

ECE4893A/CS4803MPG: MULTICORE AND GPU PROGRAMMING FOR VIDEO GAMES



Rendering 3-D Content

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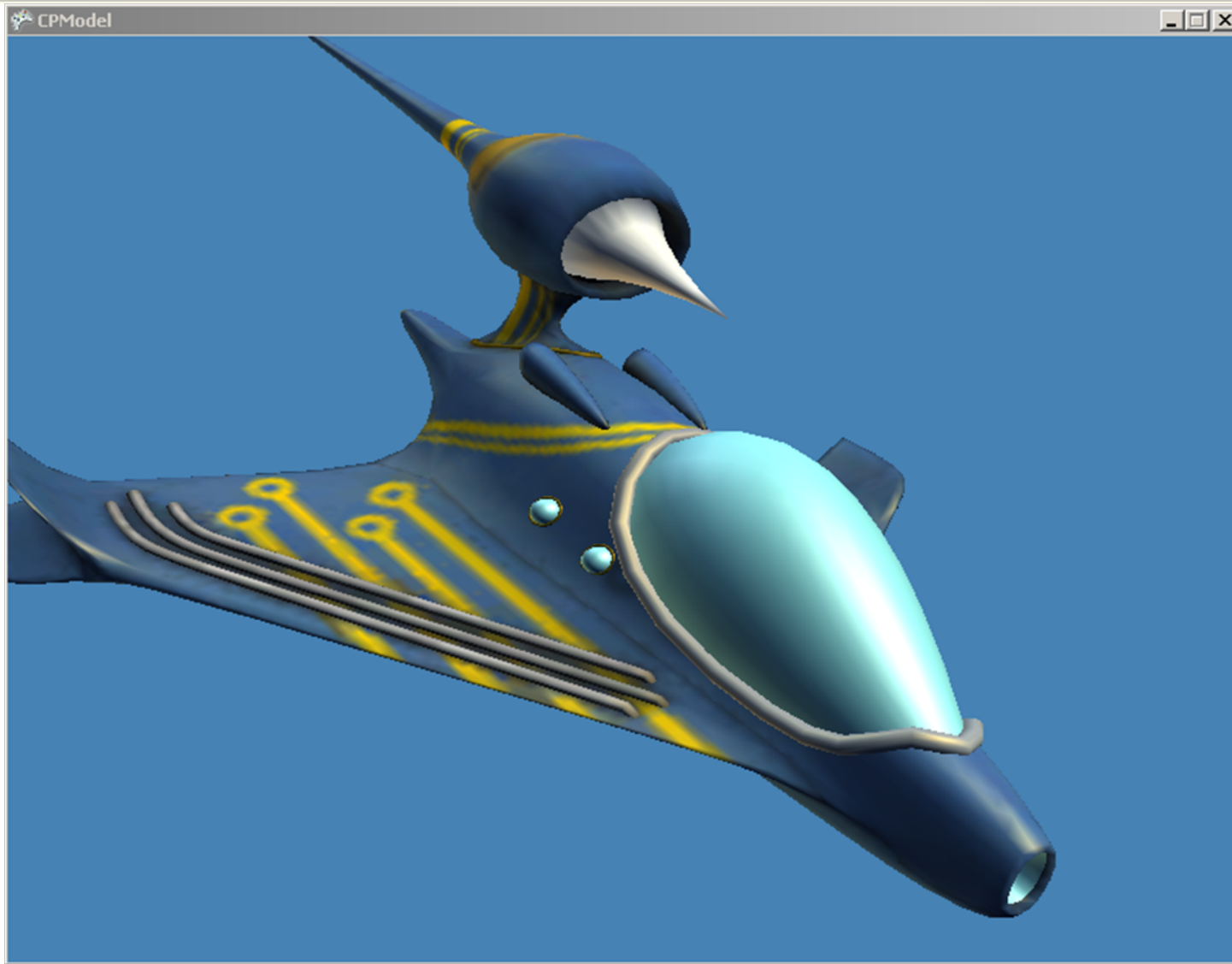
(Based on slides by Prof. Hsien-Hsin Sean Lee)

