Arch 481 :
3D Modeling and Rendering

Model & Rendering by Roark Congdon, Aut 09.

Exercise Workbook

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Prerequisites & Expectations

Different backgrounds

Architecture 380: Computers in Architecture is an undergraduate prerequisite for this course. At the time this prerequisite was put in place Arch 380 included a wide set of topics, including a short module introducing 3D modeling. The rest of the course provided a general overview of computers in environmental design professions, including topics such as 2D CAD, spreadsheets, HTML, GIS, lighting simulation, an intro to digital fabrication, and others.

In recent years Arch 380 was significantly reworked so that some content now resembles Arch 481. Undergraduates who have taken Arch 380 may therefore find that there is a great deal of subject matter that is familiar. Graduates, on the other hand, have not had the same prior exposure and may well need time to develop some of the basic skills and concepts before diving into the more advanced work. This creates a challenging situation in a course of mixed registration.

The task of modeling and rendering 3D scenes can be very different for different users, such as industrial designers to architects to landscape architects and urban planners. While students in the CBE usually work at the scale of the room or larger, there remain a variety of challenges and there is much theory that is relevant regardless of scale, and we can talk about some of the general differences in class, the experience working with modeling projects that are “appropriate” to your discipline is desirable, and varies from student to student.

Exercise “extensions” for different goals

In an attempt to address some of these challenges, the course this quarter has had a number of “extensions” added to the project definitions that should enable you to stretch your skills or catch-up, as appropriate, and also to fit the subject to your disciplinary background. Some of these are brand new, and all of them can be adjusted if needed, so your feedback on the “fit” of these extensions to your background and interests is welcomed.

One project—many vignettes

You will be developing your overall project at the same time that you learn new concepts and skills. You should expect this process to include dead-ends—techniques you don’t need right now, approaches to learn now for later use. Demonstrating understanding of the weekly subject area and techniques does not usually require their deployment across a large or complex model, which could seriously extend both modeling and rendering time, so you are encouraged to build or extract small study-models from your overall project and use them to practice on. When it comes time to turn in work, renderings from these lightweight models are usually acceptable.

One performance standard

Regardless of where you begin the quarter in terms of skill and experience, I expect you to push yourself to expand your understanding and demonstrate it through strong work in both visual production and written understanding. Projects are evaluated independently in terms of individual progress and the incorporation of prior skill areas.

Project Overview

At the center of this course is a series of exercises that are intended to help you progressively develop a 3D model and its visualization. As you complete the exercises, you will gain skill and knowledge in both modeling and rendering. You will generate a body of work that tells the story of your chosen building or environment, culminating in a video that not only shows us what the building looks like, but also tells us something about the design or use.

The exercises will introduce you to the vocabulary and techniques of modeling and rendering, but the particular building or environment you model is up to you. Regardless of the environment you choose for your project, you will revise and develop it as we investigate various features found in 3D software. Like other tools, software "fits" each project a little differently depending on the level of detail required, kinds of imagery, time available, etc. We will mostly use Rhino (and related plugins) for the in-class tutorials and demonstrations, but you may propose the use of other software if you wish. Some are suitable for all tasks, but some are not. Talk to me if you are planning to use something else (*before* you begin to do the work, please!) so we can work out any issues about submission that might arise. Recent applications used by students have included Blender, 3D Studio, SketchUp+Kerkythea, and form•Z. Some are available for free on your personal machine, but not all.

The exercise projects are designed to guide you through the development of a model in stages, working from simple to complex issues within the model making and rendering tasks. As is true in most learning situations, you will probably discover in later assignments that there are ways of doing things that might have simplified earlier efforts. While sometimes frustrating, it's actually good. It means you **are** learning! Practicing new techniques on small study models can make the process less painful.

Some Advice Concerning the Subject of Your Work

Select a design. (NOTE: *If you feel confident about your basic modeling skills, you may choose to work with your current studio project, but be aware that our schedule is not designed to fit with studio schedules, which may prove awkward*.) One of the choices you must make very quickly is what to model. It might be a design of yours, or someone else, famous or not. You are expected to do a *built environment*, but that could include a landscaped space. The goal is to select a project that we can work with throughout the quarter, refining and developing it in detail. You need to be able to find out what the detail is without getting bogged down doing design work. This suggests you should avoid projects that have unresolved design issues, such as under-developed studio projects. It is difficult to struggle with the design as well as the software.

Select a conceptually clear project. In keeping with the idea of rendering as authored visualization, we will be creating images that highlight design aspects of the project. It will be easier if the original has strong personality or character to present. Axes? Siting? Details? What is it that gives your project distinctive character? Figure it out and use the modeling and rendering process to display it.

Keep your eye on the goal. Regardless of the building chosen, you should remember that the goal of the *class* is to learn how modeling and rendering software work and understand the opportunities and tradeoffs necessary to complete the task, not simply to produce a spiffy image or learn one piece of software.

Keep it simple. You will generally learn more from challenges of *quality* than from challenges of *quantity*. In addition, one of the sure-fire ways of crashing *any* program or computer is throwing large amounts of data at it, and while you are learning it is particularly easy to make overly "heavy" (large) data files. Setting out to do a complex piece of geometry (the entire UW campus, Rome, the EMP, forest of detailed trees, etc.) on the relatively under-powered PCs available in the CBE labs is an invitation to trouble.

If you do pick a more complex building, such as a high-rise, you may want to model only a portion of the interior (e.g. the lobby of an office tower, a residential unit in a high-rise condo, etc.) There is no need to model what you do not see (remember, in this class it's about visualization, not design, so think about the story you want to tell and pick the best part of the geometry to tell that story).

Make sure data exists. You need pretty complete geometry data for the environment you model. While approximation is OK in this process, this means you will usually need more data than a few glossy-magazine pictures can provide (they tend to show plans, but not enough sections). Do think about information, but do not simply download (yet another) copy of the Barcelona Pavilion and use that—build your own model.

To assist those without a personal body of work to draw on, I have placed PDF files for several building projects on the course website, including a Tea House, a one-room studio/study, and a cabin on Decatur Island.

In summary: you may select a studio project from a previous quarter. You may model the Decatur Island cabin. You are welcome to use your developing skills in studio, but unless you have substantial modeling skill already be cautious about using your <u>current</u> studio as the course project. If you're unsure, talk to me.

