Mapping

Lecturer: Rachel McDonnell
Assistant Professor of Creative Technologies
Rachel.McDonnell@cs.tcd.ie

Course www: https://www.scss.tcd.ie/Rachel.McDonnell/
Credits: Some slides from Prof. Kavita Bala

Introduction

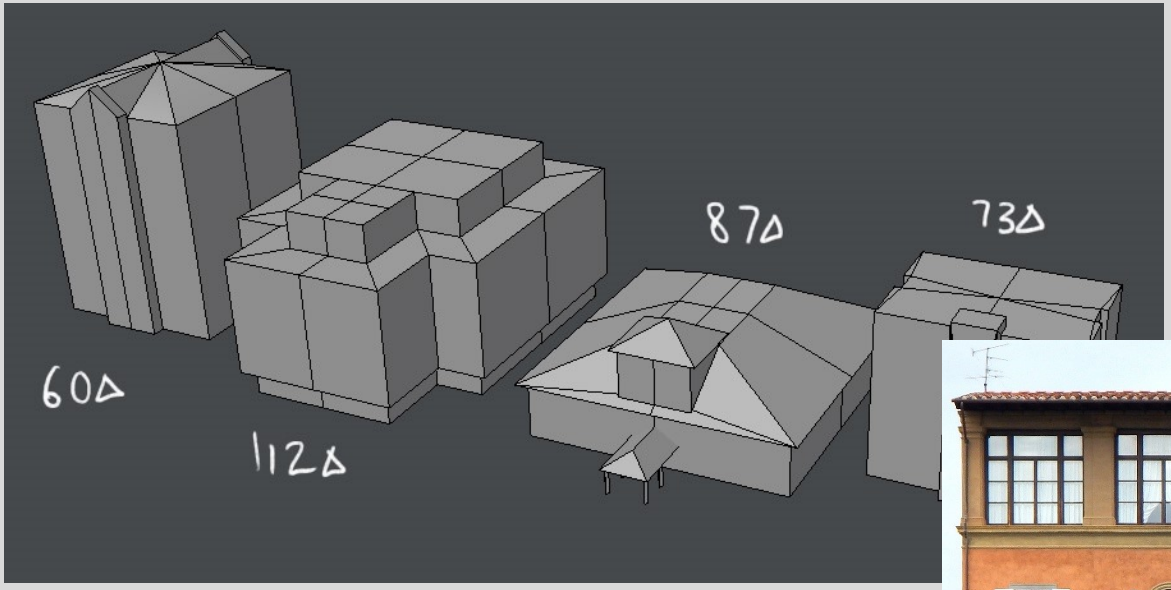
- Adding lots of detail to our models to realistically depict skin, grass, bark, stone, etc., would increase rendering times dramatically, even for hardware-supported projective methods

Unreal Engine 4

Texture Mapping

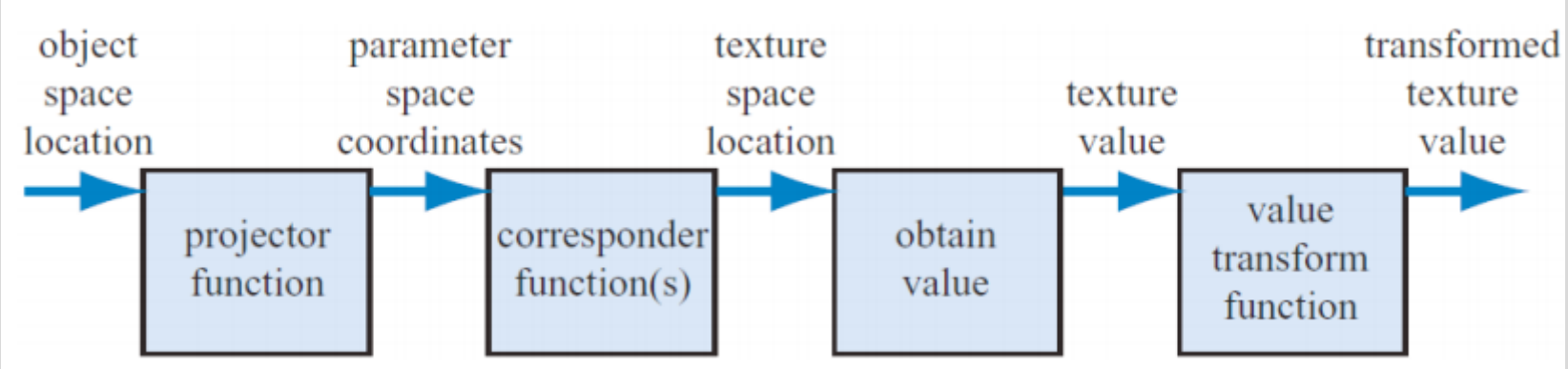
- Texture mapping allows you to take a simple polygon and give it the appearance of something much more complex
  - Due to Ed Catmull, PhD thesis, 1974
- Instead of calculating colour, shade, light, etc. for each pixel we just paste images to our objects in order to create the illusion of realism

Venice Building



How does it work?

