Computer Graphics Seminar

MTAT.03.296

Fall 2014
Conclusion

THE CONCLUSION IS CLEAR

YOU KNOW WHICH ONE TO PICK!
Geometry

- Points – locations in space – vertices
- Vectors – directions
- Polygons – objects in space

So...?
Transformations

- Matrices represent transformations:
  - Linear
  - Affine
  - Projection
Transformations

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  - Linear
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Affine transformation

Linear transformation

Translation column

Used for perspective projection

Point
Transformations

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  - Linear
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Affine transformation

? Linear transformation

Translation column

Used for perspective projection

Point
Transformations

- **Rotation** x, y, z by fixed angle
- **Shear** x, y, z by fixed angle
- **Scaling**

Shift, move, add to coordinates

Preserves straight lines. Parallel lines stay parallel.
Transformations

• What does this matrix do?

\[
\begin{pmatrix}
5 & 0 & 0 & 2 \\
0 & 5 & 0 & 2 \\
0 & 0 & 1 & 0 \\
0 & 0 & 0 & 1
\end{pmatrix}
\begin{pmatrix}
x \\
y \\
z \\
1
\end{pmatrix} = ?
\]
Transformations

What does this matrix do?

\[
\begin{pmatrix}
5 & 0 & 0 & 2 \\
0 & 5 & 0 & 2 \\
0 & 0 & 1 & 0 \\
0 & 0 & 0 & 1
\end{pmatrix}
\begin{pmatrix}
x \\
y \\
z \\
1
\end{pmatrix}
= 
\begin{pmatrix}
5 \cdot x + 2 \cdot 1 \\
5 \cdot y + 2 \cdot 1 \\
1 \cdot z \\
1 \cdot 1
\end{pmatrix}
= 
\begin{pmatrix}
5x + 2 \\
5y + 2 \\
z \\
1
\end{pmatrix}
\]

- Scale x and y by 5 times
- Add 2 to x and y coordinates.
- z stays the same
- Point remains a point
Shading and Lighting

- Shading models:
  - Per-polygon shading – flat shading
  - Per-vertex shading – Gouraud shading
  - Per-fragment shading – Phong shading

Wait, isn't Gouraud shaded cube like this??
Shading and Lighting

By default three.js uses Gouraud shading for Lambertian; Phong shading for Phong.


http://cgdemos.tume-maailm.pri.ee/
Shading and Lighting

Gouraud vertex shader:

```glsl
varying vec3 color;
uniform vec3 lightDirection;
uniform vec3 myColor;

void main() {
    // multiply each vertex by a matrix.
    gl_Position = projectionMatrix * modelViewMatrix * vec4(position, 1.0);

    color = dot(normalize(normalMatrix * normal), lightDirection) * myColor;
}
```

Gouraud fragment shader:

```glsl
varying vec3 color;

void main() {
    gl_FragColor = vec4(color, 1.0);
}
```

What lighting model is this?
Shading and Lighting

- Ambient
- Lambertian – diffuse
- Phong – specular
- Blinn-Phong – specular
Shading and Lighting

- What about Blinn-Phong?
- Which angle would we use there?
Shading and Lighting

• Phong vs Blinn-Phong

\[ I = L_A \cdot M_A + n^T \cdot l \cdot L_D \cdot M_D + (h^T \cdot n)^c \cdot L_S \cdot M_S \]
Shading and Lighting

- **Very important control question!!**
- **Which surface is more brighter?**

a)

b)
Shading and Lighting

a)

b)
Lighting and Shading

- Principles of Lighting and Rendering with John Carmack at QuakeCon 2013
  https://www.youtube.com/watch?v=IyUgHPs86XM
Shading and Lighting

JUST LOOK INTO THE LIGHT

DIYLOL.COM
Bump Mapping

- So what was a bump map?
- What about a normal map?
Bump Mapping

• Bump Map
  - Texture of surface displacements, that won't actually change the geometry, but allow for a different normal calculation.

• Normal Map
  - Texture of different normals.