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How to render a model in the Content Pipeline



<http://msdn.microsoft.com/en-us/library/bb203933.aspx>

How to peek at the model structure

```
protected override void LoadContent()  
{  
    gameShip = Content.Load<Model>("ship");  
  
    System.Diagnostics.Debugger.Break();  
}
```

.x model's
asset name

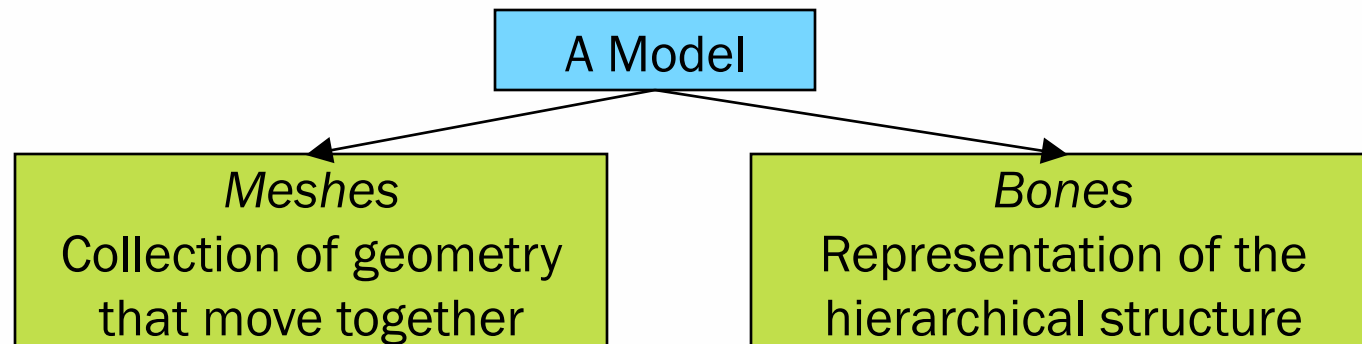
Locals			
Name	Value	Type	
this	{CPModel.Game1}	CPModel.Game1	
base	{CPModel.Game1}	Microsoft.Xna.Framework.Game {CPModel.Game1}	
gameShip	{Microsoft.Xna.Framework.Graphics.Model}	Microsoft.Xna.Framework.Graphics.Model	
gameWorldRotation	{ {M11:0 M12:0 M13:0 M14:0} {M21:0 M22:0 M23:0 M24:0} {M31:0 M32:0 M33:0 M34:0} }	Microsoft.Xna.Framework.Matrix	
graphics	{Microsoft.Xna.Framework.GraphicsDeviceManager}	Microsoft.Xna.Framework.GraphicsDeviceManager	
Position	{X:1 Y:1 Z:1}	Microsoft.Xna.Framework.Vector3	
RotationX	0.0	float	
RotationY	0.0	float	
Zoom	2500.0	float	

- The asset name of input model “wedge_player1.x” has been renamed to “ship” in the “properties” window (Content Pipeline)

