Lecture 17 of 41

Animation 1 of 3: Basics, Keyframing
Sample Exam Review

William H. Hsu
Department of Computing and Information Sciences, KSU

Public mirror web site: http://www.kddresearch.org/Courses/CIS636
Instructor home page: http://www.cis.ksu.edu/~bhsu

Readings:
Next class: no new reading – review Chapters 1 – 4, 20

Optional review session during next class period; evening exam time TBD
Lecture 18 reading (two class days from today): §4.4 – 4.7, Eberly 2e
Lecture Outline

- Reading for Last Class: §2.6, 20.1, Eberly 2e; OpenGL primer material
- Reading for Today: §5.1 – 5.2, Eberly 2e
- Reading for Next Lecture (Two Classes from Now): §4.4 – 4.7, Eberly 2e
- Last Time: Shading and Transparency in OpenGL
  - Transparency revisited
  - OpenGL how-to: http://bit.ly/hRaQgk
    - Alpha blending (15.020, 15.040)
    - Screen-door transparency (15.030)
  - Painter’s algorithm & depth buffering (z-buffering)
- Today: Introduction to Animation
  - What is it and how does it work?
  - Brief history
  - Principles of traditional animation
  - Keyframe animation
  - Articulated figures: inbetweening
Where We Are

<table>
<thead>
<tr>
<th>Lecture</th>
<th>Topic</th>
<th>Primary Source(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Course Overview</td>
<td>Chapter 1, Eberly 2^e</td>
</tr>
<tr>
<td>1</td>
<td>CG Basics: Transformation Matrices; Lab 0</td>
<td>Sections (§) 2.1, 2.2</td>
</tr>
<tr>
<td>2</td>
<td>Viewing 1: Overview, Projections</td>
<td>§ 2.3 – 2.4, 2.8</td>
</tr>
<tr>
<td>3</td>
<td>Viewing 2: Viewing Transformation</td>
<td>§ 2.3 esp. 2.3.4, PVFH slides</td>
</tr>
<tr>
<td>4</td>
<td>Lab 1a: Flash &amp; OpenGL Basics</td>
<td>Ch. 2, 16, Angel Primer</td>
</tr>
<tr>
<td>5</td>
<td>Viewing 3: Graphics Pipeline</td>
<td>§ 2.3 esp. 2.3.7, 2.6, 2.7</td>
</tr>
<tr>
<td>6</td>
<td>Scan Conversion 1: Lines, Midpoint Algorithm</td>
<td>§ 2.5.1, 3.1, PVFH slides</td>
</tr>
<tr>
<td>7</td>
<td>Viewing 4: Clipping &amp; Culling; Lab 1b</td>
<td>§ 2.3.5, 2.4, 3.1.3</td>
</tr>
<tr>
<td>8</td>
<td>Scan Conversion 2: Polygons, Clipping Intro</td>
<td>§ 2.4, 2.5 esp. 2.5.4, 3.1.6</td>
</tr>
<tr>
<td>9</td>
<td>Surface Detail 1: Illumination &amp; Shading</td>
<td>§ 2.5, 2.6.1 – 2.6.2, 4.3.2, 20.2</td>
</tr>
<tr>
<td>10</td>
<td>Lab 2a: Direct3D / DirectX Intro</td>
<td>§ 2.7, Direct3D handout</td>
</tr>
<tr>
<td>11</td>
<td>Surface Detail 2: Textures, OpenGL Shading</td>
<td>§ 2.6.3, 20.3 – 20.4, Primer</td>
</tr>
<tr>
<td>12</td>
<td>Surface Detail 3: Mappings, OpenGL Textures</td>
<td>§ 20.5 – 20.13</td>
</tr>
<tr>
<td>13</td>
<td>Surface Detail 4: Pixel/Vertex Shad.; Lab 2b</td>
<td>§ 3.1</td>
</tr>
<tr>
<td>14</td>
<td>Surface Detail 5: Direct3D Shading; OGLSL</td>
<td>§ 3.2 – 3.4, Direct3D handout</td>
</tr>
<tr>
<td>15</td>
<td>Demos 1: CGA, Fun; Scene Graphs: State</td>
<td>§ 4.1 – 4.3, CGA handout</td>
</tr>
<tr>
<td>16</td>
<td>Lab 3a: Shading &amp; Transparency</td>
<td>§ 2.6, 20.1, Primer</td>
</tr>
<tr>
<td>17</td>
<td>Animation 1: Basics, Keyframes; HW/Exam</td>
<td>§ 5.1 – 5.2</td>
</tr>
<tr>
<td></td>
<td>Exam 1 review: Hour Exam 1 (evening)</td>
<td>Chapters 1 – 4, 20</td>
</tr>
<tr>
<td>18</td>
<td>Scene Graphs: Rendering; Lab 3b: Shader</td>
<td>§ 4.4 – 4.7</td>
</tr>
<tr>
<td>19</td>
<td>Demos 2: SFX: Skinning, Morphing</td>
<td>§ 5.3 – 5.5, CGA handout</td>
</tr>
<tr>
<td>20</td>
<td>Demos 3: Surfaces, B-reps/Volume Graphics</td>
<td>§ 10.4, 12.7, Mesh handout</td>
</tr>
</tbody>
</table>

