3D Modeling, Animation, Compositing, and Special Effects
ITP 215x (2 Units)

Fall 2014

Objective

Overview of developing a 3D animation—from modeling to rendering: Basics of surfacing, lighting, animation, and modeling techniques. Advanced topics: compositing, particle systems, and character animation.

Concepts

Fundamentals of 3D modeling, animation, surfacing, and special effects: Understanding the processes involved in the creation of 3D animation and the interaction of vision, budget, and time constraints. Developing an understanding of diverse methods for achieving similar results and decision-making processes involved at various stages of project development. Gaining insight into the differences among the various animation tools. Understanding the opportunities and tracks in the field of 3D animation.

Prerequisites

Knowledge of any 2-D paint, drawing, or CAD program.

Instructor	Lance S. Winkel
Contacting the Instructor	Email Address: winkel@usc.edu OHE 530 H
Office Hours	Listed on Blackboard under Contacts
Lab Assistants	
Lecture	1.5 hours per week
Lab	1.5 hours per week

Required Textbooks

None, Resources online and at Lynda.com and knowledge.autodesk.com

Website

Class materials are posted on the USC Blackboard website. https://blackboard.usc.edu/

Grading

Ten weekly assignments / progress checks = 10 points each (100 total)
Cityscape project = 20 points
Chess Animation project = 20 points
Character Animation project = 20 points
Final project = 60 points
Attendance and Participation = 30 points (-10 points / absence)
Total = 250 points

Grading Scale

A 100-93
A- 92-90
B+ 89-87
B 86-83
B- 82-80
C+ 79-77
C 76-73
C- 72-70
D+ 69-67
D 66-65
F 64 or below

Policies

Projects: All projects and weekly assignments are due at the start of class and are considered late 1⁄2 hour after class begins. Only one project or assignment may be turned in late. All other late projects will NOT be accepted unless pre-approved by the instructor. With the instructor's approval, on time projects may be redone for additional credit but must be turned in by the following class session. The final project may not be turned in late.

Before logging off a computer, students must ensure that they have emailed or saved projects created during the class or lab session. Any work saved to the computer will be erased after restarting the computer. ITP is not responsible for any work lost.

ITP offers Open Lab use for all students enrolled in ITP classes. These open labs are held beginning the second week of classes through the last week of classes. Please contact your instructor for specific times and days for the current semester.

Incomplete and Missing Grades

Excerpts for this section have been taken from the University Grading Handbook, located at http://www.usc.edu/dept/ARR/grades/gradinghandbook/index.html. Please see the link for more details on this and any other grading concerns.

A grade of Missing Grade (MG) "should only be assigned in unique or unusual situations… for those cases in which a student does not complete work for the course before the semester ends. All missing grades must be resolved by the instructor through the Correction of Grade Process. One calendar year is allowed to resolve a MG. If an MG is not resolved [within] one year the grade is changed to [Unofficial Withdrawal] UW and will be calculated into the grade

point average a zero grade points.

A grade of Incomplete (IN) "is assigned when work is no completed because of documented illness or other 'emergency' **occurring after the twelfth week** of the semester (or 12th week equivalency for any course scheduled for less than 15 weeks)."

Academic Integrity

USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one's own academic work from misuse by others as well as to avoid using another's work as one's own. All students are expected to understand and abide by these principles. *Scampus,* the Student Guidebook, contains the Student Conduct Code in Section 11.00, while the recommended sanctions are located in Appendix A: http://www.usc.edu/dept/publications/SCAMPUS/gov/. Students will be referred to the Office of Student Judicial Affairs and Community Standards for further review, should there be any suspicion of academic dishonesty. The Review process can be found at: http://www.usc.edu/student-affairs/SJACS/.

Students with Disabilities

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to your course instructor (or TA) as early in the semester as possible. DSP is located in STU 301 and is open from 8:30am to 5:00pm, Monday through Friday. Website and contact information for DSP http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html (213) 740-0776 (Phone), (213) 740-6948 (TDD only), (213) 740-8216 (FAX) ability@usc.edu

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Course Outline

Week 1 Tuesday – Syllabus and Course Introduction
- Survey of student and 3D animation experience
- Overview of course plan and objectives
- Autodesk Student Software and Licensing
- Lab Policies and Procedures
- Online resources: Highend3d.com, Learning-Maya.com, knowledge.autodesk.com, Lynda.com
- Supplemental learning resources and recommended reading

Project: Make an Autodesk account. Download and install Maya 2014 from Autodesk

Week 1 Thursday – Syllabus and Course Introduction
- Introduction to the Maya GUI
- Configuring the user interface including hotkeys, interface color, marking menus, display modes, etc.
- Adjusting cameras, displays, and viewports
- Basic object creation
- Core 3D Concepts (XYZ, RGB)
- Cartesian Coordinates
- Right handed rule
- Basic 3D transforms (translation, rotation, scaling) and animation
- Maya's Online Help

Project: Using the provided planets scene file, animate the orbit and revolution of each of the planets, moons around the solar system. Learn familiarity with the Maya interfaces, including object selection, navigation, setting animation keys, and basic transforms. Save the scene and submit it to blackboard.