Peeking at the bones and meshes

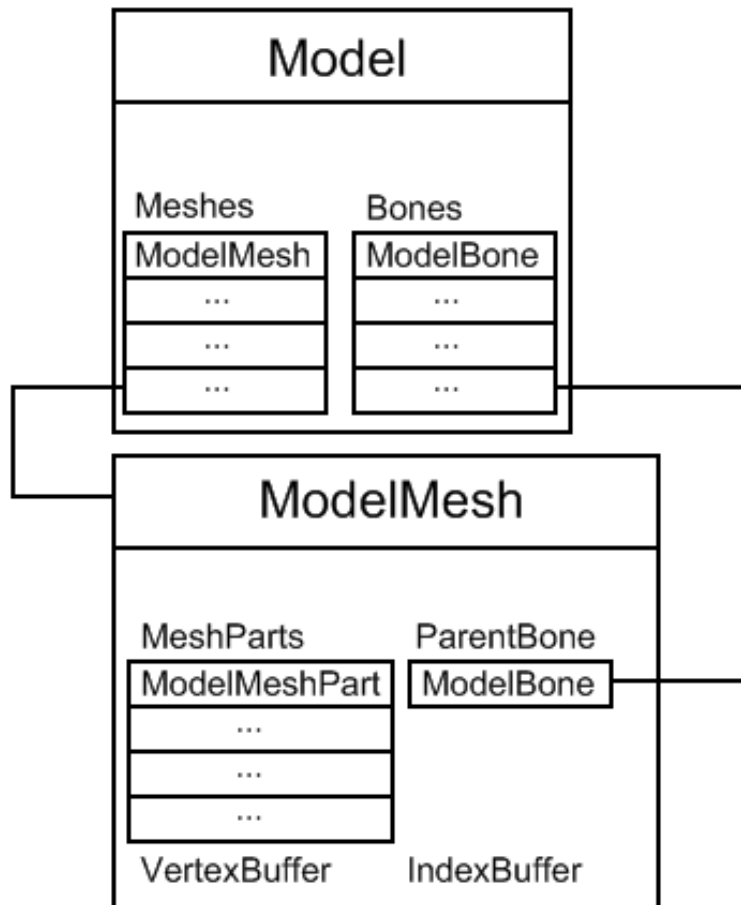
gameShip	{Microsoft.Xna.Framework.Graphics.Model}	Microsoft.Xna.Framework.Graphics.Model
Bones	Count = 2	Microsoft.Xna.Framework.Graphics.ModelBoneColle
[0]	{Microsoft.Xna.Framework.Graphics.ModelBone}	Microsoft.Xna.Framework.Graphics.ModelBone
[1]	{Microsoft.Xna.Framework.Graphics.ModelBone}	Microsoft.Xna.Framework.Graphics.ModelBone
Raw View		
Meshes	Count = 1	Microsoft.Xna.Framework.Grap
[0]	{Microsoft.Xna.Framework.Graphics.ModelMesh}	Microsoft.Xna.Framework.Graphics.ModelMesh
BoundingBox	{Center:{X:0.8337776 Y:197.7493 Z:-513.1478} Radius	Microsoft.Xna.Framework.BoundingBox
Effects	Count = 3	Microsoft.Xna.Framework.Graphics.ModelEffectCol
IndexBuffer	{Microsoft.Xna.Framework.Graphics.IndexBuffer}	Microsoft.Xna.Framework.Graphics.IndexBuffer
MeshParts	Count = 3	Microsoft.Xna.Framework.Graphics.ModelMeshPart
Name	"single_mesh_object"	string
ParentBone	{Microsoft.Xna.Framework.Graphics.ModelBone}	Microsoft.Xna.Framework.Graphics.ModelBone
Tag	null	object
VertexBuffer	{Microsoft.Xna.Framework.Graphics.VertexBuffer}	Microsoft.Xna.Framework.Graphics.VertexBuffer
Non-Public members		
Raw View		
Root	{Microsoft.Xna.Framework.Graphics.ModelBone}	Microsoft.Xna.Framework.Graphics.ModelBone
Tag	null	object
Non-Public members		

Bones and meshes (1)



- The model is “flattened” to a single list of meshes
- The bones retain the tree structure from the scene graph
- Each mesh can have a related matrix defining its own transformation

Bones and meshes (2)



- Each ModelMesh has a ParentBone
- Each Bone has a transformation matrix
- Rotate the ParentBone will also rotate the children and their children, etc.