Lightly-shaded entries denote the due date of a written problem set, heavily-shaded entries, that of a machine problem (programming assignment), blue-shaded entries, that of a paper review, and the green-shaded entry, that of the term project.

Green, blue and red letters denote exam review, exam, and exam solution review dates.
Review: Painter’s Algorithm vs. z-Buffering

© 2004 – 2009 Wikipedia, Painter’s Algorithm

© 2009 Wikipedia, Z-buffering
http://bit.ly/gGRFMA

A simple three-dimensional scene
Z-buffer representation
Transparency in OpenGL: Final Note

15.060 I want to use blending but can't get destination alpha to work. Can I blend or create a transparency effect without destination alpha?

Many OpenGL devices don't support destination alpha. In particular, the OpenGL 1.1 software rendering libraries from Microsoft don't support it. The OpenGL specification doesn't require it.

If you have a system that supports destination alpha, using it is a simple matter of asking for it when you create your window. For example, pass GLUT_ALPHA to glutInitDisplayMode(), then set up a blending function that uses destination alpha, such as:

```c
glBlendFunc(GL_ONE_MINUS_DST_ALPHA, GL_DST_ALPHA);
```

Often this question is asked under the mistaken assumption that destination alpha is required to do blending. It's not. You can use blending in many ways to obtain a transparency effect that uses source alpha instead of destination alpha. The fact that you might be on a platform without destination alpha shouldn't prevent you from obtaining a transparency effect. See the OpenGL Programming Guide chapter 6 for ways to use blending to achieve transparency.

© 1997 – 2011 Khronos Group
http://bit.ly/hRaQgk
Acknowledgements:

Computer Animation Intro

Jason Lawrence
Assistant Professor
Department of Computer Science
University of Virginia
http://www.cs.virginia.edu/~idl/

Thomas A. Funkhouser
Professor
Department of Computer Science
Computer Graphics Group
Princeton University
http://www.cs.princeton.edu/~funk/

Acknowledgment: slides by Misha Kazhdan, Allison Klein, Tom Funkhouser, Adam Finkelstein and David Dobkin
Overview

• Some early animation history
  - http://web.inter.nl.net/users/anima/index.htm
  - http://www.public.iastate.edu/~rllew/chmrnearl.html

• Computer animation
Thaumatrope

- Why does animation work?
- Persistence of vision
- 1824 John Ayerton invents the *thaumatrope*
- Or, 1828 Paul Roget invents the *thaumatrope*

Phenakistoscope

- Invented independently by 2 people in 1832
- Disc mounted on spindle
- Viewed through slots with images facing mirror
- Turning disc animates images

Phenakistoscope of couple (1893) © 2007 Wikipedia, Phenakistoscope
Zoetrope (1834)

- Images arranged on paper band inside a drum
- Slits cut in the upper half of the drum
- Opposite side viewed as drum rapidly spun
- Praxinoscope is a variation on this

Tarzan © 2000 Disney
http://youtu.be/az3MnoS5SHw
Animation History

- Animation and technology have always gone together!
- Animation popular even before movies
- Movies were big step forward!
- “Humorous Phases of Funny Faces” (1906)
Key Developments [1]:
Storytelling & Cel Animation

- Plot
- Creation of animation studios
- Getting rid of “rubber-hose” bodies
- Inking on cels

“Steamboat Willie”
Walt Disney (1928)

“You’re a Big Girl Now”
Harman & Ising (1932)

“Felix the Cat”
Pat Sullivan (1919)

“Gertie the Dinosaur”
Windsor McCay (1914)
Key Developments [2]:
Rotoscoping (1921)

- Max Fleischer invents rotoscoping (1921)
Key Developments [4]
Fleischer’s Rotoscope

© 2010 J. Lawrence, University of Virginia
Key Developments [5]:
Using Rotoscoping

- Max Fleischer invents rotoscoping (1921)
Key Developments [6]: Color

- “Flowers and Trees” (1932) uses color!
- “Snow White” (aka “Disney’s Folly”) released 1937
Overview