Week 2 Tuesday – Creating a 3D scene from primitives
- Further introduction to the Maya GUI
- Optimizing the interface for working efficiently
- Polygon components (vertices, edges, faces)
- Creating and editing geometry from primitives
- How modeling primitives relate to modern construction techniques
- Understanding form, function, and structure

Project: Cityscape (Week 1 of 7) - Create a metropolitan landscape from primitives and simple hierarchies. At least three separate building made with only polygon primitives, duplication, grouping, and parenting. Attempt to faithfully reproduce the most important details. See blackboard for

specific details.

Week 2 Thursday – Creating a 3D scene from primitives
- Arrayed Duplication
- Groups and Hierarchies
- Parent nodes
- Offset transforms
- Duplication vs. Instancing

  Project: Cityscape (Week 1 of 7) – Continued.

Week 3 Tuesday – Polygon mesh editing tools
- Additive vs. subtractive modeling
- Manually manipulating component
- Selection strategies for selecting and isolating component transform
- Splitting polygons vs. deleting edges

  Project: Cityscape (Week 2 of 7) - Populate the scene with at least three new sculpted polygon objects. These should complement the primitive models from the previous turn-in. For this phase of production we are focusing on sculpting through mesh editing techniques as detailed in class. One object should be a vehicle of some form. See blackboard for specific details.

Week 3 Thursday – Polygon mesh editing extrusion
- Polygon extrusion
- Understanding the differences between tools and commands
- Using the show manipulator tool to influence and control extrusion
- Other hybrid tools (bevel, wedge, cut faces, etc)
- Building sample model from blueprint or technical reference

  Project: Cityscape (Week 2 of 7) – Continued.

Week 4 Tuesday – Materials and Texturing
- Overview of the rendering pipeline
- Fundamental formulas and math functions (normal, tangents, cosines)
- Defining nodes and attributes
- Introduction to materials and shading groups
- Basic rendering nodes and attributes

- Lambert shader
- Building off of lambert with phong and blinn shaders

Project: Cityscape (Week 3 of 7) - Assign materials to the objects with the scene. Use the material properties to convey the appropriate type of physical look for the various surfaces in your scene. Stone, metal, glass, wood, earth, sky, plastic, marble, etc. Make sure to include at least three materials that have 'specular' shading properties, at least one surface shader, and at least one material that uses incandescence. See blackboard for specific details.

Week 4 Thursday – Basic Texturing
- Introduction to textures
- Defining textures vs. materials
- Assigning textures to material attributes
- Texture nodes and utility nodes
- Sourced vs. procedural texture nodes and concepts for mathematically generated texturing.
- Understanding the four categories of shading nodes and how they work together to shape the rendered scene.

Project: Cityscape (Week 3 of 7) – Continued

Week 5 Tuesday – Texturing and UV Coordinate Space
- Understanding UV texture space
- Simple UV projection
- Similarities between manipulating UV coordinates and polygon components
- General workflow for UV unwrapping and export to image manipulation software.
- Best practices for solving texture wrapping problems on complex objects.

Project: Cityscape (Week 4 of 7) - Assign textures to the objects with the scene. A fully UV unwrapped vehicle or objects to support accurate texturing. Use the mesh projection tools and UV texture editor menus to manually alight and sort out any problem UV areas for clean texturing. Use image editing programs to make sourced textures for color, bump, specular, and incandescence attributes. See blackboard for specific details.

