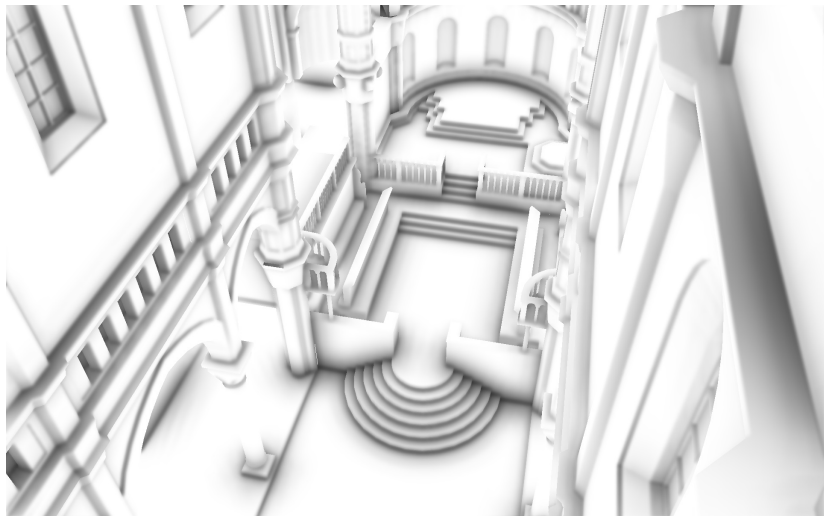


Lesson 5
Screen-space ambient occlusion (SSAO)
Depth of field (DoF)
PV227 – GPU Rendering

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Ambient occlusion

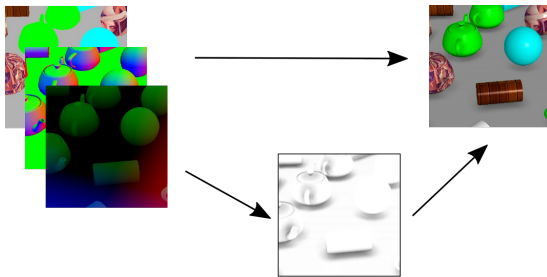


Ambient occlusion (HBAO+ technique, from *GeForce.com*)

Principles of screen-space ambient occlusion

Basic principle

- look at each pixel's neighbourhood and estimate the occlusion



Sampling the neighbourhood

Sampling points in the hemisphere

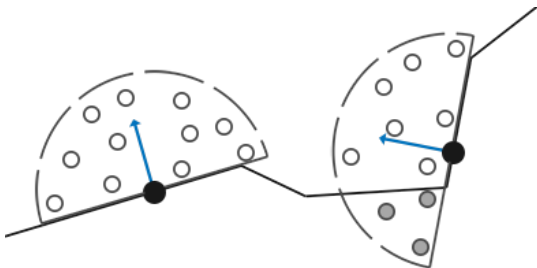
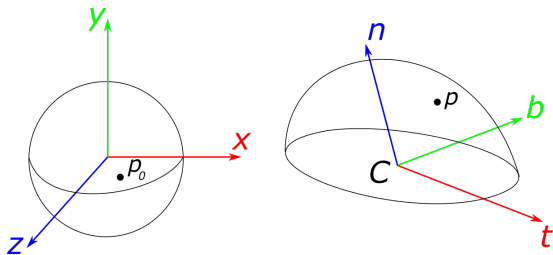


Image from *learnopengl.com*

Tangent space for the hemisphere

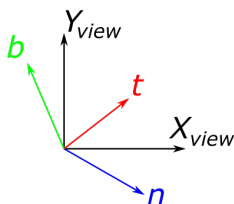
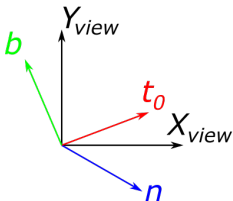
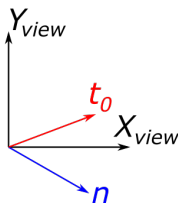
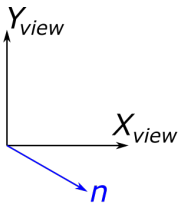
- Basic position $p_0 = (x, y, z)$
- Tangent space $(\vec{t}, \vec{b}, \vec{n})$



$$p = C + x\vec{t} + y\vec{b} + z\vec{n}$$

Finding the tangent and bitangent

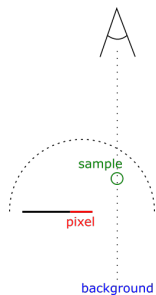
- Choose a random \vec{t}_0 in xy plane in view space
- Compute $\vec{b} = \vec{n} \times \vec{t}_0$
- Compute $\vec{t} = \vec{b} \times \vec{n}$