- Texturing works by modifying the values used in the shading equation.
- The pixels in the image texture are often called *texels,* to differentiate them from the pixels on the screen



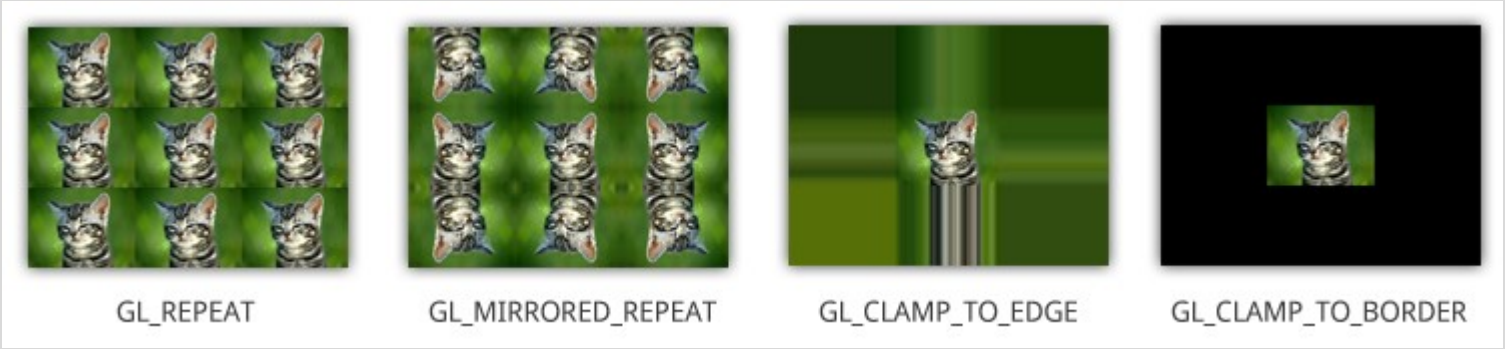
Artist intervention

Artist intervention

- Artist often manually decomposes the model into near-planar pieces
- Tools to help minimize distortion by unwrapping the mesh
- Goal: have each polygon be given a fairer share of a texture's area, while also maintaining as much mesh connectivity as possible

Corresponder Function

- Functions that convert parameter-space values to texture-space locations
- Select a subset of the image for texturing
- Decide what happens at boundaries
- In OpenGL: wrapping mode

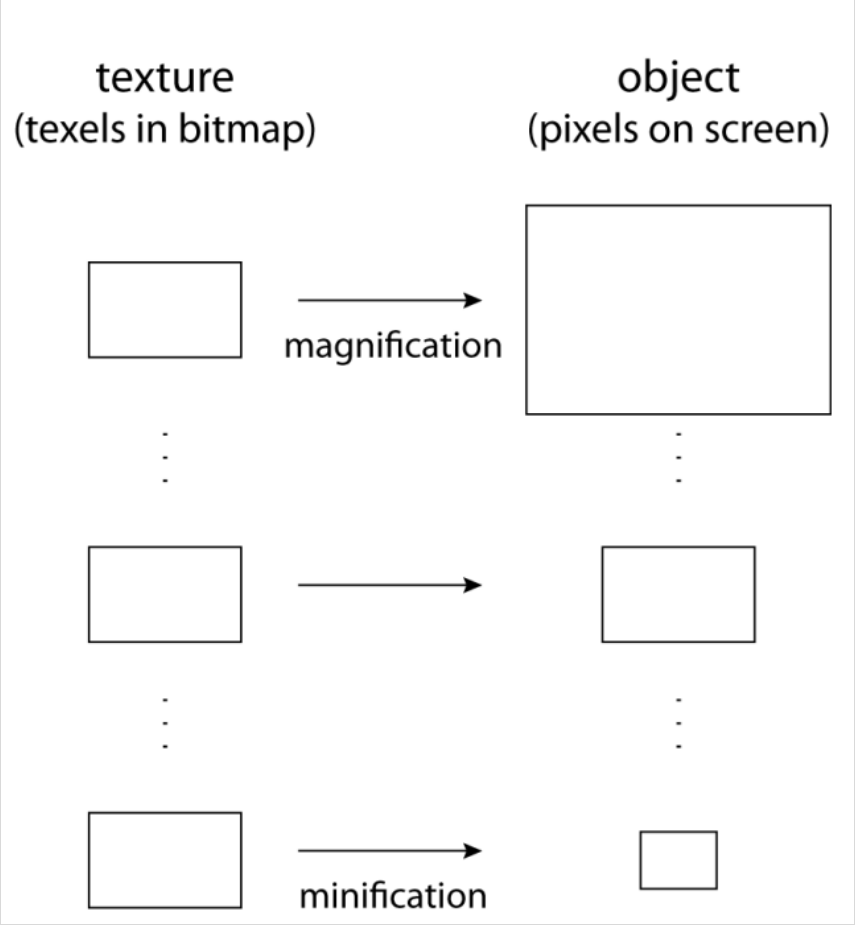


- Wrap: Repeats
- Mirror – Repeats but mirrored every other time; continuity across edges
- Clamp: Clamped to edge of texture
- Border: Clamped to border colour

Magnification, Minifaction

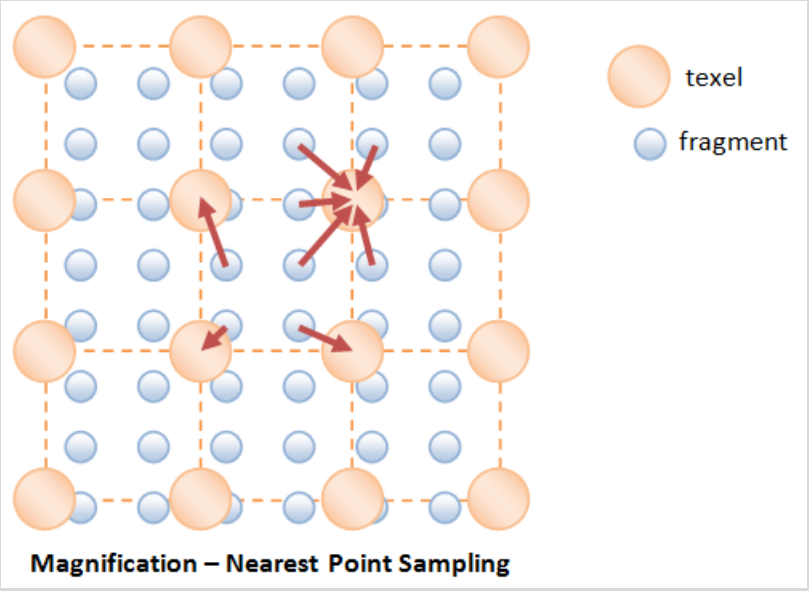
- What if the projected texture square does not match the screen size?
- Magnification, Minifaction is required.