In meshes: BoundingSpheres and Effects

Meshes	Count = 1	Microsoft.Xna.Framework.Graphics.ModelMeshColl
[0]	{Microsoft.Xna.Framework.Graphics.ModelMesh}	Microsoft.Xna.Framework.Graphics.ModelMesh
BoundingSphere	{Center:{X:0.8337776 Y:197.7493 Z:-513.1478} Radiu	Microsoft.Xna.Framework.BoundingSphere
Center	{X:0.8337776 Y:197.7493 Z:-513.1478}	Microsoft.Xna.Framework.Vector3
Radius	1609.95264	float
Effects	Count = 3	Microsoft.Xna.Framework.Graphics.ModelEffectCo
[0]	{Microsoft.Xna.Framework.Graphics.BasicEffect}	Microsoft.Xna.Framework.Graphics.Effect {Microso
[Microsoft.Xna.Fran	{Microsoft.Xna.Framework.Graphics.BasicEffect}	Microsoft.Xna.Framework.Graphics.BasicEffect
Creator	"D3DX Effect Compiler"	string
CurrentTechnique	{Microsoft.Xna.Framework.Graphics.EffectTechnique}	Microsoft.Xna.Framework.Graphics.EffectTechniqu
Annotations	{Microsoft.Xna.Framework.Graphics.EffectAnnotationC	Microsoft.Xna.Framework.Graphics.EffectAnnotati
Name	"BasicEffect"	string
Passes	{Microsoft.Xna.Framework.Graphics.EffectPassCollecti	Microsoft.Xna.Framework.Graphics.EffectPassColl
Non-Public memt		
EffectPool	null	Microsoft.Xna.Framework.Graphics.EffectPool
Functions	{Microsoft.Xna.Framework.Graphics.EffectFunctionColl	Microsoft.Xna.Framework.Graphics.EffectFunction
GraphicsDevice	{Microsoft.Xna.Framework.Graphics.GraphicsDevice}	Microsoft.Xna.Framework.Graphics.GraphicsDevice
IsDisposed	false	bool
Parameters	{Microsoft.Xna.Framework.Graphics.EffectParameterC	Microsoft.Xna.Framework.Graphics.EffectParamet
Techniques	{Microsoft.Xna.Framework.Graphics.EffectTechniqueC	Microsoft.Xna.Framework.Graphics.EffectTechniqu
Non-Public members		
[1]	{Microsoft.Xna.Framework.Graphics.BasicEffect}	Microsoft.Xna.Framework.Graphics.Effect {Microso
[2]	{Microsoft.Xna.Framework.Graphics.BasicEffect}	Microsoft.Xna.Framework.Graphics.Effect {Microso
Raw View		

In meshes: IndexBuffer & VertexBuffer

Meshes	Count = 1	Microsoft.Xna.Framework.Graphics.ModelMeshCo
[0]	{Microsoft.Xna.Framework.Graphics.ModelMesh}	Microsoft.Xna.Framework.Graphics.ModelMesh
BoundingBox	{Center:{X:0.8337776 Y:197.7493 Z:-513.1478} Radiu	Microsoft.Xna.Framework.BoundingBox
Effects	Count = 3	Microsoft.Xna.Framework.Graphics.ModelEffectC
IndexBuffer	{Microsoft.Xna.Framework.Graphics.IndexBuffer}	Microsoft.Xna.Framework.Graphics.IndexBuffer
base	{Microsoft.Xna.Framework.Graphics.IndexBuffer}	Microsoft.Xna.Framework.Graphics.GraphicsResc
BufferUsage	None	Microsoft.Xna.Framework.Graphics.BufferUsage
IndexElementSize	SixteenBits	Microsoft.Xna.Framework.Graphics.IndexElement
SizeInBytes	96708	int
Non-Public members		
MeshParts	Count = 3	Microsoft.Xna.Framework.Graphics.ModelMeshPa
Name	"single_mesh_object"	string
ParentBone	{Microsoft.Xna.Framework.Graphics.ModelBone}	Microsoft.Xna.Framework.Graphics.ModelBone
Tag	null	object
VertexBuffer	{Microsoft.Xna.Framework.Graphics.VertexBuffer}	Microsoft.Xna.Framework.Graphics.VertexBuffer
base	{Microsoft.Xna.Framework.Graphics.VertexBuffer}	Microsoft.Xna.Framework.Graphics.GraphicsResc
BufferUsage	None	Microsoft.Xna.Framework.Graphics.BufferUsage
SizeInBytes	285632	int
Non-Public members		

