal

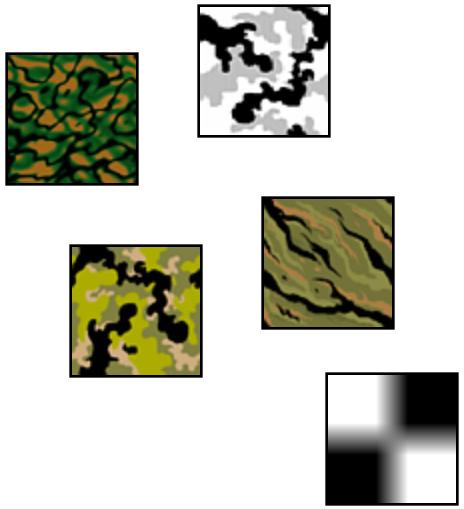
- Texture vertices do come through.
- File linkage to texture map does not.



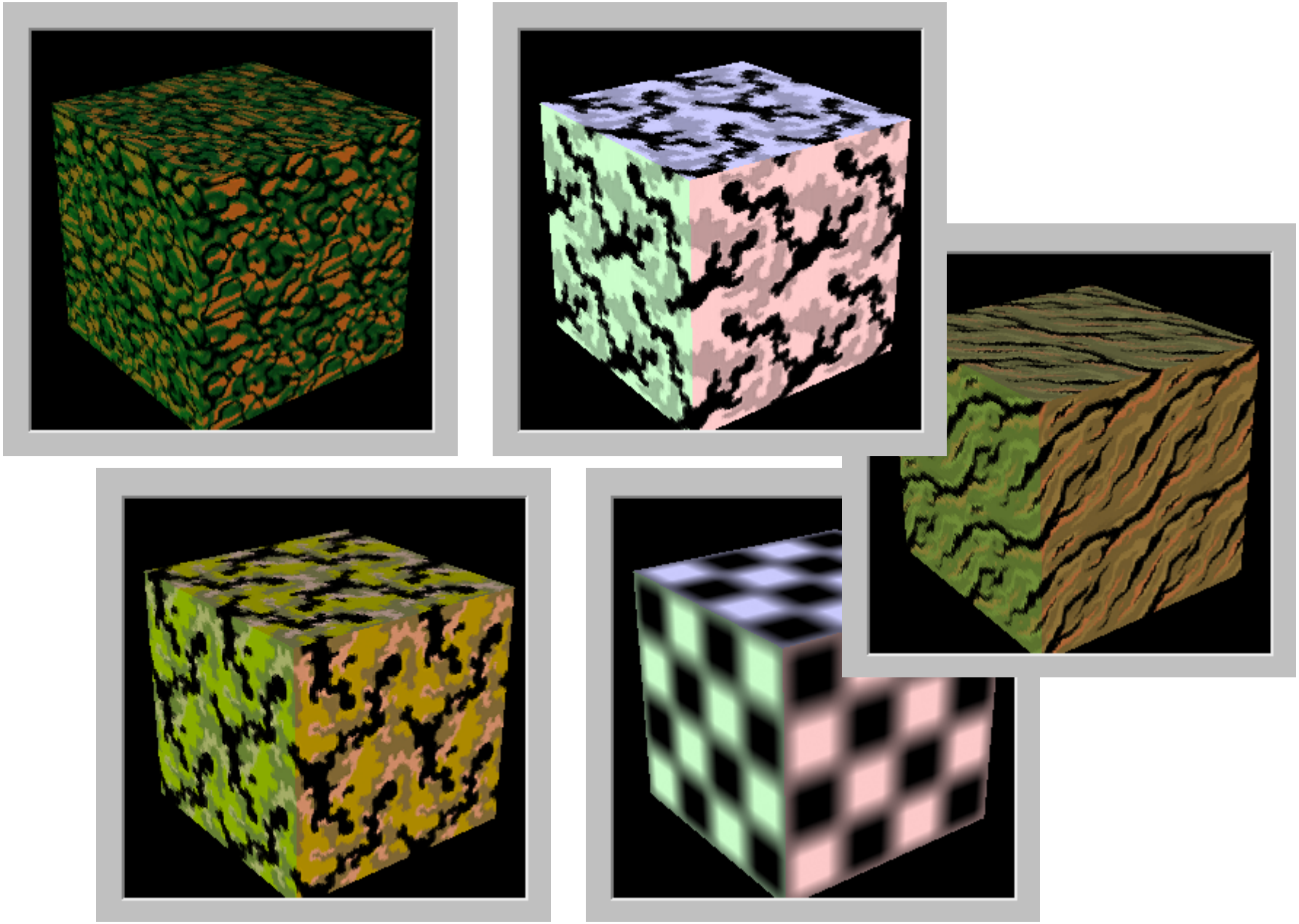