- Some early animation history
  - http://web.inter.nl.net/users/anima/index.htm
  - http://www.public.iastate.edu/~rllew/chrnearl.html

- Computer animation
Animation, Simulation, & Visualization

• What is animation?
  ○ Make objects change over time according to scripted actions

• What is simulation?
  ○ Predict how objects change over time according to physical laws

Wilhelmson et al. (2004)
http://youtu.be/EgumU0Ns1YI
http://avl.ncsa.illinois.edu

Adapted from slides © 2010 J. Lawrence, University of Virginia
2-D & 3-D Animation

Homer 2-D

Homer 3-D

http://youtu.be/TKQBz1r6PqU (Making Of)

Outline

- Principles of animation
- Keyframe animation
- Articulated figures
Traditional Animation [1]:
Lasseter's List of Principles (1987)

- Squash and Stretch
- Timing
- Anticipation
- Staging
- Follow Through and Overlapping Action
- Straight Ahead Action and Pose-to-Pose Action
- Slow In and Out
- Arcs
- Exaggeration
- Secondary action
- Appeal

Traditional Animation [2]: Squash & Stretch

- Defining the rigidity and mass of an object by distorting its shape during an action.
Traditional Animation [3]:
Timing

- Spacing actions to define the weight and size of objects and the personality of characters.
  - Heavier objects accelerate slower
  - Lethargic characters move slower
  - Etc.
Traditional Animation [4]: Anticipation

- The preparation for an action.
  - Muscle contraction prior to extension
  - Bending over to lift a heavy object
  - Luxo’s dad responds to Luxo Jr. off screen before Luxo Jr. appears.

Luxo Jr. © 1986 Pixar
http://www.pixar.com/shorts/ljr/
http://youtu.be/qGxoui3IFS0

© 2010 J. Lawrence, University of Virginia
Traditional Animation [5]: Staging

- Presenting an idea so that it is unmistakably clear.
  - Keeping the viewer’s attention focused on a specific part of the scene.
  - Luxo Jr. moves faster than his dad, and so we focus on him.

Luxo Jr. © 1986 Pixar
http://www.pixar.com/shorts/ljr/
http://youtu.be/qGxoui3IFS0

© 2010 J. Lawrence, University of Virginia
Traditional Animation [6]:
Follow Through & Overlapping Action

- The termination of an action and establishing its relationship to the next action.
  - Loose clothing will “drag” and continue moving after the character has stopped moving.
  - The way in which an object slows down indicates its weight/mood.
Traditional Animation [7]:
Straight-Ahead vs. Pose-to-Pose Action

- The two contrasting approaches to the creation of movement.
  - Straight Ahead Action:
    » Action is drawn from the first frame through to the last one.
    » Wild, scrambling actions where spontaneity is important.
  - Pose-to-Pose Action:
    » Poses are pre-conceived and animator fills in the in-betweens.
    » Good acting, where the poses and timing are all important.
Traditional Animation [8]: Slow In-And-Out

• The spacing of in-between frames to achieve subtlety of timing and movements.
Traditional Animation [9]: Arcs

- The visual path of action for natural movement.
  - Make animation much smoother and less stiff than a straight line for the path of action
Traditional Animation [10]:
Exaggeration

- Accentuating the essence of an idea via the design and the action.
Traditional Animation [11]: Secondary Action

- The Action of an object resulting from another action.
  - The rippling of Luxo Jr.’s cord as he bounces around the scene.

Luxo Jr. © 1986 Pixar
http://www.pixar.com/shorts/ljr/
http://youtu.be/qGxoui3IFS0

© 2010 J. Lawrence, University of Virginia
Traditional Animation [12]: Appeal

- Creating a design or an action that the audience enjoys watching.
  - Charm
  - Pleasing design
  - Simplicity
  - Communication
  - Magnetism
  - Etc.
Outline

- Principles of animation
  - Keyframe animation
- Articulated figures
Keyframe Animation [1]: Keyframes

- Define character poses at specific time steps called “keyframes”

Lasseter ’87
Keyframe Animation [2]: Interpolation (aka Inbetweening)

- Interpolate variables describing keyframes to determine poses for character “in-between”
Keyframe Animation [3]:
Linear Interpolation aka Lering

- Inbetweening:
  - Linear interpolation - usually not enough continuity

```
Linear interpolation
```

H&B Figure 16.16
Keyframe Animation [4]: Cubic Curve (Spline) Interpolation

- Inbetweening:
  - Cubic spline interpolation - maybe good enough
    » May not follow physical laws
Keyframe Animation [5]:
Dynamics & Kinematics

