


ECE4893A/CS4803MPG:  
**MULTICORE AND GPU  
 PROGRAMMING  
 FOR VIDEO GAMES**



**Animation on the GPU**  
 Prof. Aaron Lanterman  
 School of Electrical and Computer Engineering  
 Georgia Institute of Technology

Georgia Institute of Technology

## Typical keyframed animations

- Standing
- Running
- Kneeling
- Ducking
- Attacking
- Passing on, ceasing to be, expiring and going to meet maker, pushing up the daisies, kicking the bucket, shuffling off mortal coil, running down the curtain, joining the invisible choir, becoming an ex-parrot

From Fernando & Kilgard, "The Cg Tutorial." 2003, p. 155

Georgia Institute of Technology

## Basic keyframing (vertex shader)

```
void C6E3v_keyFrame(float3 positionA : POSITION,
                  float3 positionB : TEXCOORD1,
                  float4 color : COLOR,
                  float2 texCoord : TEXCOORD0,

                  out float4 oPosition : POSITION,
                  out float2 oTexCoord : TEXCOORD0,
                  out float4 oColor : COLOR,

                  uniform float keyFrameBlend,
                  uniform float4x4 modelViewProj)
{
    float3 position = lerp(positionA, positionB,
                          keyFrameBlend);
    oPosition = mul(modelViewProj, float4(position, 1));
    oTexCoord = texCoord;
    oColor = color;
}
```

From Fernando & Kilgard, "The Cg Tutorial." 2003, p. 159

Georgia Institute of Technology

## A Light structure

```
struct Light {
    float3 eyePosition; // In object space
    float3 lightPosition; // In object space
    float4 lightColor;
    float specularExponent;
    float ambient;
};
```

From Fernando & Kilgard, "The Cg Tutorial." 2003, p. 161

Georgia Institute of Technology

## Keyframing with lighting (vertex shader)

```

void C6E4v_litKeyFrame(float3 positionA : POSITION,
                      float3 normalA   : NORMAL,
                      float3 positionB : TEXCOORD1,
                      float3 normalB   : TEXCOORD2,
                      float2 texCoord  : TEXCOORD0,
                      out float4 oPosition : POSITION,
                      out float2 oTexCoord : TEXCOORD0,
                      out float4 color   : COLOR,
                      uniform float keyFrameBlend,
                      uniform Light light,
                      uniform float4x4 modelViewProj)
{
    float3 position = lerp(positionA, positionB,
                           keyFrameBlend);
    float3 blendNormal = lerp(normalA, normalB,
                              keyFrameBlend);
    float3 normal = normalize(blendNormal);
    oPosition = mul(modelViewProj, float4(position, 1));
    oTexCoord = texCoord;
    color = computeLighting(light, position, normal);
}

```

From Fernando & Kilgard, "The Cg Tutorial," 2003, p. 162



## Compute lighting

```

float4 computeLighting(Light light,
                      float3 position, // In object space
                      float3 normal)  // In object space
{
    float3 lightDirection = light.lightPosition - position;
    float3 lightDirNorm = normalize(lightDirection);
    float3 eyeDirection = light.eyePosition - position;
    float3 eyeDirNorm = normalize(eyeDirection);
    float3 halfAngle = normalize(lightDirNorm + eyeDirNorm);
    float diffuse = max(0, dot(lightDirNorm, normal));
    float specular = pow(max(0, dot(halfAngle, normal)),
                        light.specularExponent);
    return light.lightColor * (light.ambient +
                               diffuse + specular);
}

```

From Fernando & Kilgard, "The Cg Tutorial," 2003, p. 161



## Skinning, part 1 (vertex shader)

```

void C6E5v_skin4m(float3 position : POSITION,
                  float3 normal   : NORMAL,
                  float2 texCoord  : TEXCOORD0,
                  float4 weight   : TEXCOORD1,
                  float4 matrixIndex : TEXCOORD2,

                  out float4 oPosition : POSITION,
                  out float2 oTexCoord : TEXCOORD0,
                  out float4 color     : COLOR,

                  uniform Light light,
                  uniform float4 boneMatrix[72], // 24 matrices
                  uniform float4x4 modelViewProj)
{
    ...
}

```

From Fernando & Kilgard, "The Cg Tutorial," 2003, p. 166



## Skinning, part 2 (vertex shader)

```

...
float3 netPosition = 0, netNormal = 0;
for (int i=0; i<4; i++) {
    float index = matrixIndex[i];
    float3x4 model = float3x4(boneMatrix[index+0],
                              boneMatrix[index+1],
                              boneMatrix[index+2]);
    float3 bonePosition = mul(model, float4(position, 1));
    // Assume no scaling in matrix, just rotate & translate
    float3x3 rotate = float3x3(model[0].xyz,
                                model[1].xyz,
                                model[2].xyz);
    float3 boneNormal = mul(rotate, normal);
    netPosition += weight[i] * bonePosition;
    netNormal   += weight[i] * boneNormal;
}
...

```

From Fernando & Kilgard, "The Cg Tutorial," 2003, p. 166



## Skinning, part 3 (vertex shader)

```
...  
  
netNormal = normalize(netNormal);  
oPosition = mul(modelViewProj, float4(netPosition, 1));  
oTexCoord = texCoord;  
color = computeLighting(light, netPosition, netNormal);  
}
```

From Fernando & Kilgard, "The Cg Tutorial," 2003, p. 166