REALISTIC SIMULATION OF WEATHERED BRONZE

CMPT461 Final Project
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Motivation

- In the real world, every object is imperfect
- Materials may exhibit **wear**, **weathering**, **rust**, **dirt**, etc.
- The more detail, the more realistic the render

Motivation

- Metal is a common material

- We can add another dimension of realism to rendered metal if we take into account:
  - Exposure to weather
  - Imperfection due to fabrication
  - Wear and Tear

Project goals

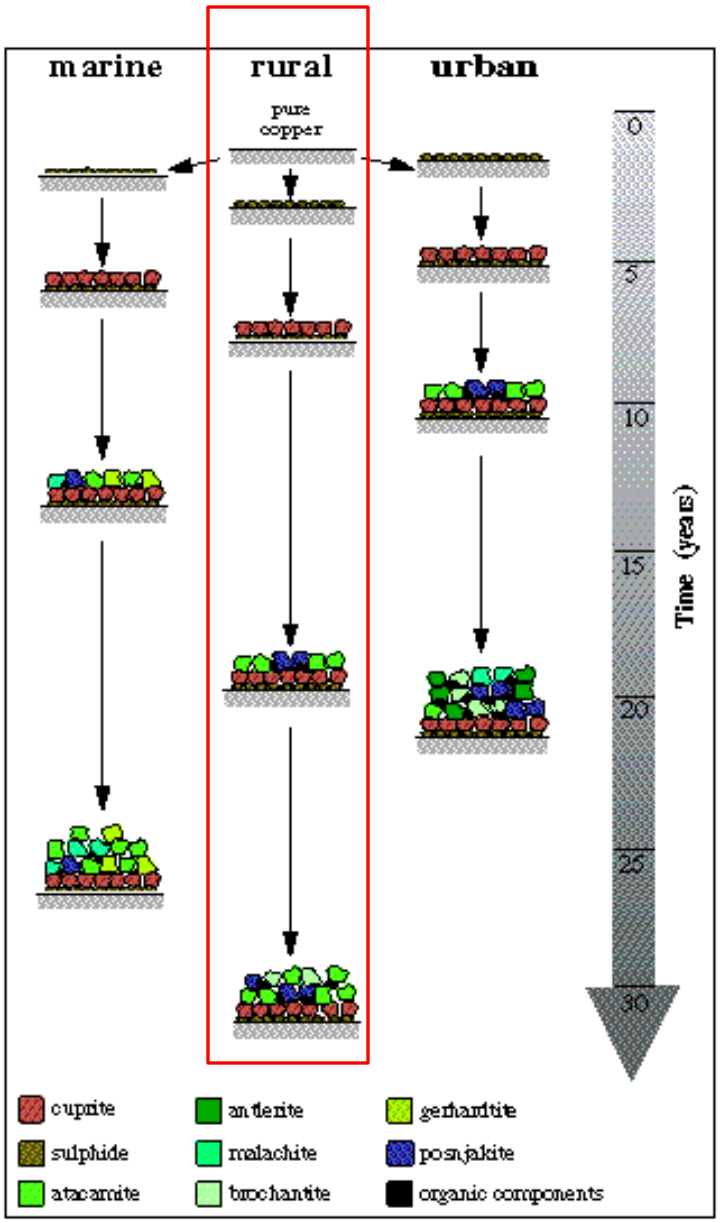
Physical Basis of Patinas

- Patina is a coating of various chemical compounds such as oxides and carbonates
- Forms on copper (bronze)

- Results in a change of *texture* and color

Physical Basis of Patinas

- Exposed Cu quickly forms a thin shiny brown layer, the color that Cu is often known for
- Over time, organic salts such as nitrates and suphides deposits on the first layer, giving the Cu its greenish colour
- Colorful array of minerals: atacamite, ankerite, malachite, gerhardtite, posnjakite
- The formation of patinas greatly depends on the environment: temperature and humidity



