

Graphics Programming

Approach to Computer Graphics programming oriented
2D as a special case of the 3D graphics using Blender

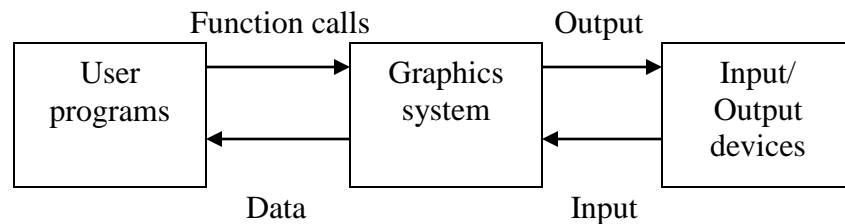
Coordinate Systems

- Device-independent Graphics – in any coordinate system
- World-coordinate systems (user's coordinate system) or application or problem coordinate system
- Physical-device coordinates or device coordinates

Raster coordinates or screen coordinates (integer type): distinction in OpenGL

World coordinates must be mapped into device coordinates (the graphics system is responsible for this task).

Graphics system
as a black box



What is Blender?

Blender is a _rendering\animation\game development open-sourced freeware program maintained by the _Blender Foundation and can be downloaded, free of charge, from www.blender.org.

Rendering

Refers to the process of taking a computer image or file and converting it into another format or applying a modification such as shading or shadows.

In 3D animation, render refers to the process of make an image appear as a 3D image or taking a series of images and making them animated.

Animation

An animation is a series of rendered images that form a movie. The quality of your movie is controlled by all of the above mentioned features including frames per second (fps), output size, file type and compression. The most common method of animation is called keyframing. Key frames are created at various points in the animation while the computer

generates all of the transition frames between the two keys. Basic animation options include changing size, rotation and location of objects.

Time Factors:

In order to animate, you must first set the length of your animation in frames and your frames per second (fps). The length in time can be calculated from these.

Frame Rate Options:

Film- Movie standard of 24 fps

PAL- European video standard of 25 fps

Custom- set your own fps

*We typically use a frame rate of 25-30 fps depending on computer speed or if we plan to save the file to DVD. Hit the “PAL” or “NTSC” setting buttons for these.

Creating Keys:

A key is placed at the beginning and end of a desired move, size change or rotation of an object. Think in terms of how long you want a change to occur and relate it to your fps. For example, if you want an object to move from point A to point B in 2 seconds and you have 15 fps, place 2 keys 30 frames apart.

Following Paths and Objects:

In most animation programs, a camera can follow a path or object (or both) as it moves. This feature saves a lot of animation time and reduces the number of keys needed.

Output Options:

We typically save our movies in AVI format for windows. This type of file plays easily on most media players. Compression agents allow us to control file size to a degree. However, animations can be rather large in size and may take up to several hundred megabytes of disk space. A compression agent, which we found to work well with most computers, is Indeo 5.1. For good output size, we typically use a resolution of 640 x 480 pixels. This is considered low resolution for computers and produces good full-screen quality when played.

Real-Time Animation (Blender only):

Real-time animation allows you to add physical properties to your objects and use the keyboard and other features to control them. You can create actors, change masses, control dampening (friction), set force and torque in x, y, and z planes and create relationships with other objects within the scene. With time and practice, interesting 3D games and real-time architectural walk-throughs can be created.

The current version of Blender is the first version to allow you to use the physics engine to create animation tracks. You can now use the physics to create realistic falling, rolling, etc. animations and use them in movies.

Basic Blender Commands

This is just a partial list of Blender commands.