Loading an .X model

```
gameShip = Content.Load<Model>("ship");
```

.x model's
Asset name

```
foreach (ModelMesh mesh in m.Meshes)
{
    foreach (BasicEffect effect in mesh.Effects)
    {
        effect.EnableDefaultLighting();

        effect.View = view;
        effect.Projection = projection;
        effect.World = gameWorldRoation *
            transforms[mesh.ParentBone.Index] *
            Matrix.CreateTranslation(Position);
    }
    mesh.Draw();
}
```

Draw all the meshes in
the model

DrawModel (Initialization)

```
private void DrawModel(Model m)
{
    // copy any parent transform
    Matrix[] transforms = new Matrix[m.Bones.Count];
    m.CopyAbsoluteBoneTransformsTo(transforms);

    float aspectRatio =
        graphics.GraphicsDevice.Viewport.Width /
        graphics.GraphicsDevice.Viewport.Height;

    Matrix projection =
        Matrix.CreatePerspectiveFieldOfView
            (MathHelper.ToRadians(45.0f), aspectRatio, 1.0f, 10000.0f);
    Matrix view =
        Matrix.CreateLookAt(new Vector3(0.0f, 50.0f, Zoom),
            Vector3.Zero, Vector3.Up);
```

CopyAbsoluteBoneTransformsTo

[-] Remarks

In an absolute transform, each bone is transformed according to the position of all parent bones.

This is the same as iterating the **Bones** collection and applying the transformation matrix of every parent of a **ModelBone** to the **Transform** property of each **ModelBone** and copying the results into an array that can be indexed into by the bone index.

An array of transformation matrices for the meshes of any model can be obtained by calling **CopyAbsoluteBoneTransformsTo** or **CopyBoneTransformsTo**. The resulting array contains the transforms that describe how each **ModelMesh** is located relative to one another in the **Model**. The transformation matrix that should be applied to each **ModelMesh** can be obtained using the index of the **CopyAbsoluteBoneTransformsTo** to retrieve a transformation matrix from this collection.

<http://msdn.microsoft.com/en-us/library/microsoft.xna.framework.graphics.model.copyabsolutebonetransformsto.aspx>

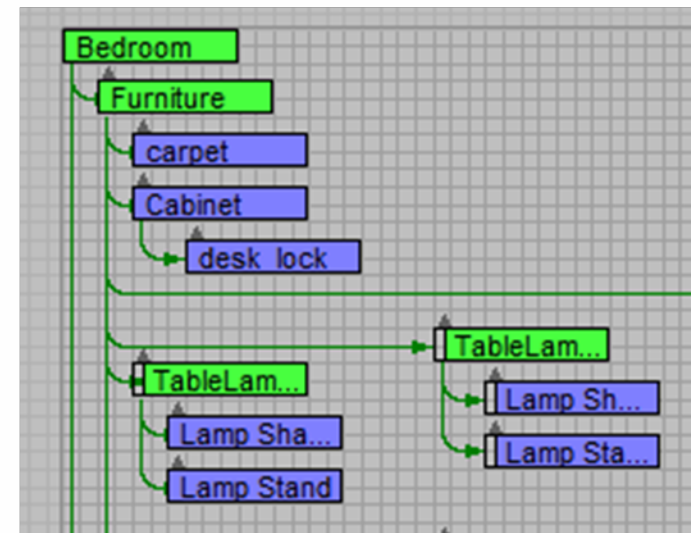
- In an absolute transform, each bone is transformed according to the position of all parent bones