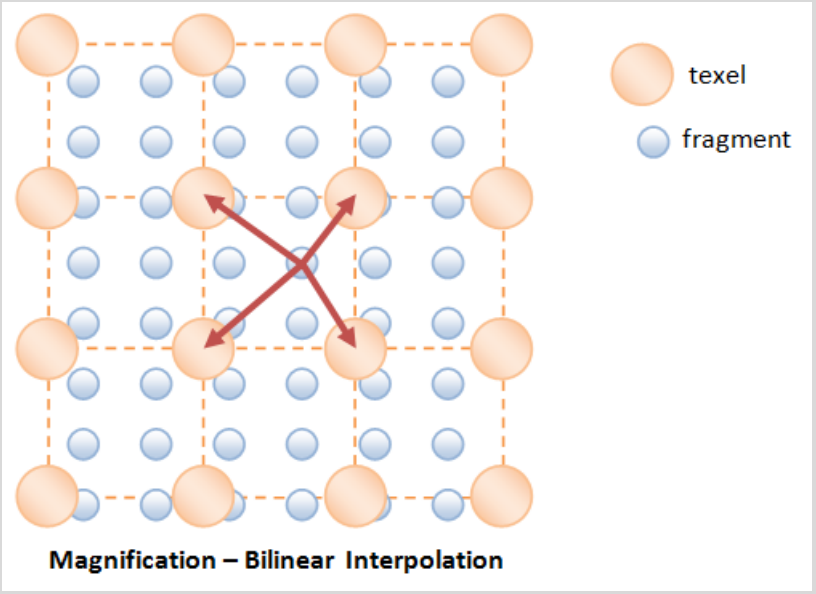
Magnification, Minifaction



- If viewer is close: Object gets larger → Magnify texture
- "Perfect" distance: Not always "perfect" match (misalignment, etc.)
- If viewer is further away: Object gets smaller → Minify texture
- Problem with minification?
  - efficiency (esp. when whole texture is mapped onto one pixel!)

Magnification





https://www.ntu.edu.sg/home/ehchua/programming/opengl/CG_BasicsTheory.html

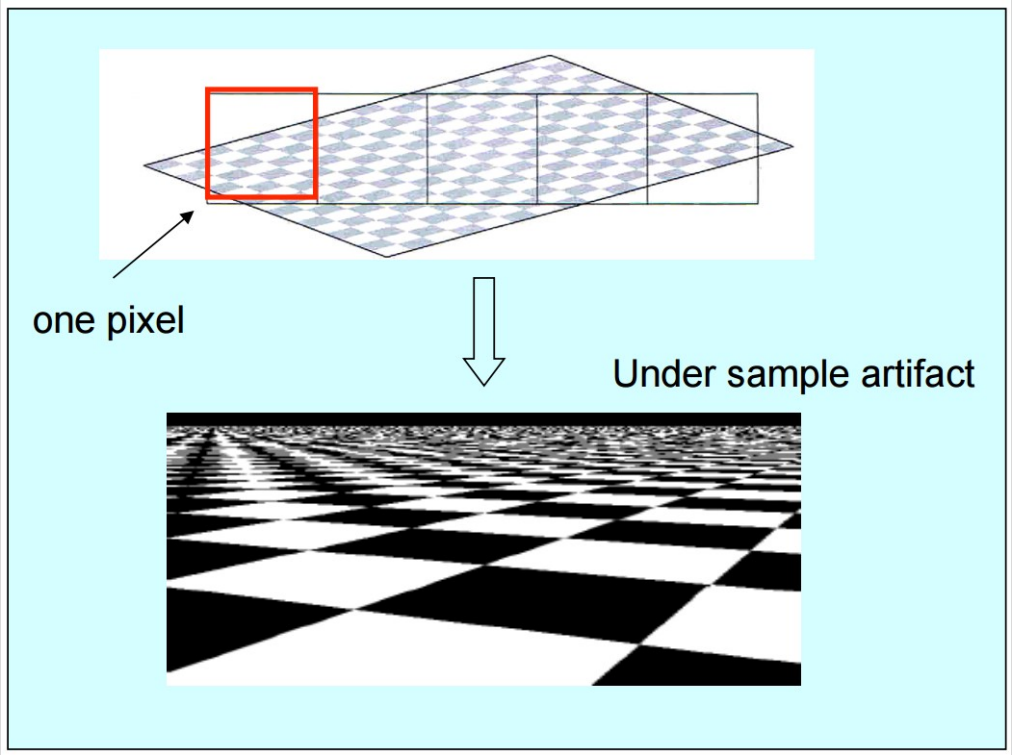
Magnification

https://csantosbh.wordpress.com/

Magnification

Magnification aliasing – walls are lower resolution than on-screen pixels (Tomb Raider, Eidos Interactive, 1996)