Why do we change the normals and not the actual surface geometry?
Bump Mapping

https://www.shadertoy.com/view/ldjSDW
Real-Time Water Surface Rendering

- Water surface reflects
- Render another scene to a buffer underneath the water to determine the reflection

What happens with the fish?
Real-Time Water Surface Rendering

• What if the surface is wavy?
Real-Time Water Surface Rendering

• Sample the reflection from the buffer based on the changed direction.

https://www.shadertoy.com/view/ld2SRy
3D Wayfinder

- Estonian business that supplies interactive wayfinders all over the world.

http://3dwayfinder.com/
Consensus on the coordinate axes directions is important!
3D Wayfinder

Not only graphical bugs, what about finding a shortest path in an environment?
Artist's View

- Programmers think that artists are lazy
- Artists think that programmers will steal their work
Artist's View

- Art asset pipeline:
  - Start with high-poly model
  - Sculpt it (change shape with a brush, affecting many vertices at a time)
  - Convert to low-poly (retopo – remake topology)
  - Use in a game?

Did not support our mysterious thing.

Enhanced Dark Engine, 1999
Artist's View

- How can artists and programmers get along?
  - Mixed meetings with artists and programmers
  - Communication
  - Established pipeline

- Avoid high-poly models in product
Procedural Generation

• Lot can be procedurally generated
  ● Single objects
    – Weapons
    – Trees
  ● Life forms
  ● Animations

Borderlands 2
Show this if there is time
Starbound
https://www.youtube.com/watch?v=SAtwQa8t_3g
Overgrowth
Procedural Generation

- Textures

From the wave sampling demo... https://www.shadertoy.com/view/ld2SRy

Different texture based on height
Texture itself generated by combination of functions

Perlin noise – combination (sum) of interpolations of differently sampled random signals
Procedural Generation

- World
  - Grid
- Voxel
- Tile

http://tume-maailm.pri.ee/ylikool/ScientificComputing/Project/

My water surface demo

Minecraft

Terraria
Procedural Generation

- World


Lenna's Inception. Large procedurally generated world. Perlin noise for heightmap + template rooms for buildings.

http://lennasinception.com/about/
Procedural Generation
Texture Mapping

- Andres, you haven't sent me your slides!
- Texture Re-Mapping
  - Andres has a photo of a red shirt
  - He wants to generate photos of blue and green shirts.
Texture Mapping

- Use an image to define the color of your object
- Image will be mapped to your 3D object

http://gabe687.deviantart.com/art/Baked-texture-map-50600743
Texture Mapping

• Different lower-resolution images of the original texture map called mipmaps. Sample from smaller resolution image if object is far away.

• Different schemes to sample from a texture (filter):
  • Nearest neighbour (interpolation / mipmap)
  • Bilinear
  • Trilinear
  • Anistropic

Raphael.js

- JavaScript library for SVG (scalable vector graphics)
- SVG – standard format for defining vector graphics

http://raphaeljs.com/tiger.html
Three.js

- JavaScript library for WebGL and 3D graphics
- Has the things we have learned here:
  - MeshLambertMaterial
  - DirectionalLight
  - OrthographicCamera
  - Matrix4
  - TorusGeometry
  - ...

CGLearn and CGDemos are both done with three.js

https://cglearn.codelight.eu
http://cgdemos.tume-maailm.pri.ee/
Virtual Reality
Virtual Reality

• Virtual Reality vs Augmented Reality?

• A lot of demanding requirements:
  • Rotational accuracy < $\frac{1}{4}$ degrees
  • Translational accuracy < 1 mm
  • At least 90 FPS
  • Less than 20 ms latency
  • More than 1k resolution per eye
  • ...

Otherwise:
Virtual Reality

• We tried out a couple of demos on the Oculus Rift DK2:
  • Sightline
  • Windlands
  • Ats's Demo Game
Virtual Reality

- John Carmack is back!
- Oculus Connect Keynote: John Carmack
  
  https://www.youtube.com/watch?v=gn8m5d74fk8
Feedback

• How did you like the seminar organization?

• Did you found our activities interesting / useful? Which ones especially?

• What would you change?
Thanks for listening!