LUNDS TEKNISKA HÖGSKOLA Institutionen för datavetenskap

Exam
EDAN 35
High Performance Computer Graphics

2015–01–13, 14.00–19.00

Remember to answer the questions as thoroughly as you can without diverging from the question.
You should strive to give as clear a picture of your understanding as possible.
Ensure that you write so that someone other than yourself can read it.
Please answer in english.

Grading: The maximum score is 6.0. A score of 3.0 or above is needed to pass.

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1. Rasterization
   a) Describe how barycentric coordinates can be calculated from edge functions. Use equations to explain your answer. *(0.2p)*
   b) Describe how barycentric coordinates can be used to interpolate a triangle's vertex attributes. Use equations to explain your answer. *(0.1p)*
   c) Some pixels lie on the edge between two triangles. When using the edge function to determine if a point is inside a triangle, how can you ensure that the pixel belongs to only one triangle in this case? *(0.2p)*
   d) Why is perspective correction necessary for triangle interpolation? Use the barycentric cordinate from the previous question and explain how to correct it's value for perspective using equations. *(0.3p)*
   e) Explain two advantages of tile based traversal. *(0.2p)*

2. Deferred Shading and Shadows
   a) Deferred Shading is a popular technique in modern games. Explain why? *(0.1p)*
   b) What values are stored for Deferred Shading in the geometry buffer and how are they used. *(0.3p)*
   c) Rendering spotlights using deferred shading requires a more complex algorithm than rendering simple point lights. In particular, special geometry is used to represent the light and then rendered using culling and depth testing. Explain the what geometry is rendered, what passes are used and what render state is needed for each pass. Mention any advantages or disadvantages of your chosen method. *(0.4p)*
   d) Give an example of an artifact you could get with shadow maps and how you can fix that artifact. *(0.2p)*

3. Texture Mapping and caching

   a) Describe how texture filtering works when minification and magnification occurs. Explain which pixels are used and how they are combined. Use diagrams to explain your answer. *(0.4p)*

   b) Describe how trilinear mip-mapping works. Describe the input data and how it is processed mathematically. *(0.2p)*

   c) How does trilinear mip-mapping affect texture cache performance? *(0.1p)*

   d) When reading texture map colors from memory, different organisation of the data can affect the effectiveness of a cache. If the pixels in the following layout are stored in memory using the address indicated, what will happen when traversal moves in a horizontal direction? What will happen when traversal moves in a vertical direction?

0	1	2	3
4	5	6	7
8	9	10	11
12	13	14	15

   Draw a better layout for the pixels and explain why it is better. *(0.4p)*

4. Z Culling and compression

   a) GPU Rasterization uses a technique called Depth Buffering. Depth Buffering compares the Z value of each pixel to a previously stored value to determine the visibility of the pixel. Explain two methods of accelerating this per-pixel comparison that also reduces bandwidth and takes advantage of tile based rasterization. Use diagrams to illustrate your answer. *(0.3p)*

   b) Explain the best method to calculate one of the stored hierarchical values used in the acceleration technique described in the previous question. *(0.2p)*

   c) There are several differences between a texture compression/decompression algorithm, and buffer (e.g., color and depth) compression and decompression algorithms. Mention two important ones, and argue why these are important. *(0.2p)*

   d) Describe how plane equation depth compression works. Mention in your answer what data is stored, how it is used to reconstruct per pixel depth values, and what advantages it has over other depth compression schemes. Use diagrams to illustrate your answer. *(0.3p)*

5. Architecture

   a) Draw a picture of the straight (non-unified) graphics hardware pipeline as discussed in the lectures.
   Describe what each stage of the pipeline does.
   Include in your answer the input and output data of each stage.
   (.1 point for each stage). *(0.6p)*

   b) GPUs are massively parallel. Mention 3 ways in which they achieve this and describe what each is. *(0.3p)*

   c) Name two differences between OpenCL and OpenGL? *(0.1p)*

6. Fixed-point, Anti-aliasing and Phong shading

   a) Given two fixed point numbers $i_1.f_1$ and $i_2.f_2$, where i is the number of integer bits and f is the number of fractional bits how many bits of integer and fractional will you get if you multiply them together? *(0.1p)*

   b) Using the fixed point numbers from the previous question, how many bits will you get if you add them together? *(0.1p)*

   c) If two fixed point numbers have different numbers of fractional bits what must be done before adding them together? What C/C++ integer operation is best used for this? *(0.1p)*

   d) Anti-aliasing(AA) is performed by increasing the number of samples inside a pixel. Draw a picture showing the possible location of 4 samples within a pixel and explain why these sample positions are better than a regular grid. *(0.2p)*

   e) Imagine you are making your own game. AA can be implemented using hardware or software, what AA algorithms or features would you use and why? *(0.2p)*

   f) The following Phong pixel shader has 3 errors. Name the errors. *(0.3p)*

```
out vec4 outColor;

in vec3 worldNormal;
in vec3 worldView;

const float kd = 0.5;
const vec3  L = vec3(1.0,1.0,1.0);
const vec4  diffuseColor = vec4(0,0.5,0.5,1.0);

void main()
{
    vec3 N = normalize(worldNormal);
    vec3 V = worldView;
    vec3 R = reflect(1.0, N);

    float diffuse =  kd       * max( dot(N,normalize(L), 0.5);
    float specular = (1.0-kd) * pow( max( dot(R,V), 10), 0.0);
    outColor = diffuseColor  * (diffuse + specular);
}
```

The end!

Course evaluation
Please answer the questions below. You can detach this page, and hand it in anonymously.

	Fully disagree				Fully agree
1. This course was fun and enjoyable	☐	☐	☐	☐	☐

2. What did you like about this course?

3. What did you not like about this course?

4. What would you like more of in this course?

5. What would you like less of in this course?

6. What did the type of examination (assignments, project, written exam) mean to your learning?

7. What did you think about the goals (i.e., what you should learn) in this course?

General comments