Week 5 Thursday – Texturing Pipeline and Texture Painting
- Types of textures (color, specular, bump, and incandescence)
- Exporting UV template
- Creating textures using image manipulation software
- Techniques for layer based image manipulation
- Assigning textures to material attributes
- Reference libraries and resources for textures and materials

     Project: Cityscape (Week 4 of 7) - Continued

Week 6 Tuesday – Overview of cameras and optics
- Overview of cameras, terms and techniques
- The mathematics of perspective in optics
- Industry standards
- Maya's virtual camera and settings
- Camera setup
- Film gate, aperture, aspect ratio, lens focal length, angle of view, zoom vs. prime lenses, frame rate, and other standards
- Overview of camera history, manufacturers, and providers

     Project: Cityscape (Week 5 of 7) – Setup a custom camera in Maya. Set it up with appropriate film gate, lens, and working settings. Use the camera's viewport as a director's viewfinder to layout and arrange the various assets of your city into the scene as a complex environment. See blackboard for specific details.

Week 6 Thursday – Cameras in 3D
- Cinematography references
- Good and bad camerawork and composition
- Laying out and populating a 3D scene
- Animating a camera
- Graph editor curves
- The Five C's, Cinematography, Fundamental techniques for good camera work

     Project: Cityscape (Week 5 of 7) – Continued.

Week 7 Tuesday – Lighting in 3D
- The application of lighting in 3D
- Types of lights and their uses
- Good lights (directional, spot, point, and area)
- Bad lights (ambient and volume)

- Ray traced and depth mapped shadows
- Soft shadows, penumbra, falloff, and other phenomena
- Using the Render Settings window to prepare a scene for lighting
- Memory efficiency and pipeline specific differences of each renderer

Project: Cityscape (Week 6 of 7) - Light the scene to establish a specific mood. Lighting reference will help to achieve the best possible emotional context and exposure quality for the scene. Animate the camera so that it makes a well-controlled cinematic camera move. Choreograph the vehicle's animation so that it travels in relation to the camera through a 10 second shot. See blackboard for specific details.

Week 7 Thursday – Animating a vehicle
- Review key framing techniques
- Animating with basic hierarchies
- Using parent – child relationships to further enhance animation capabilities
- Techniques to produce better performance
- Animating props and cameras
- Using the Render Settings window to prepare a scene for render

Project: Cityscape (Week 6 of 7) – Continued.

Week 8 Tuesday – Rendering
- Rendering image sequences from Maya
- Proper naming conventions (name.#.ext, etc.)
- Importing image sequences into post production and compositing programs
- Creating QuickTime movies
- Understanding compression codecs, quality, compression, file size
- Industry specific examples of why you only render image sequences (never render movie files!)

Project: Cityscape (Week 7 of 7) – Setup the animated scene for rendering. Render the scene out as a sequence of images and then import the sequence into the post compositing program for final QuickTime output. See blackboard for specific details.

Week 8 Thursday – History of 3D Computer Graphics
- Why Tron is the most important movie in the history of mankind… or at least 3D
- How small steps created an industry

- The hurdles and limitations of early 3D
- Trace the major innovations of 3D and technology over the last 30 years, from early experiments through the modern production and business models of today.
- Mergers, acquisitions, trends, and the future

Project: Cityscape (Week 7 of 7) – Continued.

Week 9 Tuesday – NURBS Overview
- Non Uniform Rational B-Spines
- Curve based modeling within the scope of production
- NURBS in contrast to polygons
- Modeling concepts and workflow for NURBS
- Defining NURBS and NURBS components
- Control Vertices, Control Hulls, Curve Degree, Spans/Sections
- Making sense of NURBS mathematics (#CVs = Degree + #Spans)
- Advantages to NURBS in modern production

Project: Chess Animation (Week 1 of 3) – Add image planes to your profile orthographic cameras as modeling reference. Use NURBS curves to define the profile and contours for the objects. Use curve editing and surfacing operations to build out the shape of the chess pieces in NURBS. Then convert to polygons for any remaining detailing. Build at least two different chess pieces using NURBS and/or polygon techniques. See blackboard for specific details.

Week 9 Thursday – NURBS and spline-based modeling
- Working with NURBS Curves
- Curve editing, Attachment, Detachment, and Rebuilding
- Uniform vs. Non-Uniform curves
- Converting curves into surfaces
- Using revolve to form the chess shape from a profile
- Best practices for NURBS to polygon conversion
- Boolean modeling techniques
- Construction history
- Essential steps to prepare a character model for animation

Project: Chess Animation (Week 1 of 3) – Continued.

Week 10 Tuesday – Basic character setup
- Non-linear deformers
- Curve, Bend, Twist, Wave, Sine, Squash

- Understanding deformation order
- Approaches for restructuring the deformation order for proper performance behavior
- Hierarchies for animation

Project: Chess Animation (Week 2 of 3) – Clean up the models for animation. Use animation deformers to enable the models to perform as necessary for the animation sequence that is to follow. Begin animating at least two of the chess pieces through a 5 - 10 second animation. See blackboard for specific details.