Minification



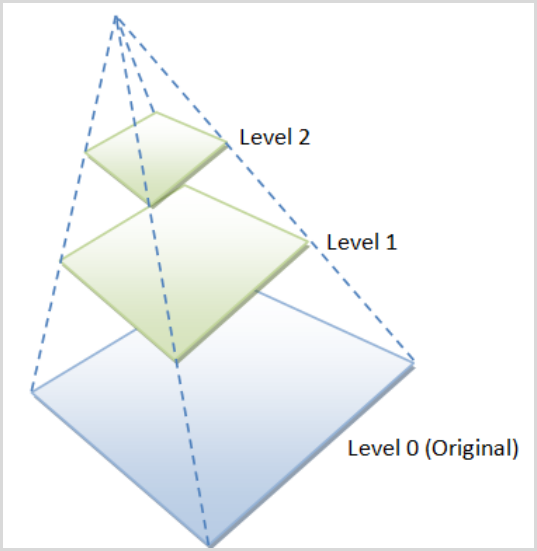
- Several texels cover one pixel (under sampling happens)
- Solution: Either increase sampling rate or reduce the texture Frequency

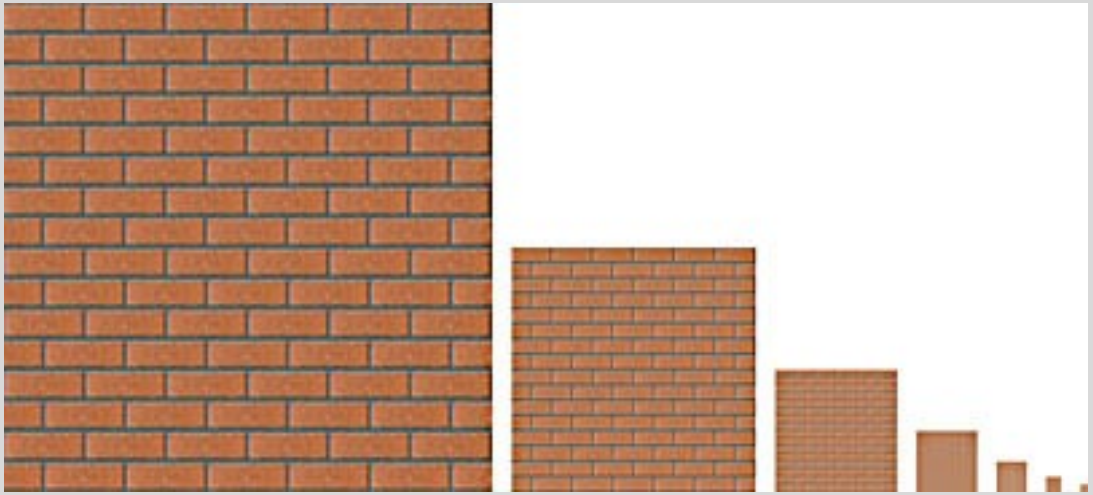
Minification

Visible flicker when camera moves

Minification aliasing – trees are higher resolution than on-screen pixels (Combat Mission, Battlefront.com, 1999)

Solution – MIP maps

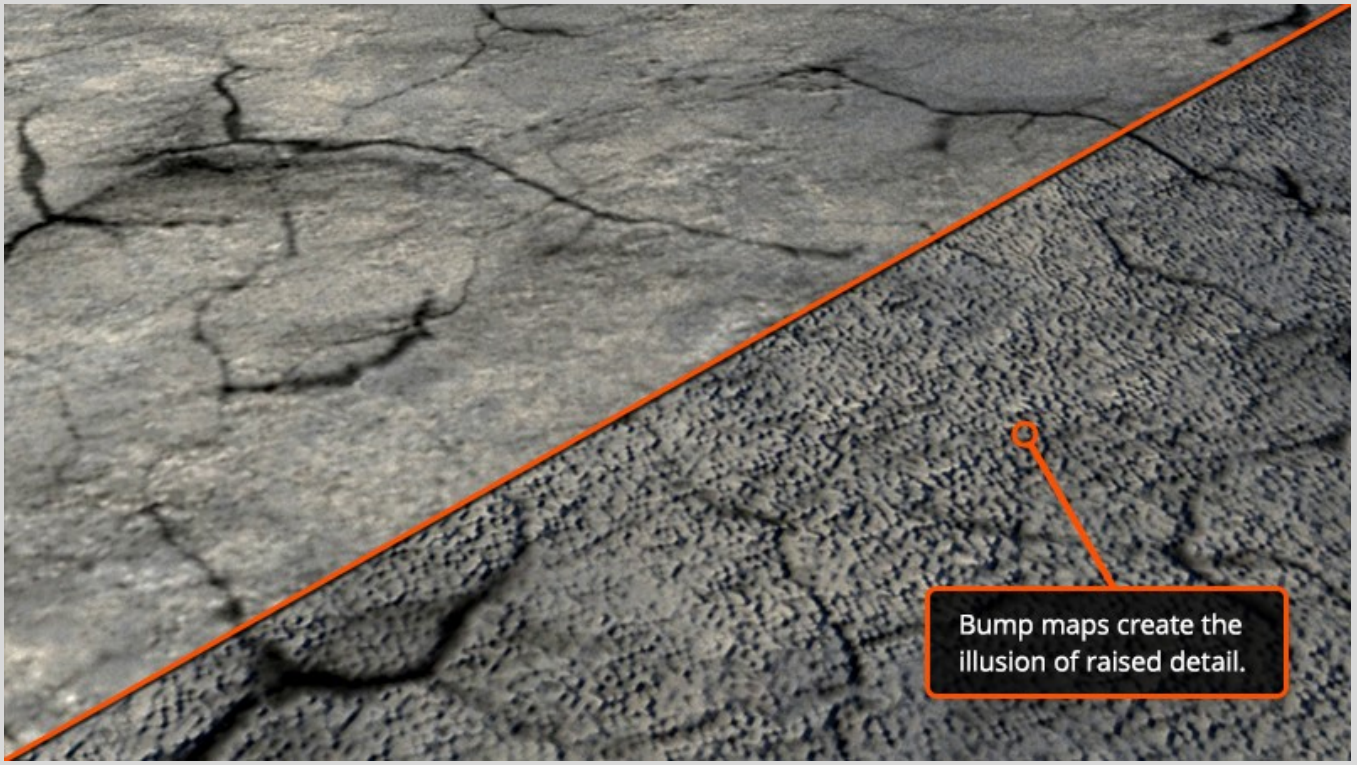




- Pre-calculated, optimized collections of images based on the original texture
- Dynamically chosen based on depth of object (relative to viewer)
- Supported by todays hardware and APIs

Bump Maps

- One of the reasons why we apply texture mapping: Real surfaces are not flat but often rough and bumpy.