More Examples



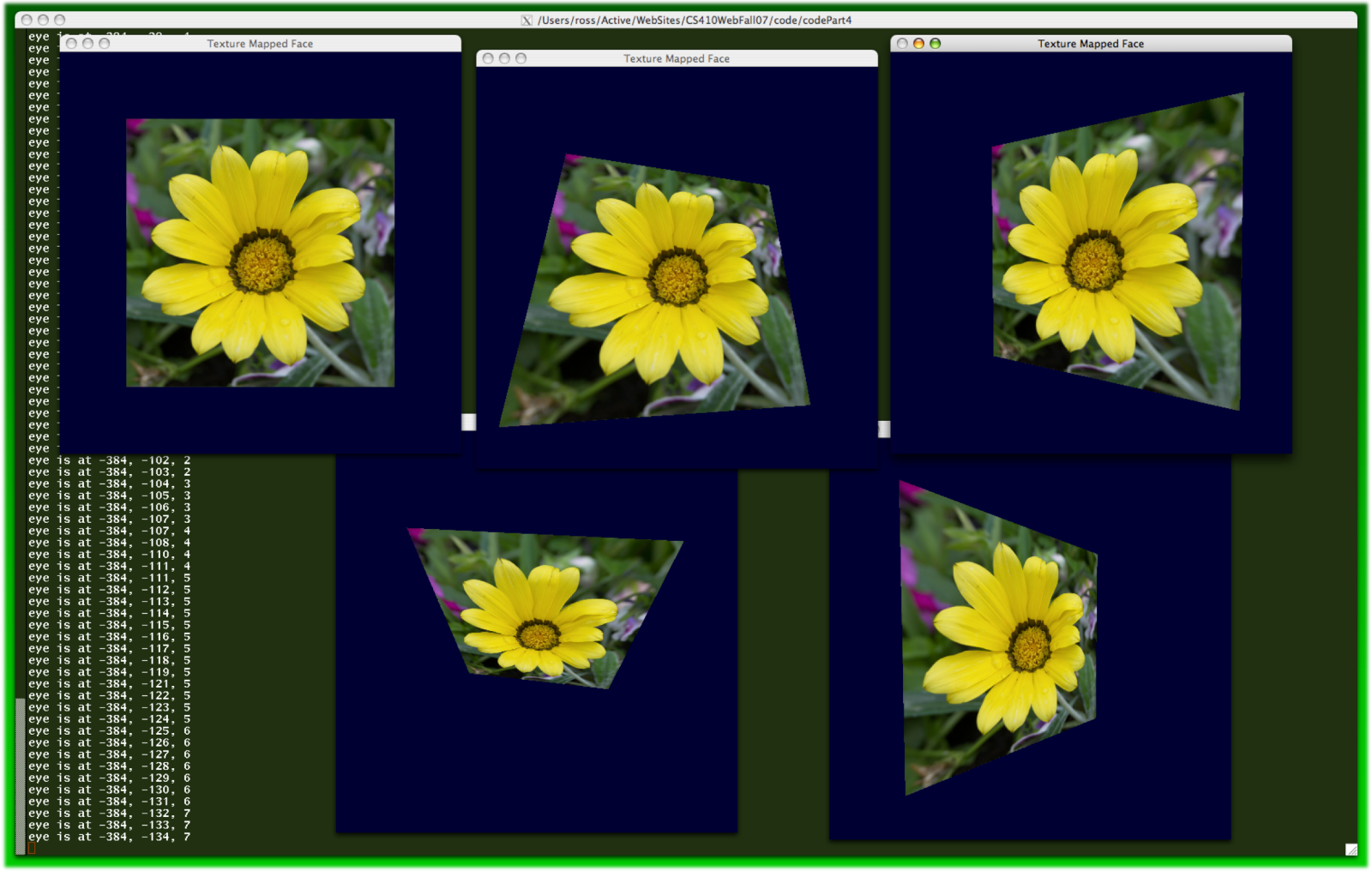
Surface



Textures

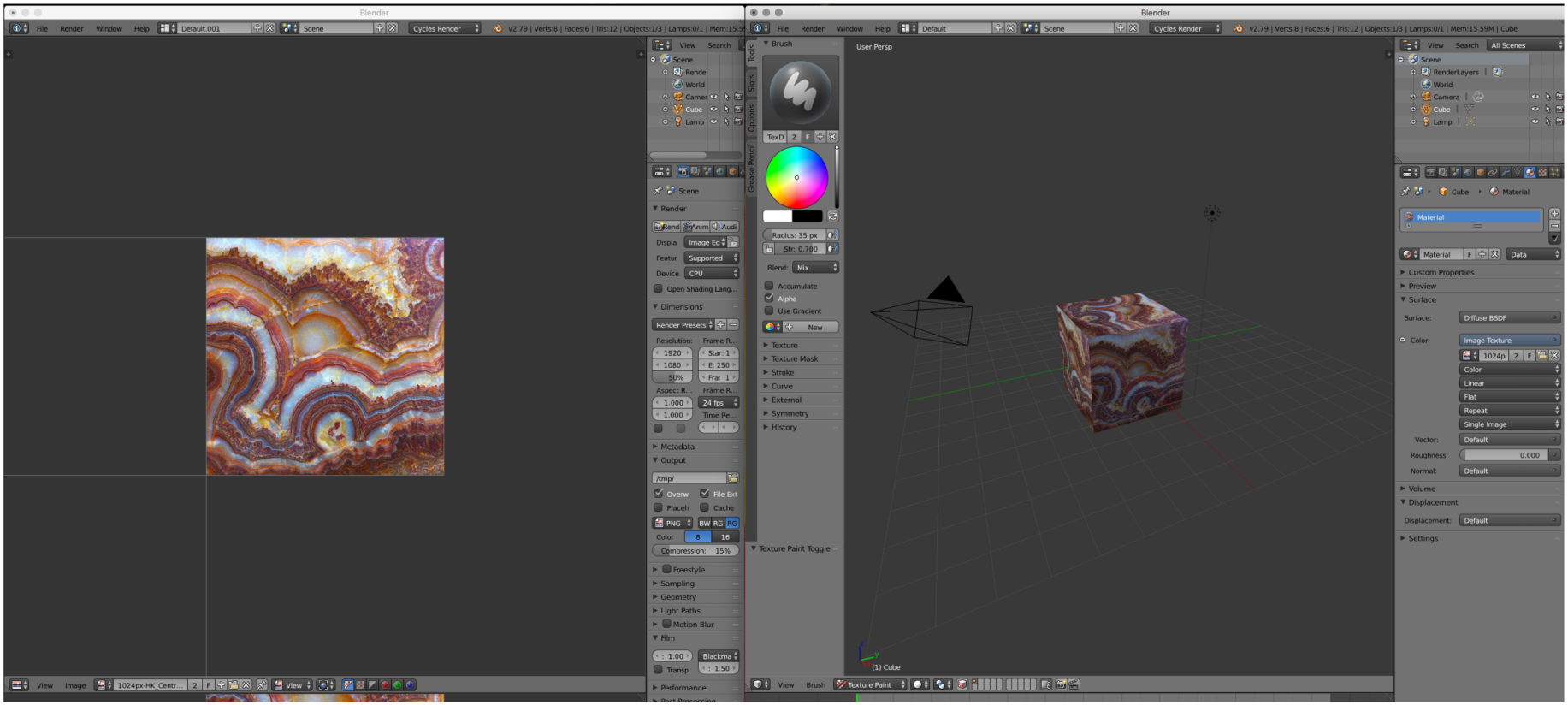


Texture Map from Image



Texture in Blender

- This is the tip of a very useful Iceberg



Credit where credit is due – YouTube video:
"TEXTURE MAPPING For Absolute Beginners - Blender Tutorial"