Storytelling

We create both hand-drawn and computer-graphic images for the purpose of communicating our ideas to co-workers, clients, critics, jurors and other interested parties. In this process it is rare to use single images without verbal or textual elaboration. There are, in fact, several programs, such as InDesign, Premiere, Illustrator, and PowerPoint, which are used primarily to create presentations not to generate the raw material of which the presentations are made. Some take little time to learn and use, some are quite complex. You should strive to make a compelling story, without being distracted by the storytelling technology.

Designing the individual images

Each image you make has a chance to tell the viewer something about the architecture. Each image is also the product of applying a rendering algorithm to a model, subject to a particular viewing condition. You control the geometry, the renderer, and the viewpoint to get the message across. Consider using actual geometry to convey difficult concepts (e.g. view corridors, functional divisions, etc.), as well as rendering options like color-coding and translucent geometry, and make sure the viewpoint works, so you don't get a big white background with a little image in the middle. Get close. Use eye level views and perspective if it's about perception. Consider the role of this image in a sequence of images (e.g. using a single viewpoint for a series of still images that display construction sequencing or model development can produce a compelling result when one image is faded into the next in a presentation).

Telling your story using a simple "Slide Show"

Presentation options are many, including simple on-screen sequences of images—slide shows, paper hardcopy of various sizes and qualities, video presentation, and (more recently) presentation via the web. Each of these has unique characteristics that suit it to different audiences and conditions. For this course, we will use a simple low-tech approach that can be readily adapted to everything from desk-crits to client presentations.

This technique is quick and simple, and works with virtually any image file type and resolution. (Also, while this particular description is tied to Macintosh computer systems, it has Windows analogues.) On a Mac one can use the **Preview** program. The basic idea is to drop a collection of image files onto the program. It opens all of them in an overlapping stack of windows, or as files in a "tray". The order in which they appear is alphabetical, by file name. Once open, a keystroke displays the next image in the sequence.

To create each slide show, you will "export" a series of images from your application. Use JPG format, but at a high quality setting and a resolution between **1024x768** and **1500x1000** pixels. As you save them, give the image files meaningful names so you won't have to open them to tell what you've got (e.g. "shadow_error.jpg" for a file showing a shadow-casting error, or "textured-brick.jpg" for one done with a brick texture).

When you know what you've got to work with, re-name the files for the slide show by *prefixing* the meaningful name with a unique letter or number to place them in alphabetical order (for up to 26 images, you could just stick a single letter on the front of each…"A_shadow_error.jpg", "B_correct-shadow.jpg", etc.). To view the slide show, select the files and drag them onto the **Preview** icon. It will open them up, displaying the first one. Now, a single keystroke (down-arrow) advances to the next image in the sequence.

While there is no permanent slide show file created in this process, it remains quick and easy to do. It simply takes advantage of a characteristic of the **Preview** program.

Hint! ☞ It might seem obvious, but remember to **look** at each image before you save it! Is it the right **point of view?** Is it **clear?** Does it **fill the frame?** (so there's not too much white space around it).

Hint! ☞ The slide show will look **much** better if you make all the images the same size and if you turn off any coordinate axes or grids before you save each image, so that they are not cluttered.

Hint! ☞ It takes a little extra time, but you can add "**narration**" to the slide show by adding labels (or other graphics) directly to the images using Photoshop/etc., or creating separate "text slides" as free-standing image files (get the size right!) with the desired descriptive text in them. Keep the text big and simple and make sure the name positions it correctly in the sequence!

Alternatively, you can use Adobe Illustrator or PowerPoint to create a multi-page document with captions or drawings on top of the images, and then print it to PDF for submission.

Turning in your work

The Catalyst "Collect It" Dropbox

The work you do in this course will produce image sequences (slide shows). Rather than having you print those out and turn in hardcopy, I want you to turn in files. The best way to do this is to have you transfer your finished files to a shared file space. This quarter we will be using a Catalyst tool called "Collect It" for this job. The URL for uploading your files is

`https://catalysttools.washington.edu/collectit/dropbox/brj/40857`

There will also be a link to the drop-box on the course web site. Log in to Catalyst using your UW Net ID.

The write-up — printed and handed in

Being a literate user of computer graphics is more than being able to produce imagery. It means you own and can use the vocabulary of the field, to communicate with colleagues and technical support when needed. For this reason, each project in this class includes several questions you are expected to respond to in writing. Please remember to print out and turn in the write-up as part of your assignment.

You should feel free to share your understanding and knowledge with your classmates, but use your own words when writing-up the projects. If you are using someone else's words, like a snippet of the Tapestry, be sure to enclose them in quotes and say where you got them ("Tapestry" or "Wikipedia" is enough for us).

Hint! ☞ The best way to simplify turning in several files is to collect them together in one folder, compress (ZIP) the folder into a single file, and upload that file.

Hint! ☞ You can't delete files in the Dropbox, even if they are yours and you put them there. So if you decide to revise your submission after uploading your file(s) to the Dropbox, just give the new file an obvious name ("proj 1 rev 2") and add it to the Dropbox. Duplication is pretty obvious and I'll assume the later stuff is the "real" submission. However, if you're past the due date, send me a note via email to make sure I know it's there.

Other Hints & Suggestions …

File naming and Milestone backup conventions

There is a subtle trap that appears when working with a single project for the whole quarter–editing and saving the same file over and over again. Most programs don't directly overwrite the 'old' file when you save a 'new' one—just in case they crash during the save. Instead, they save to a temporary filename, then delete the old file before renaming the temporary file with the original file name. Others maintain a "rolling backup"–each time you save a new copy of the file they rename the old one by changing the extension (e.g. to ".fzb"–form•Z backup–in form•Z's case, or ".bak" in AutoCAD's or Rhino's case) after deleting any older backup file first. That may seem safe enough, but if you save periodically during a session, it doesn't provide much protection against the "big boo-boo", like accidentally deleting something from your model that you don't notice is missing for a couple of days. To recover from this situation, it is really nice if you have regular "milestone" backups so you can go back to an earlier version to recover a lost idea, or some lost data.

Therefore, I recommend that at the beginning of each day's work you **duplicate and rename** the model file, using a name that is derived from the date. Like this ("3dm" is the extension of Rhino models).