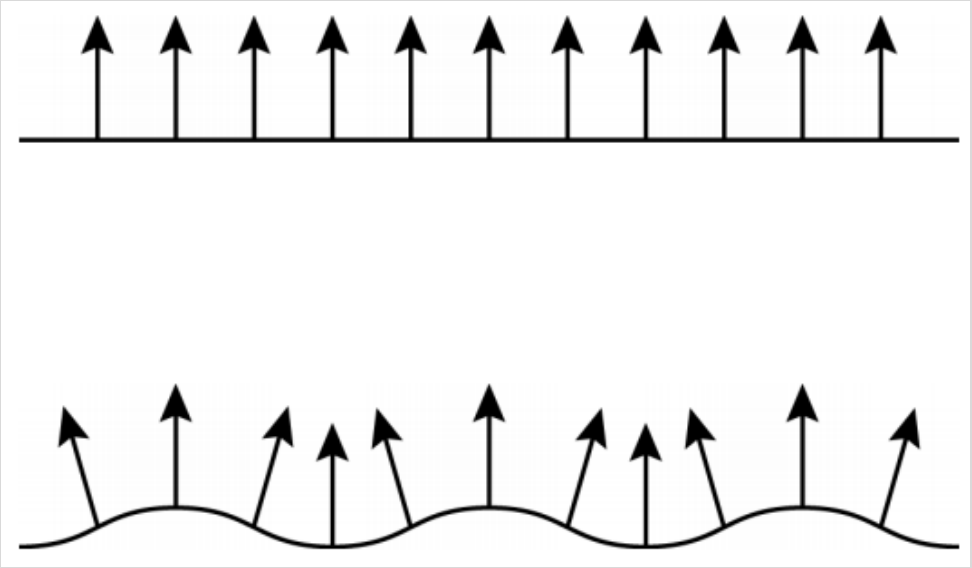
http://blog.digitaltutors.com/bump-normal-and-displacement-maps/

Bump Maps

- Bump maps create the illusion of depth on the surface of a model using a very simple lighting trick.
- No additional resolution is added to the model as a result of a bump map.
- Typically, bump maps are grayscale images that are limited to 8-bits of color information. That's only 256 different colors of black, gray or white. These values in a bump map are used to tell the 3D software basically two things. Up or down.

Normal mapping

- Normal maps can be referred to as a newer, better type of bump map
- Also faking detail
- These bumps cause (slightly) different reflections of the light



Normal mapping

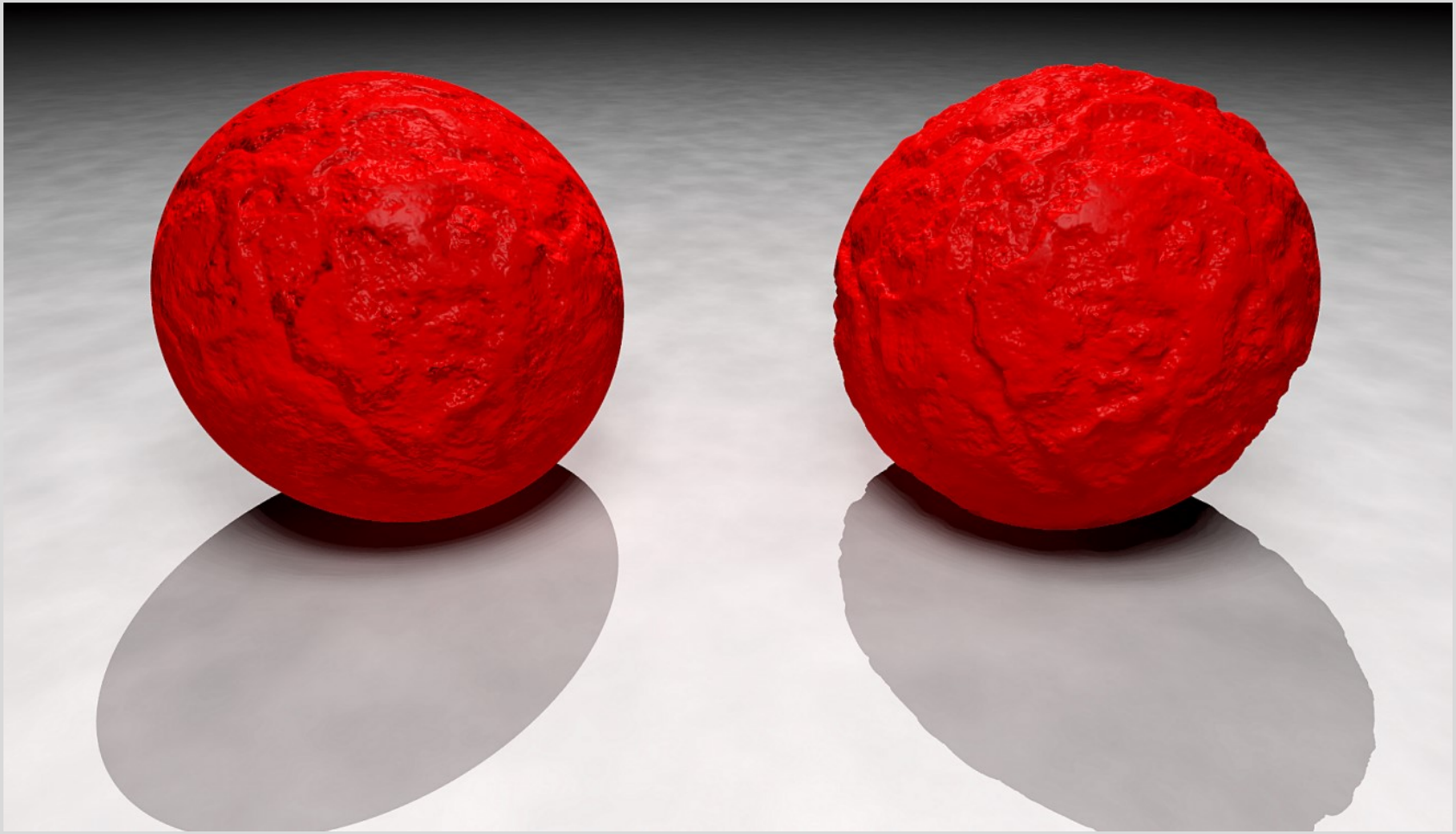
- Instead of mapping an image or noise onto an object, we can also apply a normal map, which is a 2D or 3D array of vectors. These vectors are added to the normals at the points for which we do shading calculations