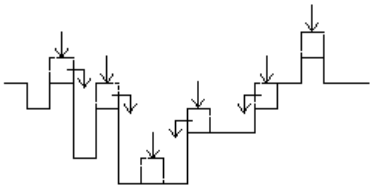
Modeling *(Related Work)*

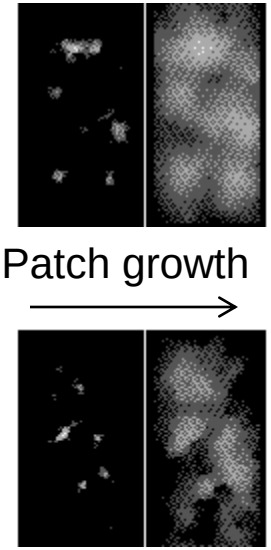
- Dorsey & Hanrahan [1] proposed a method for modeling patinas:
  - Stack of layers of 2D arrays
  - Each layer represents a composition of minerals
  - Different transmittance and reflectance properties
  - Finally map the stack as a texture on the object

[1] J. Dorsey & P. Hanrahan, "Modeling and rendering of metallic patinas". http://tinyurl.com/6tkw4w5

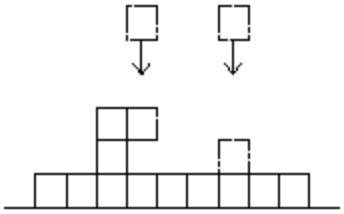
Thickness Map *(Related Work)*

- To simulate the variation of thickness over time, Dorsey [1] implemented several surface growth models:
  - random deposition





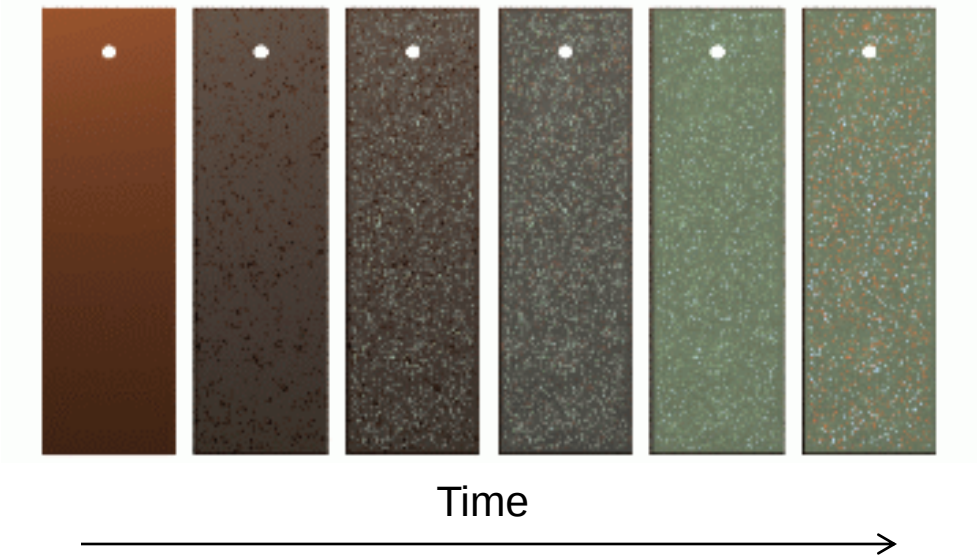
  - ballistic deposition (BD)