March 10: create and save a new model … "StudioA17.3dm"
March 11: duplicate and rename " StudioA17.3dm" creating " StudioA17.3.11.3dm". Now edit & save this file.
March 13: duplicate and rename " StudioA17.3.11.3dm" creating " StudioA17.3.13.3dm". Now edit this file, etc.

At any time you can roll back the clock to an earlier model, to borrow a piece of geometry, to generate a comparative picture, etc.

Or can you?

It is important to realize that all storage media (hard disks, USB flash drives, etc.) are temporary. It is not a question of *if* they are going to fail, but only a question of *when.* Thought about in those terms, all our backups (the StudioA17.3dm files, etc.) are pretty meaningless if the flash drive they live on is stolen, lost, or dropped under a Metro bus.

Try to make a habit of placing at least one recent copy of your file (a) on another disk, or (b) on another computer. Buy two USB drives. Even better, learn to use FTP to put files on your UW student account (where you can reach them from anywhere), Google Drive, or Dropbox to backup online. Don't rely completely on one flash or removable drive.

If a disaster happens while you're in this class, I'll try to help you out. I can make allowances (e.g., I will ignore the fact that the last two exercises are done with a different model than the first ones), but it is a known hazard, and *it is avoidable,* so build safe habits. It's like excusing yourself for being late to an important meeting by saying "Sorry I'm late -- I stopped to buy coffee."

Don't store your work on a public computer

Sure, you sit in the same seat in the lab each class, and you come in and use it in the evening, and it takes time to download and upload files each day, but please don't leave your work sitting on a public computer! It can be deleted at any time–by another user, by an administrator, or by the death of the hardware. Put your files where you can be reasonably sure they are safe!

Don't work directly on your removable disk/drive

However you transfer your data from one editing session to another. I highly recommend that you COPY the file to the LOCAL desktop (or a folder) BEFORE you open it. Then go ahead and work on it. When you are done, COPY it back to the storage medium.

Why?

1. During an editing session you want the fastest access possible to this file. Placing it on the local disk will insure this. Thumb drives are slower. Network drives can be even slower.
2. During the editing session the application may create temporary ("scratch") files to store transitory data (undo lists, etc.). This is often done on the same disk the project file is on. These files can be quite large and you may not have as much space on your disk as you think, which can cause performance or behavior problems. Copying to the local disk should insure that there is adequate space available.
3. If something goes seriously wrong during your session, the OS or the application is much less likely to trash your disk/thumb-drive if that's not the medium it is actively writing to or reading from.

As your project gets bigger than a single file (there will be textures, etc.) you will want to use a folder to contain the current version, copying it onto and off of the local disk. Backups can be made by ZIP archiving the folder from time to time.

How to read for this course

Reading lots of detail is tedious. Doing something complex without help is frustrating. The readings I suggest for each exercise are important to that exercise and the future, but may take a while to “soak in.” I suggest skimming them first, reading so you know what the subjects are and where to find them again when you need them. Then, later, come back and read them again when you need the information for a task. Regular skimming will help you find and learn new tools, discover new strategies, and generally improve. Set aside some time for reading each week, even if you’re not sure what you’ll read. It will help, I promise.

Getting Started P0

Project goals

This is just a simple "getting started" exercise to shake out and eliminate any problems we might have with accounts, network connections, file transfers, etc. No points are awarded in connection with this work, but use this time to check out the supporting software and websites and get clear in your own mind what you are going to work on.

Learning goals

Get acquainted with the course, it's goals, the exercise sequence, the website, my email address, uploading to the Catalyst drop-box, etc.

Learn to use the Catalyst "Collect It" drop-box to turn in work.

Production goals

A decision about what you will work on. As stated above, something with strong conceptual structure will probably be easier. Write up a paragraph describing the building/project you selected and why.

Readings

Arch 481 Workbook (this document), pp 2-8.

Course Website > Gallery (browse a few old projects, keeping in mind that these represent a *selection* of work turned in, not necessarily the best, and that goals for this quarter's projects may be slightly different).

Instructions:

1. Pick a project. If you're not happy with your own work, take a look at the "Starter drawings" linked to the Admin webpage. If none of those appeals to you, talk to me (email or f2f).
2. Create a text document for this week's write-up. This can be done with Word or some other text editor:
   a) Always include your **name** and the **project number** ("P0") at the top.
   b) Include information about your **previous experience** with 2D and 3D software in general and your goals for this course.
   c) Write about the **building/environment** you have selected to model. Tell me what geometry data (drawings, photos, etc.) is available and what you find interesting about the environment.
   d) Write about the **software** you plan to work with, even if that is Rhino & VRay. Tell me why you've chosen to work with that software, what your previous experience is, what you are most interested in learning, etc.
5. Save one screen image from your software. Place it in a folder with your write-up. ZIP the folder.
6. Turn in the ZIP file using the "CollectIt Dropbox" tool. There are links to it on the course website, in the syllabus, and in your "myUW" course info page for this class.
7. Email me (brj@uw.edu) to let me know you're done.

NOTE: In the future you will print out the write-up file and hand it to me in class. I assume you don't need to practice that. This exercise is about making sure you can carry out all the steps of our projects, so the text file is going into the Dropbox.

Basic Modeling P1

Topics

Modeling: 3D pointing problem, reference planes, snaps, & keyboards. Points, lines, surfaces & solids. Primitives & Attributes (color, layer, visibility, etc.). Pseudo-primitives. Euclidean transformations (move, turn, scale, mirror). Surface normals. **Rendering:** Controlling the virtual camera. Parallel and perspective projection.

Learning goals

The first stage of the project is to learn/review the most basic operations and concepts. It is assumed that you have some prior experience with Rhino or another modeling program, but a little review may still be fruitful. The more tricks and options which you uncover and master at this stage, the easier it will be in later stages. The challenge is to build a strong and complete foundation, so that you don't have to return to this material at a later date for shoring up.

Production goals

A 3D massing (or concept) model of the project.

Images illustrating how the environment is organized, or how the basic masses relate to one another, as well as demonstrating your control of the virtual camera and simple data-creation and editing operations.

Instructions:

1. As you work on your model, generate and save (as JPG files) images. These should tell a story—illustrate the logic of the design, site constraints, the sequence of the construction, etc.
2. Construct a massing model of the design using basic tools. You may well start from scratch for the next exercise, so don't get bogged down in detailed dimensions. Still, do pay attention to spatial relationships, interpenetration, etc.