- The effect of normal mapping is an apparent change of the geometry of the object.

Normal mapping

- Instead of using a texture to change colour component in the illumination equation, we access a texture to modify the surface normal.
- Geometric normal remains the same; we merely modify the normal used in the lighting equation
- Implemented by modifying the per-pixel shading routine
- A normal map uses RGB information that corresponds directly with the X, Y and Z axis in 3D space

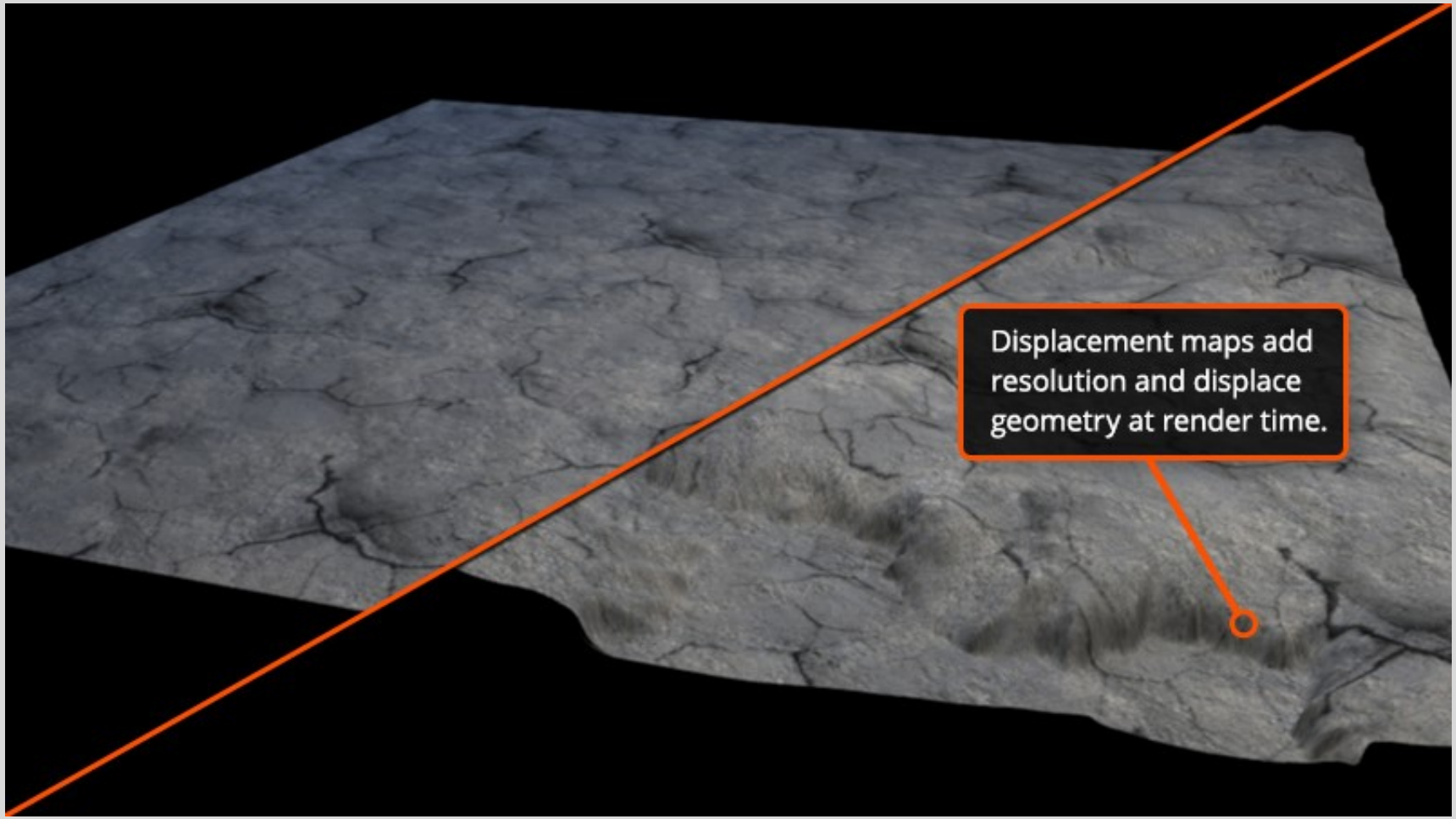
Major problem?



