ECE4893A/CS4803MPG:

Multicore and GPU Programming for Video Games

Rendering 3-D Content

Prof. Aaron Lanterman
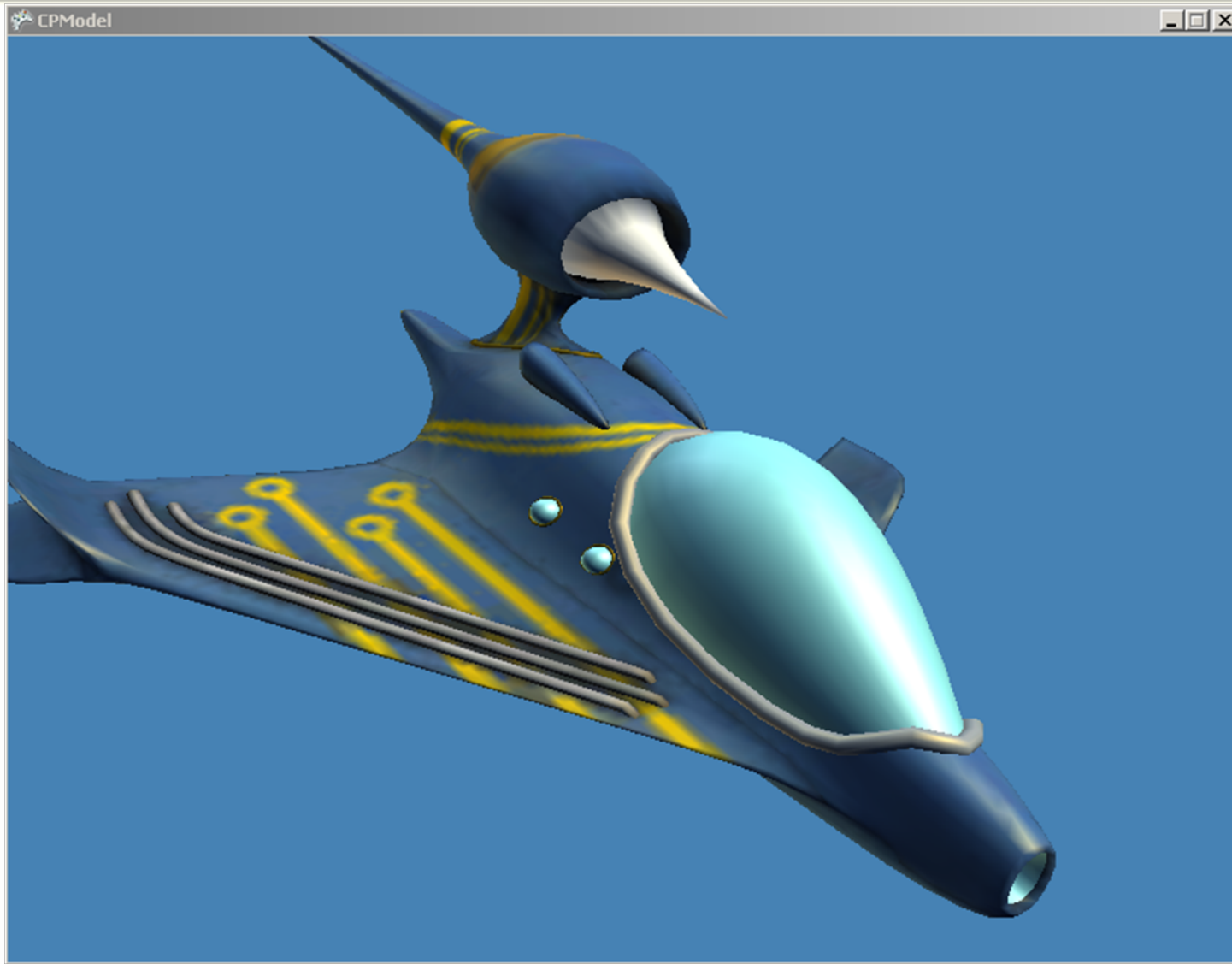(Based on slides by Prof. Hsien-Hsin Sean Lee)
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How to render a model in the Content Pipeline