Hint! ☞ You should be using **layers** to separate different building elements. This will make editing much easier later on when space becomes somewhat cluttered and makes pointing more awkward.

3. Think about the model as a 3D diagram. Can you represent *function*? *material* changes? *structural systems*? *circulation*? interior *organization*? *siting*? future *expansion*? Experiment a little. If you need to, create more than one model! It's like a sketch on a piece of paper, so why limit yourself to just one?.

Hint! ☞ Adding text to your images can <u>really</u> help. Also, keep unmodified versions for the final project!

4. Make sure you understand how to use the program to overcome the pointing problem using object *snaps* (end-point, near-point, intersection, etc.), typed dimensions/coordinates, and construction planes.
5. Include points, wireframe, surface, and solid (polysurface) data elements in your model. Make sure you know how to *set and query* basic object attributes (layer, visibility, color, etc.).
6. Use the basic Euclidean *transformations* (move, rotate, scale), to duplicate and position repetitive elements within the design.
7. Work with the camera-manipulation tools to identify a couple of strong view-points in the model. Save the view-points for later recall (you can adjust these later if they aren't quite what you need).
8. Make a folder with your name on it and create a "slide show" in the folder from your collection of images. Make a ZIP archive of the folder.
9. Turn in the files by uploading the zipped folder to the "Collect It" web site using the link mentioned in the syllabus or provided on the course website.
10. Answer the <u>write-up questions</u> below. Print it. Turn that in to me <u>in class</u> as <u>hardcopy</u>.

Extra Credit! + Create a 3D concept model in addition to a geometry (massing) model, and generate some images. Add a paragraph to your writeup that talks about the concept.

Write-up Questions

Hint! ☞ You can copy & paste the questions from this PDF to a Word document, then edit.

At the top of this (and every) write-up, please include your name, the project name, and (if not Rhino+V-Ray) the name of the software you are using

1. How is **solid model** data different from and similar to **surface** or **boundary representation** data?
2. Pseudo-primitives appear in the user interface as something different from what they are in the data. Can you identify any pseudo-primitives in Rhino? What reveals this to be the case?
3. What is the "pointing problem"? What input features or options can you use in your program to overcome this problem?
4. What is the function of the "Project" option in the list of o-snaps?
5. Using the "virtual camera" analogy, explain the difference between an elevation and a two-point perspective?

Extra Credit! ☞

6. Why do most modeling programs use polygon-based geometries rather than true smooth-surface geometries like spheres, cylinders, etc?

Derivative Geometry P2

Topics

Modeling Making *some* data into *more* data via extrusion, revolution, sweep, loft. **Boolean operations:** sculpting shape with shape. **Symbols:** (aka "blocks") & Groups. **Rendering**: Hidden surface removal through back-face culling, depth sorting and z-buffering.

Learning Goals

Understand some of the ways in which two or more 2D objects and simple 3D objects may be combined to produce more complex 3D forms. Understanding copies vs. instances.

Production goals

The addition of model detail, including window and door trim, and furnishings, both custom-built and imported from libraries. Images of detailed components of the model, including furnishings, light fixtures, window details, etc. Model enhanced with interior furnishings in at least one space.

Instructions:

1. Use the Sweep Revolve operations to add details to your model (e.g. use Booleans to punch holes in the walls, add trim to the edges of window and door openings). Be sure to use appropriate layers so their colors can be different from the walls. Place glass in the windows and make it transparent.

Hint! ☞ One easy way to put glass in all the windows of a wall is to place a single large "plane of glass" within the wall, so one polygon provides the glazing in all the windows!

2. Construct a table, a vase, a bowl, and some sort of lamp using your modeling tools. We'll add a light to the floor lamp later.

Hint! ☞ Make each object separately, in it's own file, and then use Insert, or copy and paste to add them to your base model. This is a great technique for creating (and saving) stand-alone parts in an uncluttered environment; just remember to work to the same scale.

3. Look online for additional add-on (entourage) objects you can use to enhance your model (maybe a chair?). Download one or two and add them to the model. Remember where you got them.
4. Arrange the various objects together into a scene in one part of your model--inside your building, outside the building, etc. Compose several views which show the individual objects clearly and which demonstrate that the objects are "on" the table or floor, not "in" or "above" it. Save these for the slide show.
5. Create a slide show that illustrates the work you did in this exercise and the suggested views above. Turn it in as before.
6. Complete the write-up. Print it. Turn it in.

Extra Credit! ☞ Create a sectional view of your model. Depending on the application you are using, this may be fairly straight-forward, or it may require using Boolean operations to "delete" (temporarily!) parts of the model so you can see into the space. See if you can make an orthographic section (cut perpendicular to the plan and parallel to walls), in parallel and perspective projection, as well as a "cut-away" view of the design (cutting through surfaces at right-angles to each other). Can you control the way the 'cut' is rendered?

Write-up Questions:

1. Backside culling, depth-sorting, and z-buffering are hidden-surface algorithms that take different approaches to the problem: (a) How does each work? (b) When is each likely to fail? (c) Which would be suitable as part of producing traditional 2D (line drawing) construction documents?
2. One important characteristic of symbols (aka blocks, etc.) is the ability to create "instances" of a symbol rather than simply making "copies". Explain the difference between "instance" and "copy" as used here.
3. How can symbols help you to manage the development of your model?
4. How are *revolve*, *sweep*, and *extrude* similar to or different from each other? (drawing diagrams may help)

XC ☞ 5. How easy was it to produce a sectional view? Could you control the rendering of the section cut? Which of the rendering configurations did you find most appropriate for telling a "section" story? Why?

Lights & Cosine Shading P3

Topics

Modeling: Lights (ambient, distant, point, spot, area, & real). **Rendering**: Flat (also called Lambertian or Cosine) shading. Shadows. Anti-aliasing. "Smooth" vs. “Flat” shading.

Learning goals

Understand basic flat shading algorithm and the limitations it exhibits with regard to light sources. Understand the common types of lights. Understand basic lighting, shading, and shadow options. Begin to manipulate object attributes and material properties related to light (transparency, shadow casting, smooth (Phong) shading, etc.)

Production goals

Images illustrating the progression of development, showing major building components using abstract materials (uniform colors), interior and exterior, using different light sources.

Instructions:

At this point the major techniques related to the geometry of your model have been covered. It is time to get a handle on basic lighting options and begin refining rendering operations. Next week we’ll go over surface textures, but you might apply simple solid colors that are representative of the materials you plan to use.