Results from Dorsey & Hanrahan

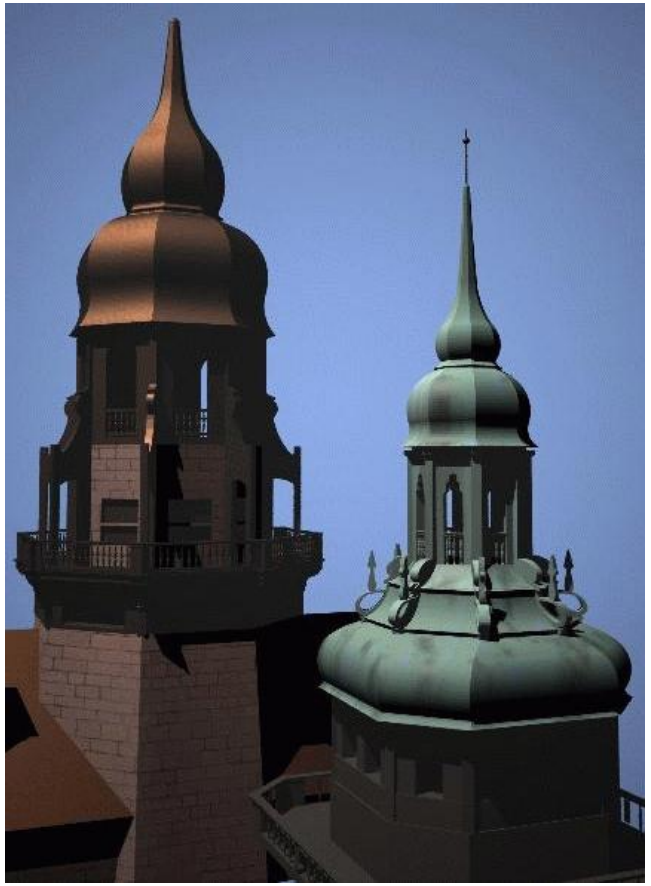
- Results from [1] using simple strips of copper

- These are 2D textures



Results from Dorsey & Hanrahan

- The texture mapped onto objects



My Method

- Problem with Dorsey's method:
  - Still doesn't look very realistic
  - No actual thickness

- Solution:
  - Create the 3D geometric model to realistically mimic patina surfaces, not just map a texture

My Method

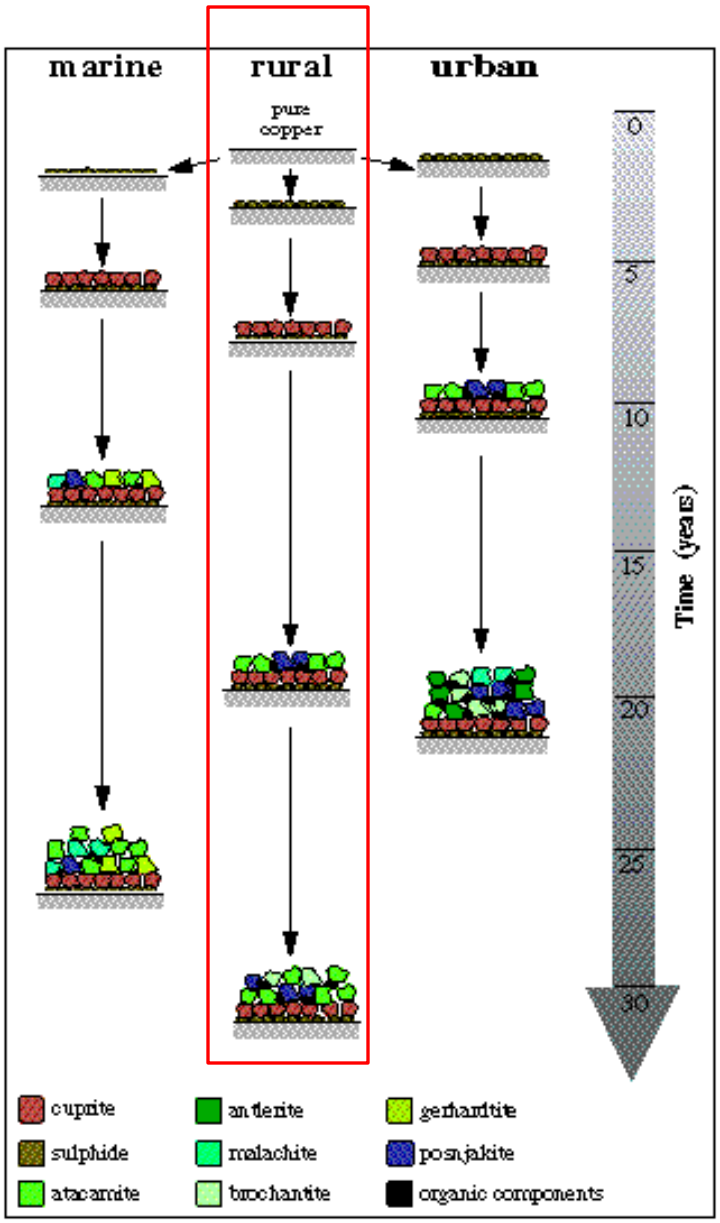
- Parse vertices from a geometric model
  - 1. Randomly pick a few vertices (sample points)
    - Based on the fact that as metal initially weathers, a majority of the change occurs in narrow regions
  - 2. Begin a very short random walk to find a few successive neighboring vertices.
    - This helps to avoid creating circular clumps
  - 3. Insert triangle geometries near the random walked vertices
    - Using Euclidean distance to measure nearness