Week 10 Thursday – Advanced character setup concepts
- Advanced controller setups
- Adding custom attributes to Maya nodes
- Driving automation by connecting attributes
- Input and Outputs, and the connection editor

Project: Chess Animation (Week 2 of 3) – Continued.

Week 11 Tuesday – Animating a simple character
- Planning a performance
- The importance of acting out a performance
- Key framing tools and techniques
- Using the Graph Editor
- The relationship between motion curves and nuances of movement
- Understanding motion curves, keys, and tangents

Project: Chess Animation (Week 3 of 3) - Finish animating the chess pieces and render the scene using the same procedures as we used at the end of the previous project. See blackboard for specific details.

Week 11 Thursday – Refining the performance
- Refining and further developing an animation
- Isolating erroneous movement behavior
- Fine tuning the timing and performance
- More Graph Editor

Project: Chess Animation (Week 3 of 3) – Continued.

Week 12 Tuesday – The Final Project
- Solve any animation problems with the Chess Animation
- Adding texture to a deforming character mesh

- Lighting for animation
- Discuss the Final Project
- Overview of the remaining timeline for the class

Project: Final Project: Discuss the final project. Final project listed at bottom of syllabus. Also see blackboard for specific details. Due at the start of our Finals Week class session. In-class screening and critique will follow. Progress checks will be due each week.

Week 12 Thursday – Posing a character
- Animating a full human character using a pre-rigged character rig
- Setting motion keys across arrays of joints and skeletons
- The importance of pose in expressing character personality
- Blocking in a performance

Project: Continue Final Project.

Week 13 Tuesday – Animating a character
- IK – Inverse Kinematics
- FK – Forward Kinematics
- Understanding the fundamental differences between animating IK and FK hierarchies.
- How and where to apply IK and FK to movement and articulation problems
- Working with a rig

Project: Final Project Proposals Due & Progress Check

Week 13 Thursday – Advanced Rendering topics
- Batch Rendering
- Command line rendering
- Rendering across multiple machines
- Networked, farmed, and distributed rendering
- Types of renderers

Project: Continue Final Project.

Week 14 Tuesday – Mental Ray and special topics in 3D rendering
- Differences between the software and Mental Ray renderer
- Benefits of Mental Ray
- Final gathering
- Image based lighting (IBL) and High Dynamic Range Images (HDRI)

       Project: Continue Final Project.

Week 14 Thursday – Thanksgiving Holiday

       Project: **Don't be at school. Eat!**

Week 15 Tuesday – Special Topics and Open Lab
- To be determined based on course needs

Week 15 Thursday – Special Topics and Open Lab
- To be determined based on course needs

Week 16 – Final – Tuesday, December 16, 2-4pm, OHE 540
       Final projects must be submitted onto Blackboard by 8am.
       In class review and critique of Final Projects will follow.
       All students must attend Final Exam session!

Final Project:

       Due Date: Tuesday, December 16, 2-4pm, OHE 540
       Must be submitted onto Blackboard by no later than 15 minutes after the START of our Final Exam session – room and time based on Final Exam schedule.

       Using any and all of the techniques we have covered in the class thus far, create a 20 second animated sequence consisting of at least four consecutive shots. You may do more if you feel ambitious.

       A complete Final Project submission will consist of a finished rendered QuickTime movie file as well all Maya scene files, project folders, textures, and supporting materials.

       QuickTime file should be Sorensen 3 codec; 640x480 minimum resolution, HD and other aspect ratios are okay.

- At least three new detailed assets must be built and showcased in this project.
  - An asset can be anything from a building, to an environment, to a detailed prop, to a vehicle, or even a full character.

- o In order to optimize your time, you may use any previous assets and models to supplement this project. If you are recycling assets in this way, make sure to significantly improve them so that they compliment this new project (i.e. better texturing, shape language, edge topology, or detailing.)
- Demonstrate your best animation in the project
  - o Weight
  - o Timing
  - o Controlled key-framing
  - o Secondary animation.

The Final project is worth 60 points. Progress checks are due each week leading up to the Final deadline. The Final project will be graded based on:
- Meets base requirements (20 seconds, four consecutive shots, rendered)
- Demonstrated effort
- Complexity, range, and effective use of tools
- Quality of the finished product (performance, visual quality, etc.)

Have fun! Make awesome work!