Example heirarchical model

The Absolute Transform for a Lamp Shade

Product of 4 transformation matrices

LampShade * TableLamp *
Furniture * Bedroom



Ship Example



CPModel Effect
(See Demo in Visual Studio)

Ducky Example



DuckBasicEffect
(See Demo in Visual Studio)

Draw a subset of a model

Set up mesh IB and VB yourself

```
graphics.GraphicsDevice.Indices = mesh.IndexBuffer;  
graphics.GraphicsDevice.Vertices[0].SetSource(mesh.VertexBuffer, 0, VertexPositionNormalTexture.SizeInBytes);
```

```
// HHLee: the following code is pain in the ass to draw the first 2 meshes  
// because the 3rd mesh of this stupid model is a rectangle which is kind of annoying
```

```
int i = 0;  
foreach (ModelMeshPart meshpart in mesh.MeshParts)  
{  
    i++;  
    if (i == 3)  
        break;  
    effect.Begin();  
    foreach (EffectPass pass in effect.CurrentTechnique.Passes)  
    {  
        pass.Begin();  
  
        graphics.GraphicsDevice.DrawIndexedPrimitives(PrimitiveType.TriangleList,  
            meshpart.BaseVertex,  
            meshpart.StreamOffset,  
            meshpart.NumVertices,  
            meshpart.StartIndex,  
            meshpart.PrimitiveCount);  
        pass.End();  
    }  
    effect.End();  
}  
//mesh.Draw();  
}
```

Draw only MeshPart[0] and [1]

Use your own Draw call
instead of mesh.Draw()

```
base.Draw(gameTime);
```

Teapot Example



TeapotBasicEffect
(See Demo in Visual Studio)

Mixing 2-D and 3-D drawing

```
mySpriteBatch.Begin(SpriteBlendMode.None,  
SpriteSortMode.Immediate, SaveStateMode.None);
```

- May mess up rendering of 3-D objects
- SpriteBatch will change renderstates to things inappropriate for 3-D drawing

From Shawn Hargreaves, "SpriteBatch and renderstates,"
<http://blogs.msdn.com/shawnhar/archive/2006/11/13/spritebatch-and-renderstates.aspx>

Easy solution

```
mySpriteBatch.Begin(SpriteBlendMode.None,  
SpriteSortMode.Immediate, SaveStateMode.SaveState);
```

- Caveat: saving and restoring state is slow, may lower your frame rate

From Shawn Hargreaves, “SpriteBatch and renderstates,”
<http://blogs.msdn.com/shawnhar/archive/2006/11/13/spritebatch-and-renderstates.aspx>

Not as easy solution (1)

- Set the renderstates back yourself before drawing 3-D objects
- See Shawn Hargreaves' blog for a full list of what renderstates get changed by SpriteBatch

From Shawn Hargreaves, "SpriteBatch and renderstates,"
<http://blogs.msdn.com/shawnhar/archive/2006/11/13/spritebatch-and-renderstates.aspx>

Not as easy solution (2)

- “before you draw anything in 3D you will probably want to reset these states:”

```
GraphicsDevice.RenderState.DepthBufferEnable = true;  
GraphicsDevice.RenderState.AlphaBlendEnable = false;  
GraphicsDevice.RenderState.AlphaTestEnable = false;
```

- “Depending on your 3D content, you may also want to set:”

```
GraphicsDevice.SamplerStates[0].AddressU =  
    TextureAddressMode.Wrap;  
GraphicsDevice.SamplerStates[0].AddressV =  
    TextureAddressMode.Wrap;
```

From Shawn Hargreaves, “SpriteBatch and renderstates,”

<http://blogs.msdn.com/shawnhar/archive/2006/11/13/spritebatch-and-renderstates.aspx>

In case of shader weirdness

Instead of

```
myEffect.Begin( );
```

try

```
myEffect.Begin( SaveStateMode.SaveState );
```

From Dark Codex Studios, "SaveState not working?,"
<http://digierr.spaces.live.com/blog/cns!2B7007E9EC2AE37B!747.entry>