1. Using your complete exterior model generate an accurate sun-light rendering for noon on Sept 21 (does your model have a north arrow?). Select one or two viewpoints that are interesting and capture images.
2. To explore the other light types we need a room with furnishings. Extracting just part of the model will allow it to render more quickly, but isn’t absolutely required.
3. You previously created a light fixture. Here’s your opportunity to turn it into a fixture that actually fits into your renderings. Is the shade translucent? What’s the edge of the lamp’s “hot spot” look like?
4. See if you can create both "hard edged shadows" and "soft edged shadows". If so, what’s the difference, and please include a rendering sample illustrating each.
5. Explore lighting options (number/type of lights, kind of shadows, casting of shadows, location of lights, etc.) Save and carefully label images from these explorations. Take “how to” notes so you could do them again (see question 3).
6. In an earlier exercise you made a vase using Revolve. It probably appears perfectly smooth, even if you reduce the render mesh complexity. See if you can make a faceted version of the vase.
7. Organize a slide show and turn it in. Write up your answers to the questions below and turn in a printout.

XC ☞ 7. See if you can carve a nice Halloween pumpkin, put a candle in it, add it to your model, and render it.

Write-up Questions:

1. (a) How is "sunlight" different from light coming from a spotlight?
   (b) What is "falloff" (or, sometimes, “decay”)?
   (c) What falloff value is found “in the real world”?
   (d) Why might you *not* use the real-world value when rendering?
2. What attributes does a point light have? How about a spot light?
3. What is anti-aliasing (AA)? What effect does using AA have on render times? Why?
4. Why might it take longer to render a scene with shadows?
5. What effect would you expect on rendering time from adding more light objects to the scene?
6. What changes did you have to make to get your lamp to look as desired?
7. Were you able to produce the faceted vase? How was that done?

XC ☞ 7. What was hard about carving or lighting your pumpkin to get it to render as desired?

Surface Detail - Textures P4

Topics

Modeling: Applying, defining, and manipulating Texture maps. **Rendering:** Texture Maps: surface maps, bump maps, procedural maps, displacement maps, transparency maps, *et al.* **Lighting:** glowing surfaces, translucency.

Learning goals

Learn what textures are and how they can add detail to your model without adding geometry. Learn how to define, apply and control textures. Understand the value and limitations of smooth shading.

Production goals

A model with appropriate material texture assignments.

Instructions:

1. Using some or all of your model, or a vignette "test scene," select and edit each object or layer in turn, using the texture palette that comes with the program to apply textures to the various shapes of your model. Include at least one glass object.
2. Define at least two new personal textures. They might represent work by a favorite artist, a favorite family photo, an earlier rendering, etc. In your slide show, include copies of the images used. Apply these textures to objects in the scene (art on the wall, photo on the desk, etc.).
3. Create a "one-polygon scale figure" of yourself using an image of yourself and appropriate texture maps. Your figure should cast the appropriate shadow on the ground. Include your scale figure in some of your saved renderings and include the textures in your slide show.
4. There is often a difference between "environments," "sky domes," and "backgrounds" when rendering. You should be able to add a background image to your renderings. If the image shows your actual site, you might explore the tools available to align your model view to the image.

Extra Credit ☞ Apply a DECAL (secondary texture, such as bottle label or graffiti) to one of your objects. Make sure to include a rendering that shows the Decal applied to a textured surface. As before, include the texture images used in the decal as part of your slide show.

Extra Credit ☞ See if you can use a displacement map. Pay attention to how it's use changes rendering times and what, if any, adjustments you have to make to the model to complete the task.

5. When you have suitably "materialized" your model, compose an interesting view, set the window to 1200 x 900 pixels, and do several different renderings, experimenting with the rendering controls of the program (keep notes!).
6. Assemble the files into a slide show. Turn them in, then answer the questions below, print it out, and turn it in.

Write-up Questions:

1. What is the difference between *procedural* textures (sometimes called "solid" textures) and raster, or *image-mapped* textures? What are the ways to deduce or guess which is being used by examining the rendering?
2. What is a *bump map*? How does it work? What is the difference between a *bump map* and a *displacement map*?
3. Identify the most important controls (attributes) you would expect to find in a modeling program with regard to the application of textures? Does your program provide all of them?
4. How might you reduce your polygon count using a transparency map?
5. Please note any ways you have found in which V-Ray behaves differently from Rhino-Render or Flamingo.

Extra Credit ☞ Write a little about your experience using the displacement map.

Photorealism P5

Topics

Modeling: n/a **Rendering:** Reflection, Refraction, color-bleed, diffuse inter-reflection. Global illumination, phton-maps, ray tracing, final gather, ambient occlusion.

Learning goals

Understand how high-end algorithms attempt to bridge between totally specular and totally diffuse renderings using image-sampling concepts such as “ray tracing”, “radiosity”, “photon maps”, “global illumination”, “ambient occlusion” and “final gather”.

Production goals

High-quality visual imagery showing your model in photorealistic fashion, including custom texture maps, diffuse lighting effects and specular effects.

Instructions:

1. This assignment assumes you are beginning with an appropriately textured model containing both diffuse and specular surfaces, opaque and transparent objects, as well as in-scene light sources.
2. Review your textures for appropriate scale, orientation, mapping, etc. Test-render areas to assess the need for texture-anti-aliasing or image-anti-aliasing.
3. Select or define an "environment map". If you are working on a building in a “real” environment and can get a “context” image to use as a background, consider doing so.
4. Using a resolution of **1200x900**, render several images of your model using a variety of rendering algorithms or variations in order to Illustrate how the different algorithms bring out different aspects of the model. Try to produce as realistic an image as possible. Pay attention to lighting, materials, and point of view. Try out several (at least 5) different combinations of effects/algorithms/etc. and save images from each.
5. Submit your renderings online. Print and submit hardcopy of the write-up.

Extra Credit! ☞ opt #1 part “A”

Review the information covering radiosity, global illumination and final gather algorithms. Prepare a rendering of one space inside your project using a diffuse-interreflection renderer. Render the same view using a ray-trace or z-buffer algorithm that helps reveal how the diffuse interreflection changes the rendering. Compare the images.