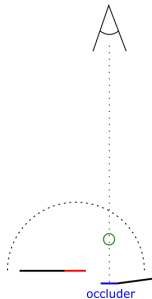
Comparing the distance

Compare the distances from the viewer of:

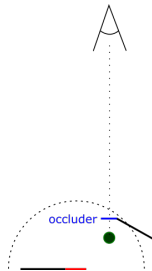
- sample (occludee)
- object visible at that point (occluder)



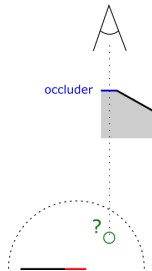
a)



b)



c)

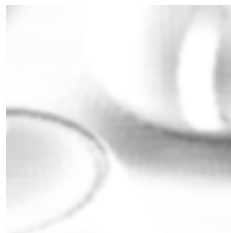


d)

Blurring the result



Without blur



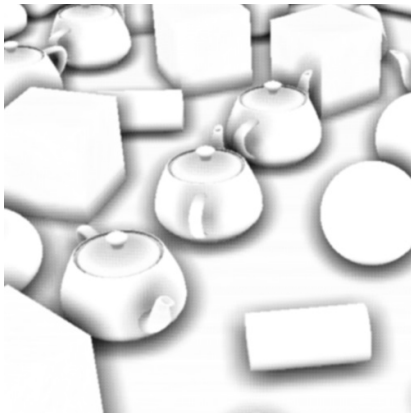
With blur

Task: Evaluate SSAO

● Task 1: Evaluate SSAO

- ▶ Don't worry, a lot of things is already done.
 - ★ G-buffer already contains positions and normals in view space.
 - ★ Random positions of samples are already computed and stored in a UBO.
 - ★ Random directions for the tangents are already computed and stored in a texture.
 - ★ Blurring of SSAO texture is already implemented.
 - ★ Computation of the tangent and bitangent is already done.
 - ★ Computation of the position of the sample and the position of the possible occluder is already done.
- ▶ In *evaluate_ssao_fragment.glsl*, compute the distance of the possible occluder and the sample (occludee) from the camera.
- ▶ Implement comparing cases a), b), and c).

Task: Evaluate SSAO

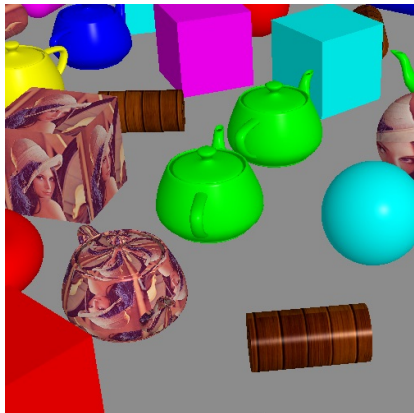


Result

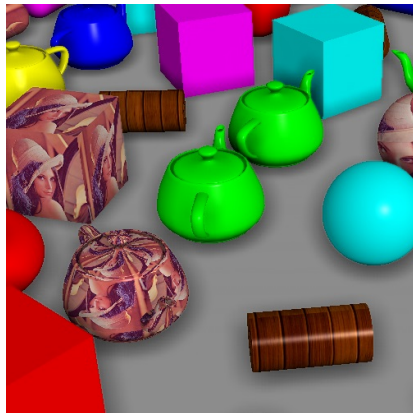
Task: Apply SSAO

- **Task 2:** Apply SSAO to the lighting
 - ▶ In *evaluate_lighting_fragment.glsl*, apply the value in texture *ssao_tex* in the computation of lighting.