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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

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 M	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

Locals

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

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Peeking at the bones and meshes
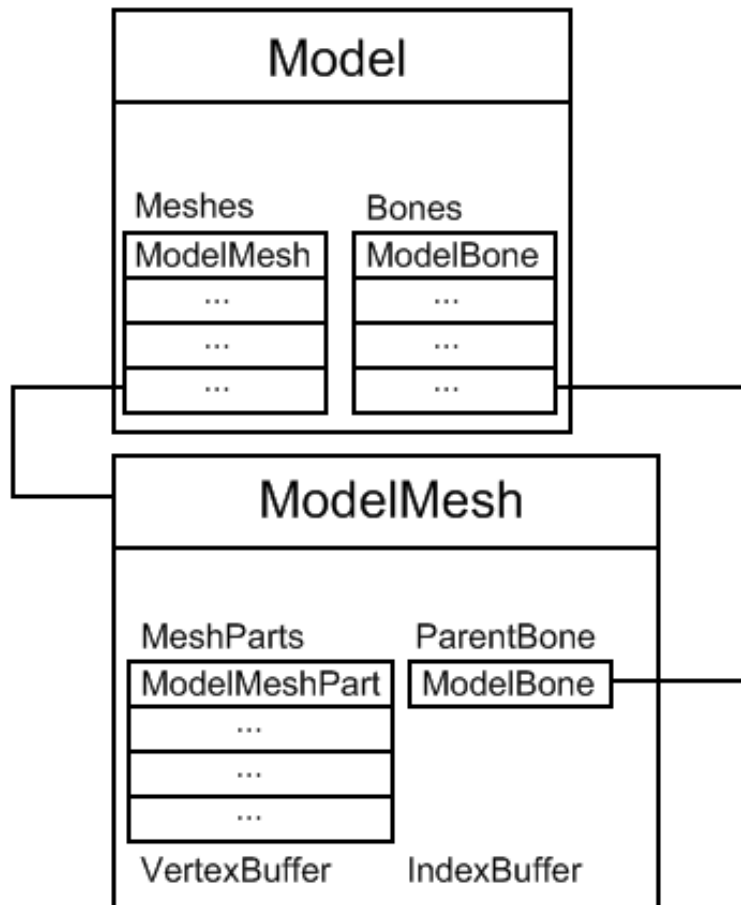
gameShip	{Microsoft.Xna.Framework.Graphics.Model}	Microsoft.Xna.Framework.Graphics.Model
Bones	Count = 2	Microsoft.Xna.Framework.Graphics.ModelBoneColle
[0]	{Microsoft.Xna.Framework.Graphics.ModelBone}	Microsoft.Xna.Framework.Graphics.ModelBone
[1]	{Microsoft.Xna.Framework.Graphics.ModelBone}	Microsoft.Xna.Framework.Graphics.ModelBone
Raw View		
		Microsoft.Xna.Framework.Grap
Meshes	Count = 1	Microsoft.Xna.Framework.Graphics.ModelMeshCol
[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
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)
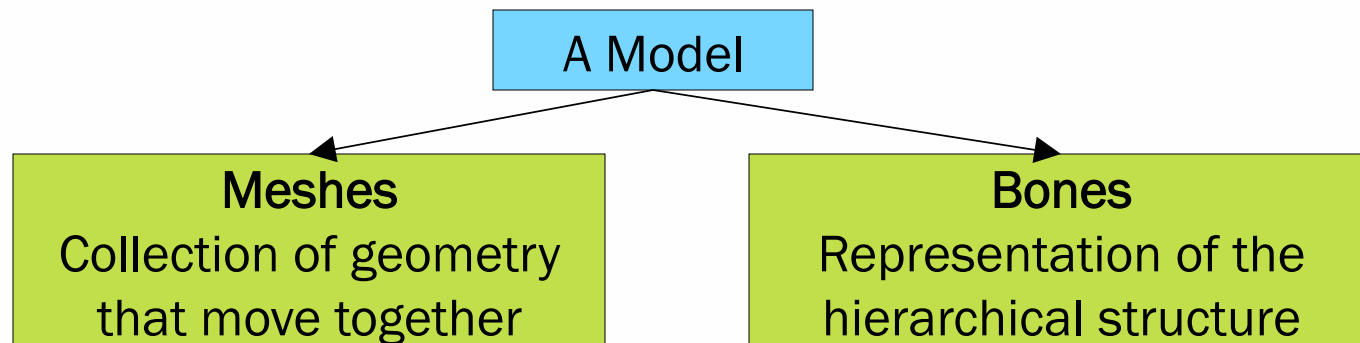
- The model is "flattened" to a single list of meshes
- The bones retain the tree structure from the scene graph
- Each mesh can have a related matrix defining its own transformation