- Inbetweening:
  - Kinematics or dynamics

© 2010 J. Lawrence, University of Virginia

Rose et al. ’96
Outline

- Principles of animation
- Keyframe animation
- Articulated figures

© 2010 J. Lawrence, University of Virginia
Articulated Figures [1]: Definition

- Character poses described by set of rigid bodies connected by “joints”

Scene Graph

Base

Arm

Hand

Angel Figures 8.8 & 8.9
Articulated Figures [2]: Character Modeling

- Well-suited for humanoid characters

```
Root
  /       \
 /         \
Chest      LHIp
     |       |
  |       |
Neck      Rcollar
     |       |
  |       |
Head      Lshld
     |       |
  |       |
LElbow    RElbow
     |       |
  |       |
LWrist    RWrist
```

© 2010 J. Lawrence, University of Virginia
Articulated Figures [3]: Angular Interpolation

- Inbetweening
  - Interpolate angles, not positions, between keyframes

Good arm

Bad arm

© 2010 J. Lawrence, University of Virginia
Articulated Figures [4]: Bones & Joints

- Articulated figure:

  - Hip
  - Upper leg
    - Knee
      - Lower leg
        - Ankle
          - Foot
  - Upper leg (hip rot)
    - Hip rotate
  - Lower leg (knee rot)
    - Hip rotate + knee rot
  - Foot (ankle rot)

© 2010 J. Lawrence, University of Virginia
Articulated Figures [5]: Example – Walk Cycle 1

- Hip joint orientation:
Articulated Figures [6]: Example – Walk Cycle 2

- Knee joint orientation:

      Watt & Watt

© 2010 J. Lawrence, University of Virginia
Articulated Figures [7]: Example – Walk Cycle 3

- Ankle joint orientation:

© 2010 J. Lawrence, University of Virginia
Articulated Figures [7]: Example – Walk Cycle 4

© 2002 D. M. Murillo
Looking Ahead: Scene Graph Traversal
Looking Ahead:
Scene Graph Rendering

Performer © 1997 D. Pape
http://www.evl.uic.edu/pape/talks/VSI97/pf/
Problem Set 3: Hour Exam 1 Review

Instructions and Notes:

- You should have 45 minutes to complete this exam. Do each page at your time carefully.
- There are five (5) problems on this exam.
- No calculators, writing instruments, or other calculating devices are needed or permitted.
- Rulers and straight edges are permitted.
- Show your work on problems and proofs.
- Blank paper is available and you may add pages of work if needed.
- In the interest of fairness to all students, no questions will be answered concerning the content of questions. If you believe there is a typographical error or ambiguity, state your assumptions.

If a course number is designated, do only the parts that correspond to the course number you are enrolled in. No credit will be given for CIS 636 problems done by CIS 736 students, or vice versa.

- Circle which course number (536, 636, or 736) you are enrolled under, both on this page and for each question, and answer the questions for that course number.
- You may use any consistent naming system for vectors and coordinate systems. However, if it does not match the OpenGL conventions or the systems used in Eberly or Foley et al., then you are responsible for defining every vector by its full, unambiguous name.

- There are a total of 100 possible points in this exam.
Summary

- Reading for Last Class: §2.6, 20.1, Eberly 2e; OpenGL primer material
- Reading for Today: §5.1 – 5.2, Eberly 2e
- Reading for Next Lecture (Two Classes from Now): §4.4 – 4.7, Eberly 2e
- Last Time: Shading and Transparency in OpenGL
  - Alpha blending
  - Painter’s algorithm – less efficient, can handle non-opaque objects
  - Depth buffering (z-buffering) – in hardware, fast, opaque only
- Today: Introduction to Animation
  - What is it and how does it work?
  - Brief history
  - Principles of traditional animation
  - Keyframe animation
  - Articulated figures: inbetweening
Terminology

- Shading and Transparency in OpenGL: Alpha, Painter’s, z-buffering
- **Animation** – Bringing Still Objects “to Life” (Change Over Time)
- **Early Animation**
  - **Thaumatrope** (c. 1824) – early Victorian toy prefiguring flipbooks
  - **Flipbook** – simple paper-based animation technique
- **Action in Traditional Animation**
  - Before: squash & stretch, timing, anticipation, staging
  - During: exaggeration, secondary
  - After: follow-through & overlapping action
  - Design: straight-ahead vs. pose-to-pose
- **Keyframe Animation**
  - **Inbetweening** – interpolation technique
    - **Lerping** – linear interpolation
    - **Splines & other cubic curves**
  - **Articulated figures**: angular interpolation