Extra Credit! ☞ opt #2

Returning to your light fixture from the earlier exercise, see if V-Ray gives you a better rendering. Pick a light source of appropriate type, color and intensity. If there’s a translucent shade, look at glowing or emissive textures for the shade. You may need to “cheat” (add extra lights, etc.) to make it look right when rendered. Do renderings showing the scene with and without this light source turned on, and one wire-frame rendering that shows positions of all related lights/etc. Include them in your slide show.

Extra Credit! ☞ opt #3

Create a night-time view of your project.

Write-up Questions:

1. In general what visual phenomena does ray tracing correctly render which simpler algorithms (cosine shading) rendering does not?
2. In general what visual phenomena does global illumination render correctly which ray tracing does not? What, if any, global-illumination program did we use?
3. Where does radiosity fit into this? Identify important characteristics of the algorithm that make it more or less well suited to architectural rendering.
4. What do *final gather* and *ambient occlusion* contribute to the ‘reality’ of a rendering?

Extra Credit! ☞ all opts

Which option did you develop? Which image shows the work? Describe the changes or adjustments you had to make to achieve the results submitted. What, if any, aspects are you still unhappy with?

NURBS & Meshes P6

NURBS operate on mathematically defined surfaces, while meshes simply stretch a network, or mesh, of small polygons over a bunch of points. NURBS are easier to edit, but meshes are faster to render (so Rhino actually invisibly converts it's NURBS surfaces into "render meshes" during rendering), and most "real world" data is captured as mesh data, so we need to learn how to work with both.

Topics

Modeling: irregular geometry using NURBS, Meshes, and "cage editing" in Rhino. **Render-mesh** global and object-specific settings and effect.

Learning goals

Gain awareness of different approaches to the challenge of irregular forms and gain some first-hand experience with some of the tools. In Rhino there are several distinct sets of operations. One covers mathematically defined (NURBS) "surfaces" and terminology (knots, weights, kinks). Another covers Rhino "meshes". They are both (by and large) managed from the "Transform" menu. Another set of tools allows you edit NURBS by moving, adding, or changing the "control points" that govern them. These are largely available from the "Edit > Control Points" menu.

Production goals

Several irregularly-shaped objects that can be included in your model if you wish, including the Rhino reader Rubber Duck and a glazed "NURBS Gazebo" or façade.

Readings

Wikipedia NURBS article.
The "Edit Control Points" Rhino video on YouTube

Instructions:

1. The goal of the exercise is to learn something about each of the different ways of managing complex irregular surfaces, as made available in Rhino via Meshes, and NURBS, so make a Mesh > Polygon Mesh Primitive > Box and extrude a rectangle surface to make a NURBS box.
2. Use the Transform tools to Twist, Scale and Bend both shapes. Using the NURBS shape extract both the "Mesh > from Control Polygon" and the "Mesh > from NURBS Object " and line them up next to your original shape. Now extract the edges (Curve > Curve from Objects > Extract wireframe" will do this, but maybe there is another way??) Move this mesh next to the other derivative shapes.
3. Use "Pipe" on (some of?) the lines of the mesh to produce a "3D Wireframe".
4. Select one of your shapes from the first two steps and use "Transform > Cage Editing > Cage edit" to transform the shape. See if you can make an asymmetrical shape like a liquor or perfume bottle. Generate a rendering of this scene showing all the shapes, but focused on the final form.
5. Do the **Rubber Duck** tutorial in Ch 7 of the Rhino training doc (pp 149-164).
6. **Merge** your rubber duck into the first model. Render a "money shot" at a **high resolution** (1200x1000).

Extra Credit! ☞ NURBS can easily represent single and double curvature, but glass likes to be planar, so see if you can construct a gazebo, greenhouse, or other "warped surface" with solid mullions along polygon edges and flat glazed panel elements. Give it a little context – a base or foundation, side-walls or columns, etc. so it isn't simply floating in space. You may have to approximate some of the geometry.

7. **Prepare and turn in the Images and Write-up** in the usual ways.

Write-up Questions:

1. What is a "polygon budget" and what can you do to conserve it? Is there any way to find out how complex a Rhino model really is? i.e. how many polygons your model uses?
2. What was the most interesting kind of surface that you worked with in this exercise? Which ones do you think you'll use again? Why?
3. What did you find to be the **most challenging** aspect of complex curvature?

Extra Credit! ☞ Describe how you produced your freeform rain-shade, how long it took, etc.

Terrain/Site Models P7

This exercise is explores different kinds of “site models” – those used to represent *natural* (“green field”) settings and those more suitable for *urban* sites (mostly streets & buildings). You should know how to construct both. Site models (esp with trees) can consume most of your polygon budget too, so this is a good time to think about abstraction and what geometry really needs to be there.

Topics

Modeling: Landforms at different scales. Small sites as Patch or Loft data. Large sites as step models, urban street grids, GIS data. Other irregular geometry: people and trees. Abstract vs. representational geometry.

Learning goals

Consider how different traditional representations of land shape rely on different process needs. Examine how the geometry of urban sites and natural sites are similar and different and learn modeling strategies for each.

Think about how best to represent vegetation (which can be very complex geometry).

Production goals

Site model to choose from in final project model. Associated images.

Instructions:

1. Whether you are developing a project on a real site with known contours, or making up a site, you may need to input the contours. You can often scan a contour drawing (low res is fine), place it as a "background", and then use “polyline” tools to trace the contours (make sure to trace an object of known size so you can get the scale right). This site should include a water feature, such as a creek, lake, or pond on part of the site, plus a man-made feature, such as a pathway, road, or a set of stairs—plus your building, of course.
2. Make and save a *natural* site model using two of the three fashions discussed in the readings: step models, mesh model, and triangulated contour model. Make sure they are volumetric (closed polysurfaces).
3. One benefit of a solid modeling program and Boolean operations is that it can compute volumes. Compare your site volume before and after inserting your design onto the site.
4. Place several *trees* and *people* on your landform models (If necessary, download them from the web) and generate several perspective images that give an experiential sense of the site. A good view might show the person in the foreground, with the majority of the landform and several trees in the background.

Extra Credit! ☞ Create an *urban* site in a new file using the “Urban Base Block”. Following the guidelines in the Tapestry readings, make and save a 3x3 block “urban site” centered on your building. The model should not be flat, but sidewalks and streets should slope only in the direction of travel. For this exercise it is fine if you make up the geometry. Include rough versions of adjacent buildings, as well as trees, people, cars, parking meters, etc. Generate both aerial and street-level views.