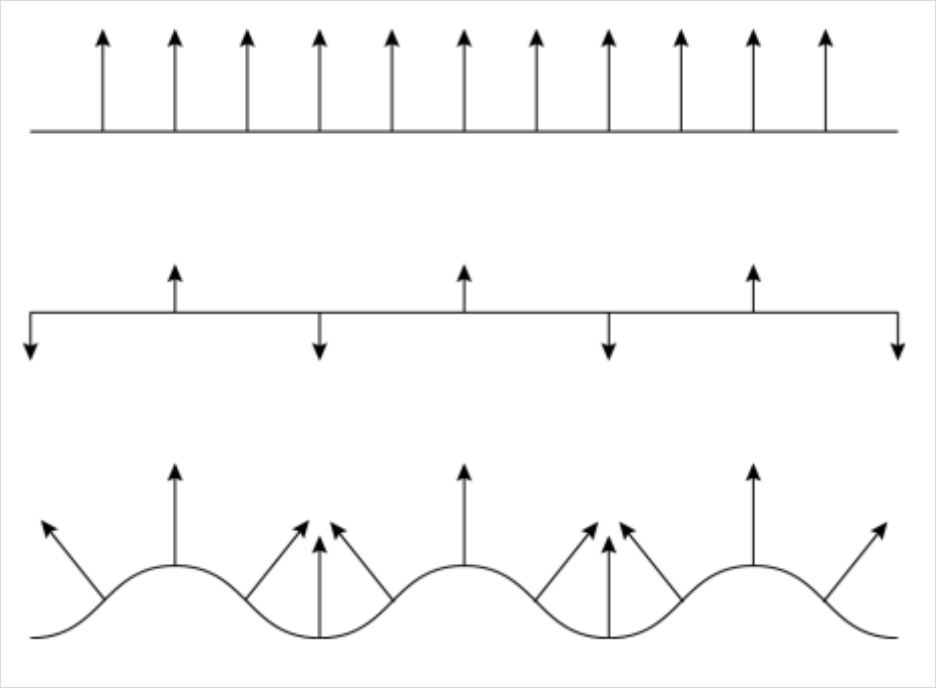
Displacement mapping

- To overcome this shortcoming, we can use a displacement map. This is also a 2D or 3D array of vectors, but here the points to be shaded are actually **displaced**.
- Normally, objects are refined using the displacement map, giving an increase in storage requirements

Displacement Maps



Displacement Mapping

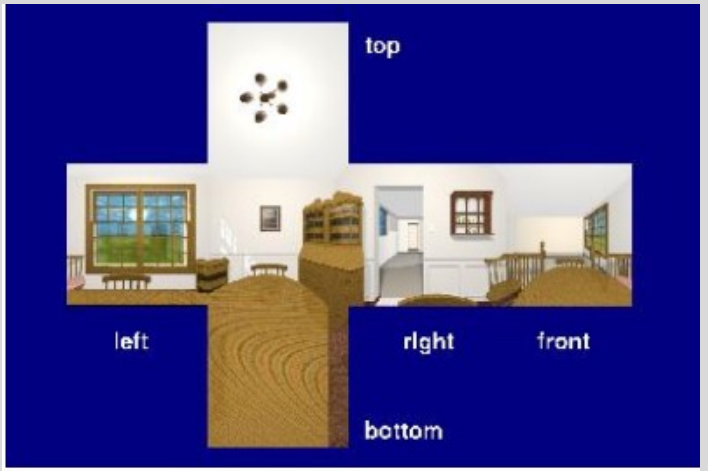


Problem?

- More challenging:
  - Collision detection
  - Object intersection
  - Foot placement

Environment Mapping

- ... why not use this to make objects appear to reflect their surroundings specularly?
- Idea: place a cube around the object, and project the environment of the object onto the planes of the cube in a pre-processing stage; this is our texture map.
- During rendering, we compute a reflection vector, and use that to look-up texture values from the cubic texture map.



Environment Mapping

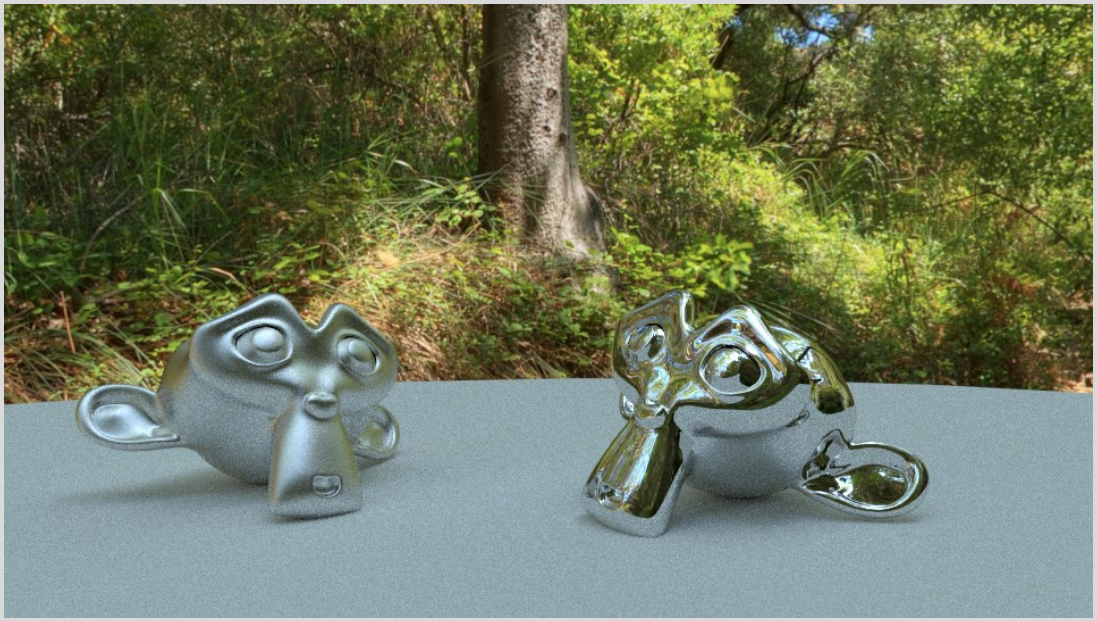
- When you look at a highly reflective object such as a chrome sphere, what you see is not the object itself but how the object reflects its environment.