$$d = \sqrt{(p_1 - q_1)^2 + (p_2 - q_2)^2 + (p_3 - q_3)^2}.$$

- 4. Repeat and let the patch grow in size
  - Patch size determined by a coefficient *K*
  - New triangles inserted near existing triangles
- 5. Now I have one patina layer of a specific mineral

My Method

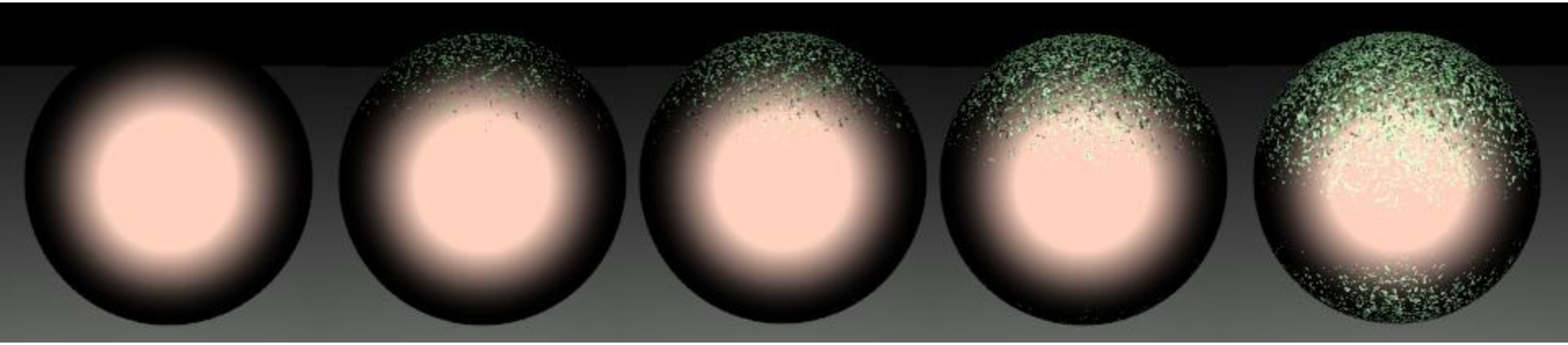
- Repeat above for other minerals



Experiment

- Experiment on Cu sphere as *K* is increased
  - Only 3 different minerals are modeled