Extra Credit ☞ Today site info is often available as GIS data (either contours of digital elevation data). There is a description of how to build a model this way in the “Case Studies” part of the course website. Use that to produce a model of the area on the UW campus near the “UW Club” (aka “the faculty club”). Generate 2 or 3 renderings of the site.

5. Create a slide show showing the different landform models and views. Turn it in.

Write-up Questions:

1. Almost all models are (ultimately) made of polygons, but models of buildings and hillsides are still somehow different from each other. What’s different? And how does that affect your modeling?
2. Describe how you made your “green field” site model.
3. Describe the process you followed to place/create the man-made feature (road, path, etc) on the natural site, including any 'tweaks' you found it necessary to make the two fit together.

Extra Credits ☞ What was your process for the urban site? Did you use the pre-existing “urban base block”?

Extra Credits ☞ Describe what you tried, what worked, what was familiar or hard. Critique visual qualities of different approaches and utility of different models.

Advanced Geometry Options P8

Topics

Symbols (instances vs. copies). “Face me” billboards. Geometry proxies (aka “replace me” components). Displacement maps. Procedural texture geometry (fur/grass). Particle systems (smoke). Fractals.

Learning goals

Understand some of the ways in which very dense or large models may be made manageable through the use of specialized aspects of the geometry or rendering engine in use. Learn about some of the advanced rendering or modeling options available in other software.

Production goals

Several images illustrating the options available in your software (for R+V: instances, proxies, fur).

Readings

Tapestry > (forthcoming)

Instructions:

1. Read about the various options or techniques. This may involve Tapestry pages as well as web bookmarks to other websites, academic papers, etc. (some of these topics involve features not available in the software we currently use).
2. Identify the features that are available in your software and construct test rigs for each. Some of these should be easy (e.g. blocks) while others may require several steps (e.g. proxies or fur).
3. Explore the controls available in each case, capturing images to illustrate the effect a you refine the control values for each.
4. Most of these exist to reduce the time it takes for a model to open/save or wire-frame-render during model development, while producing desirable image features. To appreciate the benefit, it would be good to compare the rendering time with and without the feature active.
5. Turn in your “exploration” images and timed “with / without” images to the dropbox.
6. Turn in answers to the following questions.

Write-up Questions:

1. In your own words describe briefly what each of these terms are talking about and why they are part of our vocabulary:
   a. Block
   b. Proxy
   c. Billboard
   d. Displacement map
   e. Fur
   f. Particle system
2. Identify which of the above you were able to use and share your thoughts regarding the visual benefit and costs (in time and data) associated with their use. Do you see yourself using any of these again?
3. How long did this exercise take?

Finishing Touches P9

Topics

HDR (High Dynamic Range) images as textures or light sources.

Learning goals

Learn to do apply an HDR image as a skydome or background texture, align model to background photograph, etc.

Production goals

Images exhibiting appropriate lighting relative to an HDR image, or correctly aligned with a photograph of the "current" site.

Instructions:

1. Turn in the finished images to the dropbox.
2. Write-up and turn in answers to the following questions.

Write-up Questions:

1. Describe briefly the procedure that *you* followed in putting together *your* finished product. What would you do differently on a second project? (Note: the most common answer is "start sooner" …)
2. Why would a dissolve transition take longer to render during post-processing than a wipe?
3. What is the story you were trying to tell with your video?
4. How long did this exercise take?

Post Production P10

Topics

Codecs, 'tweening, transitions, rhythm, pace, tracks, the "safe area," Compression. Credits.

Learning goals

Learn to do a simple layout in Premiere, including stills, transitions, animation (if you have one), sound, and titles. Learn how TV presentations differ from presentations on the computer monitor. Gain some appreciation for different compression options. Ideas for combining "cheap" imagery (with short rendering times) with "expensive" content (with long rendering times). Consider the importance of sound in communicating emotion and mood.

Production goals

A finished video presentation of your building, with stills, titles, possible animation, and sound. The finished movie will be placed on the course website.

Instructions:

1. Do your prep work: this includes pre-reading the questions below, doing background reading in the manual, devising and performing directed experimentation with the software, and diagramming the final solution.

   It would be a good idea to run the whole process through to finished form on a simple experimental bundle of data, just to work out the kinks.
2. Convert any images or animations that might need to be converted into the proper file format (# of colors, resolution, etc.). You can re-render or re-animate content if you have time and inclination.
3. Work through the project. You should be able to do the most important elements first, filling in detail later on. Try not to get trapped into spending hours resolving less important details when you haven't got the big ones worked out yet.
4. A sound-track is highly recommended. However, if you use protected music in your movie and later place it on (e.g.) *YouTube*, it may be taken down (they test movies for protected content). You can look for royalty-free music online (it is fairly rare). YouTube provides links to a variety. I also have a bunch of piano music that a student (musician) gave us permission to use a while back. Ask if you'd like to use it.
5. When you have completed the Premiere movie, save it to disk as a 1024x768 movie (AAC audio and H.264 video). This one file is what you will turn in for the exercise.
6. Turn in the finished movie to the dropbox. Note the deadline for receiving these files. At the end of the class, the finished projects will go on the web site (sometimes after re-compressing to make them smaller).
7. Turn in answers to the following questions.

Write-up Questions:

1. Describe briefly the procedure that *you* followed in putting together *your* finished product. What would you do <u>differently</u> on a second project? (Note: the most common answer is "start sooner" …)
2. Why would a dissolve transition take longer to render during post-processing than a wipe?
3. What is the story you were trying to tell with your video? How successful do you think you were?
4. How long did this exercise take?

XC: Data Exchange (partial) XC 1

Partial/XC?

This experience has been separated from the rest of the exercises in recognition of the fact that moving data to some other application may require some extra effort (so there's some extra points). However, as developed here, the exercise isn't as challenging as the normal Arch 481 exercise, so its value is only "partial".

Topics

Modeling: DXF file transfer. Y-up vs. Z-up coordinate systems.

Learning goals

Gain exposure to the issues of data transformation-during-exchange. Learn how to structure a model so as to use it in another program. Learn something about what transfers and what doesn't when exporting a model. Learn how to transfer textures.

Production goals

Whole/partial model containing 3d data from a different application, imported into your main model.