Bones and meshes (2)

- Each ModelMesh has a ParentBone

- Each Bone has a transformation matrix

- Rotate the ParentBone will also rates 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 {Micros
⊞ 🔵 [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 memb		
📑 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 {Micros
⊞ 🔵 [2]	{Microsoft.Xna.Framework.Graphics.BasicEffect}	Microsoft.Xna.Framework.Graphics.Effect {Micros
⊞ 🔵 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
⊞ 📒 BoundingSphere	{Center:{X:0.8337776 Y:197.7493 Z:-513.1478} Radiu	Microsoft.Xna.Framework.BoundingSphere
⊞ 📒 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.GraphicsReso
📒 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.GraphicsReso
📒 BufferUsage	None	Microsoft.Xna.Framework.Graphics.BufferUsage
📒 SizeInBytes	285632	int
⊞ 🔷 Non-Public members		

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Loading a .X model

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

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

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

Draw all the meshes in the model

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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

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Example heirarchical model

The Absolute Transform for a Lamp Shade

Product of 4 transformation matrices

LampShade * TableLamp *
Furniture * Bedroom

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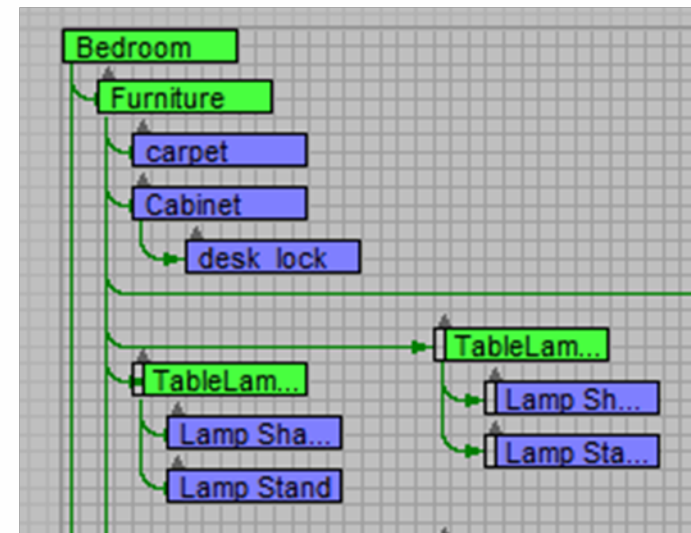
Ship Example

CPModel Effect
(See Demo in Visual Studio)

Ducky Example

DuckBasicEffect
(See Demo in Visual Studio)

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Draw a subset of a model

```
int i = 0;
foreach (ModelMeshPart meshPart in mesh.MeshParts) {
// the third mesh is a plane
  i++;
  if (i == 3)
    break;

  foreach (EffectPass pass in effect.CurrentTechnique.Passes) {
    pass.Apply();

    graphics.GraphicsDevice.Indices = meshPart.IndexBuffer;
    graphics.GraphicsDevice.SetVertexBuffer(meshPart.VertexBuffer);

    graphics.GraphicsDevice.DrawIndexedPrimitives
        (PrimitiveType.TriangleList,
          meshPart.VertexOffset,
          0,
          meshPart.NumVertices,
          meshPart.StartIndex,
          meshPart.PrimitiveCount);
  }
}
```

Draw only MeshPart[0] and [1]

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

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Teapot Example

TeapotBasicEffect
(See Demo in Visual Studio)

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