Task: Apply SSAO



Without SSAO



With SSAO

Task: Improve SSAO

- **Task 3:** Implement comparison case d)

Task: Improve SSAO



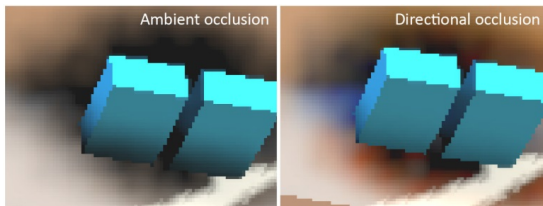
Without comparison d)



With comparison d)

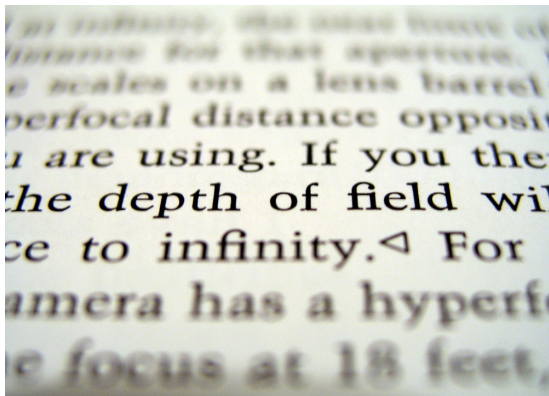
Other methods for ambient occlusion

- Screen-space Directional Occlusion (SSDO)



- Horizon based: HBAO, HBAO+
- Voxels: VXGI

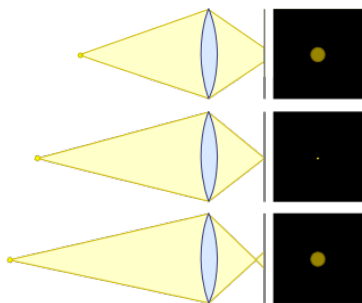
Depth of Field



Depth of field (Source Wikipedia)

Circle of confusion

- Objects out of focus appears as circles (**circle of confusion**)
- Radius of CoC can be calculated from the parameters of the camera

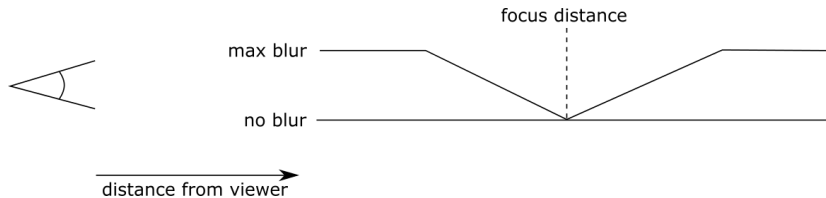


Circles of confusion (Source Wikipedia)

Our simple solution

A simple version:

- Linearly increase the blur radius, up to some maximum



Task: Evaluate Depth of Field

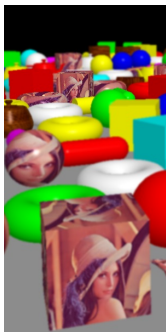
- **Task 4:** Evaluate DoF

- ▶ Shader *dof_fragment.glsl* already blurs the image using gaussian blur.
- ▶ Compute width of the blur and store it into *blur_width*. The distance of objects in focus is in uniform variable *focus_distance*.

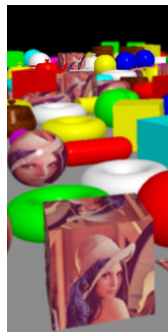
Task: Evaluate Depth of Field



Close focus



Middle focus



Far focus

Other methods for DoF

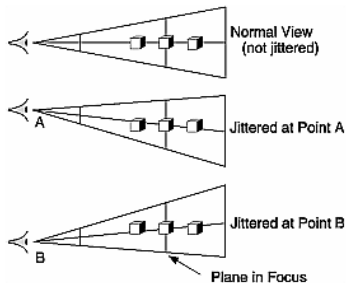
- Splat circles or polygons, one per pixel → create bokeh



Bokeh (Source Wikipedia)

Other methods for DoF

- Render the scene multiple times, each time with a slightly shifted camera, and average the results



Source OpenGL Programming Guide

- Render multiple layers, blur each layer uniformly
- In raytracing, simulate the optics of the camera.

Things we used

- *textureLod*
 - ▶ Just like *texture*, but explicitly states LOD for mipmap.
 - ▶ Necessary when LOD cannot be computed automatically (in divergent code like if's, for's etc.)
- *textureSize*
 - ▶ Returns the size of given mipmap level of the texture
- *gl_FragCoord*
 - ▶ Only in fragment shaders
 - ▶ *.xy* contain the coordinate of the fragment on the screen
 - ▶ *.z* contains the depth to be stored into depth buffer
 - ▶ *.w* contains $1/w$ of *gl_Position* variable, after interpolation.