Instructions:

1. Decide what alternative modeler to use and construct the desired part of your model. If it's a simple piece of geometry, make a few other 'test objects' to help you test the usefulness of this operation.
2. Consult the software or manual to ascertain the "best fit" to your data and "export" or "save as" your model to that format (might be DXF, or OBJ, or 3DS, or …) (check the "How To" section of Tapestry for help). Often you will be able to try (and *should* try) several file formats. Each will have it's own strengths and weaknesses (and may lose particular aspects of your model). Save a results image from each format you try and turn it in as part of your submission.
3. Import the file(s) into your modeling program. Check it out. Has anything changed? Are the layers still layers? with spaces in the names? What about primitives (box? cylinder? etc).? Did the original color or texture assignments come through? Did you have light sources? (and did they come through)?
4. Be sure the model comes in "right side up". If not, try again.
5. Create several (3-5) images in the data "as created" and "as imported -- to show the quality of the transfer, especially any un-expected results. See if you can correct for any problems.
6. Assemble the image files into a slide shows. Turn the files in, then answer the questions below, print it out, and turn it in.

Write-up Questions:

1. What were the two programs you transferred data between, and what file formats does each support for import/export?
2. What seemed to be the best file format for transfer between the two programs? Why? How did it work out?
3. Was it necessary to customize the export or import? One way to do this is to do a screen-dump of the relevant dialog box(es).
4. Was it necessary to go back and either change the export parameters or modify your data before the data transfer worked properly? If so, provide details.
5. What does it mean for an application to be "Y-up"?
6. How long did you spend on this exercise?

XC: Atmospherics XC 2

Topics

Modeling: n/a **Rendering:** night-scenes, rain.

Learning goals

Independent exploration of sensitivities and techniques usable to create atmospheric rendering effects suitable for "night" and "rainy".

Production goals

A series of images exploring your project under different weather/atmosphere conditions.

Note! ☞

> Some applications include "one button" atmospheric rendering options for "fog" and other features. You should certainly experiment with these as part of your exploration of atmospherics but the goal of this exercise is to *think outside the box* and stretch to capture characteristics of an environment that these simplistic strategies do not capture. Do not settle for pre-packaged solutions. You can do better.

Instructions:

1. This is a challenging exercise involving careful exploration and may involve a fair amount of work. I will work with anyone who chooses to undertake it, but I do not have a selected set of readings to which to direct you, nor is there a lecture on this subject that I will give the class as a whole.
2. Pick one scene around your building that can be rendered under several different atmospheric conditions.
3. Consider carefully what cues *you* use when you look around, or look out a window, cues which help you to assess the time of day, weather conditions, etc. What *color* is the dominant light source? Are there *shadows*? with soft edges or hard? How does the *sky* look? The ground? Other objects or light sources in the environment? Think about how to create the necessary effects in the rendering. In many cases you will want to use a "trick". Rather than creating millions of small raindrops to create the rain effect, for example, you might use a single screen-filling polygon on which "rain streaks" might be rendered, or puddles on the ground with bump-mapped ripples from the drops.
4. Create renderings for each of the following weather/atmospheric conditions:
1. Night, with some lights on in the scene, 2. Dawn/Sunset, 3. Rainy day
5. Select the image that you feel is your most successful attempt at each of the different atmospheric conditions and write a short "How to" description of how you did it. Be sure to provide as much detail as possible about rendering settings, textures, etc.
6. Turn in all the final images, plus an electronic version (file) of the "How To" document.

Write-up Questions:

1. The write-up for this exercise is the "How to" documents containing text and graphics which explains how to achieve the effects you produced in your renderings. For full credit, details are important.
2. How is light different at night than in the day? What changes did you make in your project to achieve your results?
3. How is light different during rain than on a dry day? What changes did you make in your project to achieve your results?
4. How would you compare this exercise relative to the others you've done, in terms of time required to complete it, difficulty, etc?

XC: Motion XC 3

Topics

Modeling: Challenges in defining animation. Keyframing. Tweening. Morphing. **Rendering:** Global vs. Local parameters. Linear interpolation. Splines. Bottlenecks in animation playback. Compression: lossless v. lossey. Codecs.

Learning goals

Understand the issues related to authoring animations. Understand the technical challenges of real-time animation on a computer and the roles of keyframes, 'tweening, codecs, etc.

Production goals

One good animation sequence that achieves the desired goals.

Instructions:

1. Write out a brief sentence or two that describes what you want the animation to illustrate. Think simple, not complex. What were the key concepts you wanted to convey? What "story" will communicate those concepts?
2. On no more than one 8.5x11 piece of paper, divided into 12 roughly square sections, sketch the *story board* for the animation. This is the visual comic-book version of your story. How does it begin? How does it end? What happens in between? *Turn this in with your writeup.*
3. Create an animation sequence, using at least 10 key frames.
4. After you have defined a series of key frames, you want to be sure to save your model.
5. Define and generate your own movie segment. Aim at 5-10 seconds of animation. Your finished animation should be **30** fps, **640** x **480** pixels, using the **H.264** video codec [this may change].
6. **Turn in** your written story (step 1), storyboard (step 2), and finished animation (step 3) and model (with the animation defined), plus hardcopy answers to questions.

Extra Credit! ☞

Include in your animation(s) motion by a portion of the model (make part of the model move). Use it to tell a story, whether about the conception of the building, the sequence of construction, the way users would enter or use the building, or something else.

Write-up Questions:

0. What was your written description of the animation?
1. What are the two fundamental types of animation (i.e., what kinds of motion)?
2. Imagine creating a one minute animation of ***your*** model. Based on the actual time and space requirements of your animation, estimate the required *compute time* and *disk storage* requirements for such an animation. Do you foresee any problems or difficulties using the program for such an exercise?
3. What is a "key frame"?
4. What is "tweening"? List two ways it can be done that were discussed in class.
5. What is "easing"? How is it related to 'tweening?
6. What are "codecs" and why are they necessary? What is an example of a codec?
7. Were there particular effects or results that you had difficulty achieving? Explain.
8. Animation can be a black hole for time during design and a system killer during production. Identify two helpful strategies for approaching the design of the animation. Identify two strategies for to make production of the animation go more smoothly and quickly ("buy a new computer" isn't acceptable).
9. How long did it take to complete this exercise?

Extra Credit! ☞

How was animating part of the model similar to or different from animating the camera?