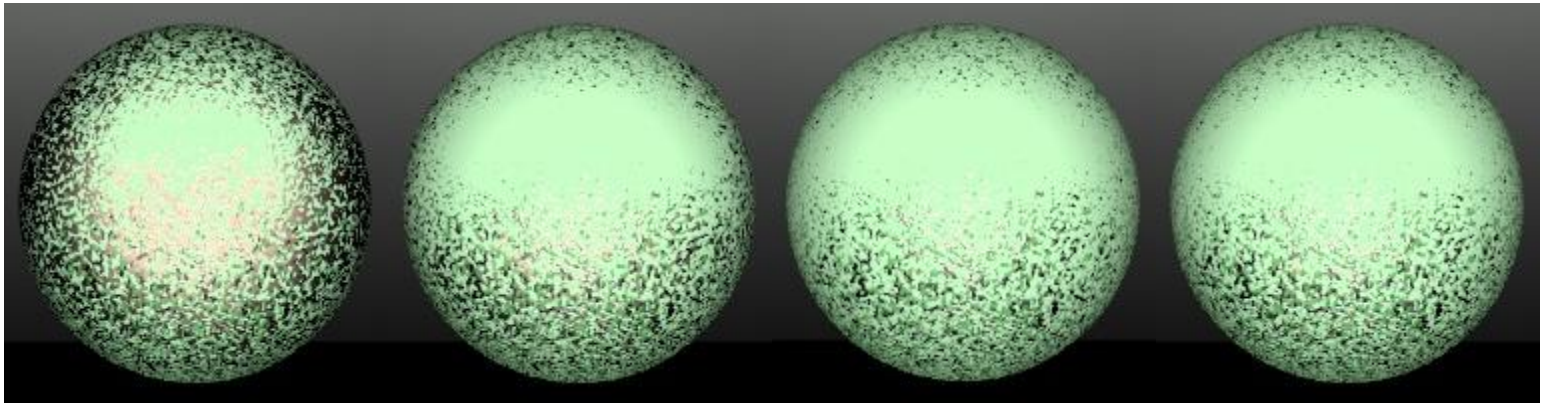
$K \propto$ age



Experiment (cont'd)

- Experiment on Cu sphere as *K* is increased
  - Only 3 different minerals are modeled

$K \propto$ age



Armour Model

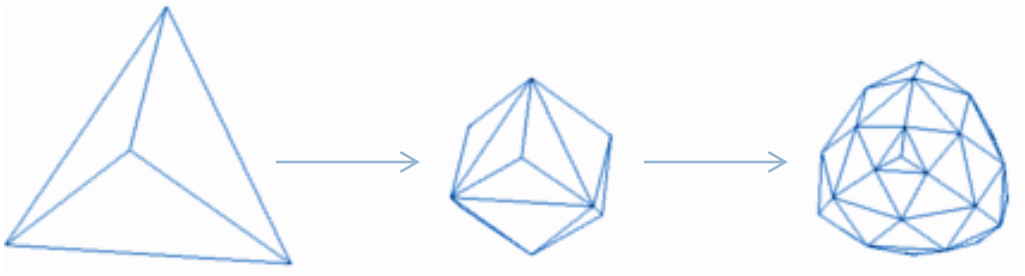
- Reference Images:
  - Ancient bronze armour