http://http.developer.nvidia.com/CgTutorial/cg_tutorial_chapter07.html

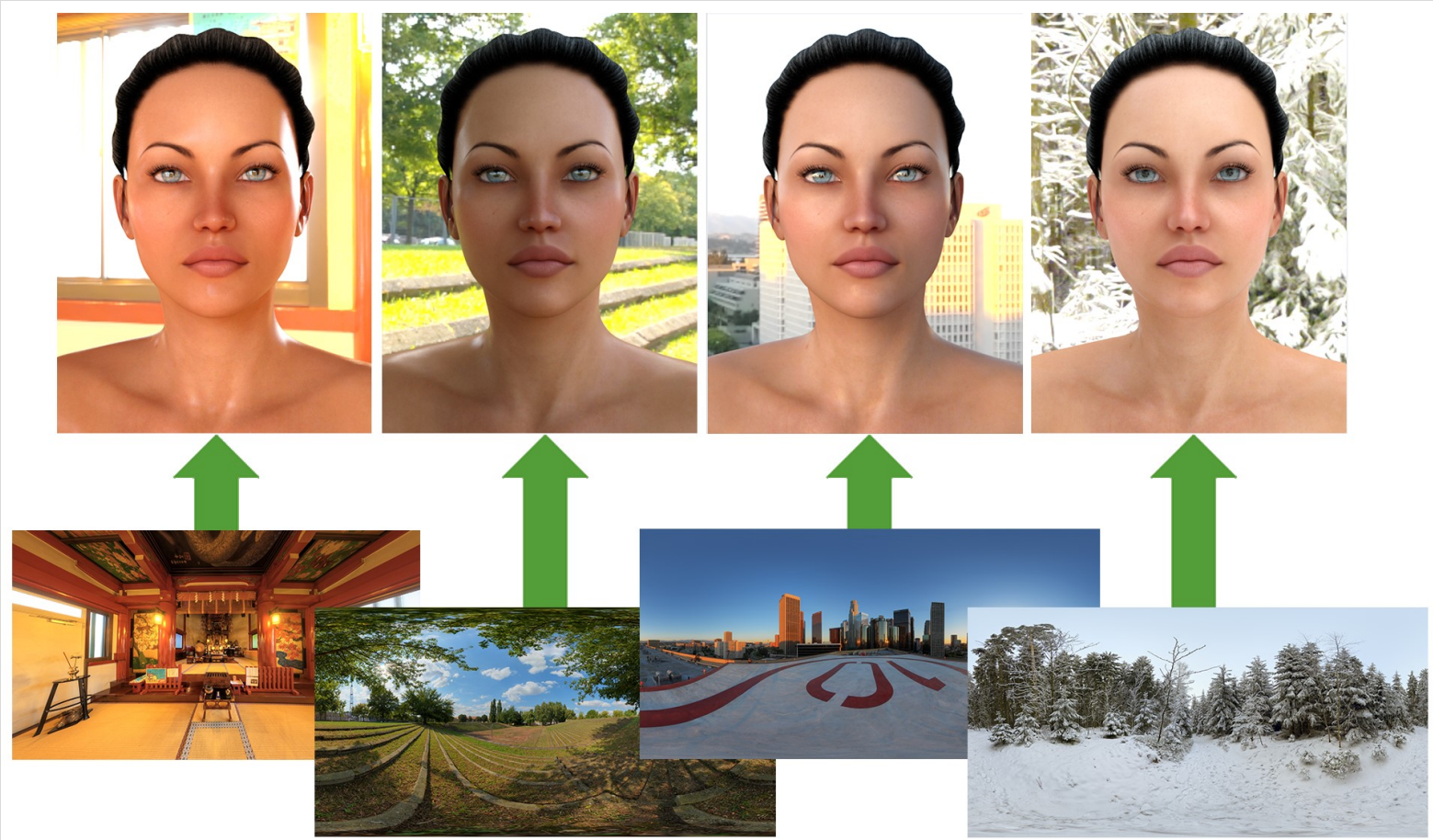
Environment Mapping

- Ideally, every environment-mapped object in a scene should have its own environment map.
  - In practice, objects can often share environment maps with no one noticing.
- In theory, you should regenerate an environment map when objects in the environment move or when the reflective object using the environment map moves significantly relative to the environment.
  - In practice, convincing reflections are possible with static environment maps.
- Because environment mapping depends solely on direction and not on position, it works poorly on flat reflective surfaces such as mirrors, where the reflections depend heavily on position.
- In contrast, environment mapping works **best on curved surfaces**.

Environment Mapping



Environment Mapping



http://docs.daz3d.com/doku.php/public/software/dazstudio/4/new_features/start

Extra Reading

- Environment Mapping: http://www.pauldebevec.com/Probes/
- Real-time Rendering, 3rd Edition, Akenine-Moller