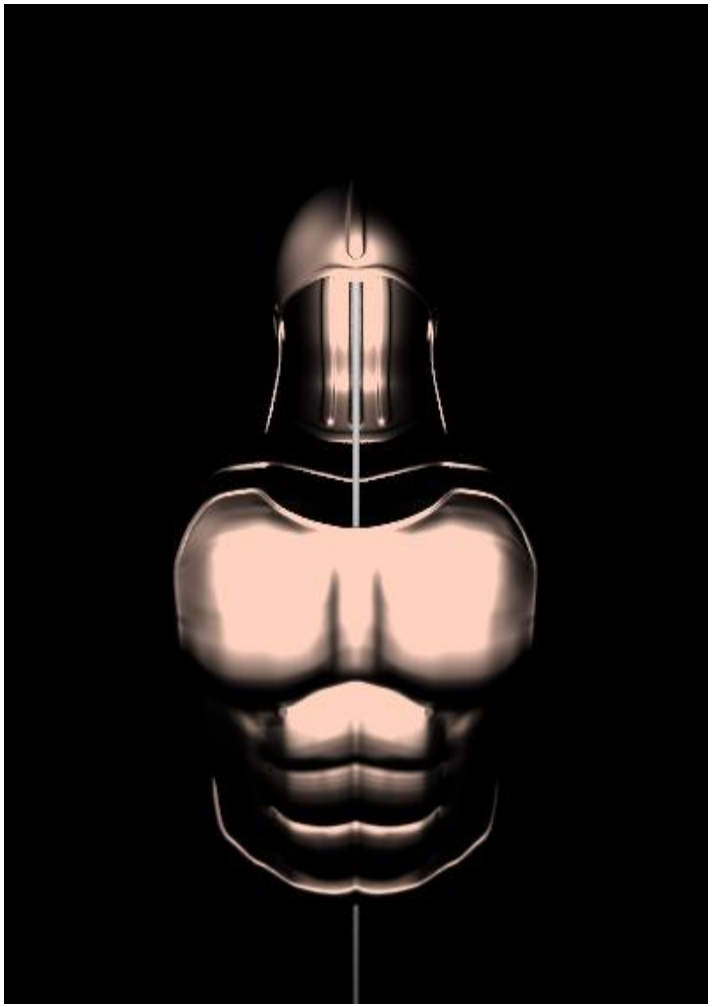
Armour Model

- Luckily, I found a 3d model of an armour online:
  - www.sharecg.com (search “armor m4”)
- Use OBJ2PBRT converter to convert the model to pbrt format
  - http://groups.google.com/group/pbrt/browse_thread/thread/78848e1c87e73347

Armour Model

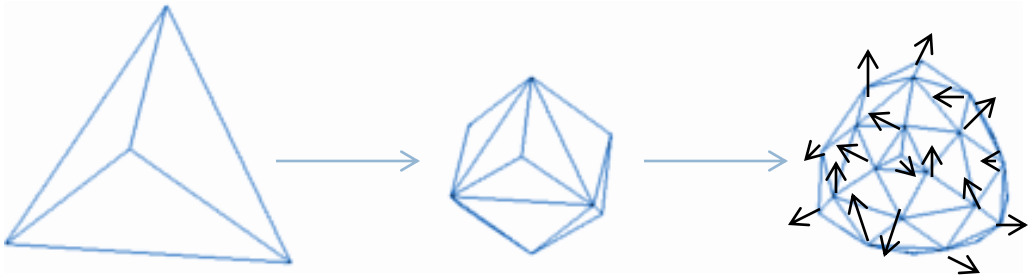
- Use pbrt's loopsubdiv:
  - refines & smoothens the geometric model with more smaller triangle meshes

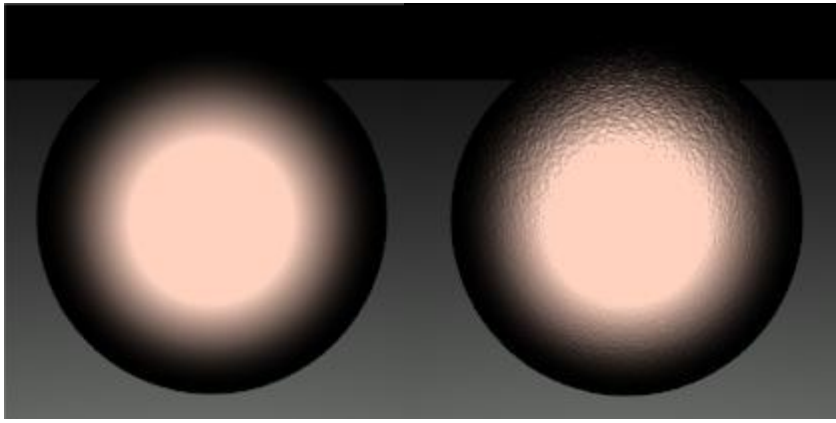




Armour Model

- I modify the loopsubdiv and trianglemesh Classes:
  - Add isotropic noise to displace the points of the refined geometry
    - The noise is created with a pseudo-random number generator and a seeding strategy, Seed(x,y), to ensure consistency [2]
  - This mimics the imperfection caused during fabrication as well as corrosion of the material it ages





Light Source

- For light source and background, I use the following EXR image (mimicking a museum environment)

http://gl.ict.usc.edu/Data/HighResProbes/

- References:

- Final render:

Thank you!

References:

[1] J. Dorsey & P. Hanrahan, "Modeling and rendering of metallic patinas". http://tinyurl.com/6tkw4w5

[2] A. Lagae et al, “Procedural Noise using Sparse Gabor Convolution” http://graphics.cs.kuleuven.be/publications/LLDD09PNSGC/LLDD09PNSGC_paper.pdf