Please visit the Blender.org website for more details and tutorials

TAB key-	Toggles between edit mode (vertex editing) and object select mode. If you're in edit mode when you create a new object, it will be joined to the selected object.
"O" key-	The "O" key (not zero) will put you into proportional vertex editing while in edit mode.
"A" key-	While in edit mode it's good for selecting all vertices for commands like remove doubles and subdivide. "A" twice will clear selected and reselect.
"B" key-	Gives you a box (window drag) to select multiple objects. In edit mode, works the same to select multiple vertices, but hitting "B" twice gives you a circle select that can be sized by scrolling the mouse wheel.
Space Bar-	Brings up the tools menu where you can add meshes, cameras, lights, etc.
Number Pad-	Controls your views. "7" top, "1" front, "3" side, "0" camera, "5" perspective, "." Zooms on selected object, "+" and "-" zoom in and out. The +- buttons also control affected vertices size in proportional vertex editing.
Mouse-	Left to manipulate, right to select, center wheel to zoom and rotate view. If you hold down "shift" and center wheel you can pan around on the screen.
Shift Key-	Hold down the shift key to make multiple selections with the right mouse button.
Arrow Keys-	Used to advance frames in animation. Left/right goes 1 frame at a time, up/down goes 10 frames at a time.
"R" key-	Rotates an object or selected vertices.
"S" key-	Scales a selected object or vertices.
"G" key-	Grabs or moves the object or selected vertices.
"P" key-	While in edit mode, selected vertices can be separated into a single object by pressing P.
Shift-"D"-	Duplicates or copies selected objects or selected vertices.
"E" key-	While in edit mode, selected vertices can be extruded by pressing E.
"U" key-	In Object Mode, brings up the Single-User menu to unlink materials, animations (IPOs), etc. for linked or copied objects. Undo command. Only works in edit mode and can now go back multiple steps. Sorry, no system-wide undo command.
"M" key-	Moves selected objects to other layers. Mirror- while in edit mode, "M" will give you a mirror command.
"Z" key-	Toggles view from wireframe to solid.
Alt "Z"-	Toggles a rough texture/shaded view.
"P" key-	Starts game mode
ATL/CTRL "P"	Creates or breaks child/parent relationships. To create C/P relationships, hold down shift key and select child first, then parent. Hit Ctrl P. To clear a relationship, do the same except hit Alt P.
"N" key-	Brings up the numeric info. on a selected object (location, rotation and size). Info. can then be changed in the window.
Ctrl "J"-	Joins selected objects together.
Alt "A"-	Plays animation in selected window. Your cursor must be in that window for it to play.
"F" key-	Makes a face in edit mode of the selected vertices. You can only select 3-4 vertices at a time to make a face.
"W" key-	Boolean expression to union, create a difference, or subtract objects from one another. "W" will also give you a "specials" menu while in edit mode.
"X" or Delete-	Delete selected objects, vertices or faces.

Function Keys-

F1-Load File; F2-Save File; F3-Save Image; F4-Lamp Buttons; F5-Material Buttons; F6-Texture Buttons; F7-Animation Buttons; F8-Real Time Buttons; F9- Edit Buttons; F10-Display Buttons; F11-Last Render; F12-Render

“I” Key-

The “I” key is used to insert animation keys for various things. Objects can be animated with basic Rotation, Location and Size keys and combinations there of. If your cursor is down in the buttons portion of the screen, animation keys can be added to lights, materials and world settings.

“Alt” “U”-

New to Blender, a **Global Undo Command**. Pressing “Alt U” will give you a list of commands that can be undone. By default it is set for 32 steps, but can be changed in the User Preferences panel at the top of the screen.

“Alt” “C”-

Used to convert meshes, text and curves. For example, if you create text and would like to convert it into a mesh, Alt-C will convert it into a mesh, then Alt-C again will convert it into a mesh.

“Shift” “Space”

Toggles between multiple screens to full screen of active viewport.

Ctrl “0”-

If using multiple cameras, this will switch to the selected camera. (Number pad “0”)

Armatures-

Meshes can be controlled by “bones” or armatures. Create a mesh with vertices at the joint locations, then create an armature string within it. Child/Parent the mesh to the armature using the armature option. You can then animate the armature in Pose Mode.

Ctrl-Tab-

Puts you into Pose mode for manipulating armatures.

Import/Export-

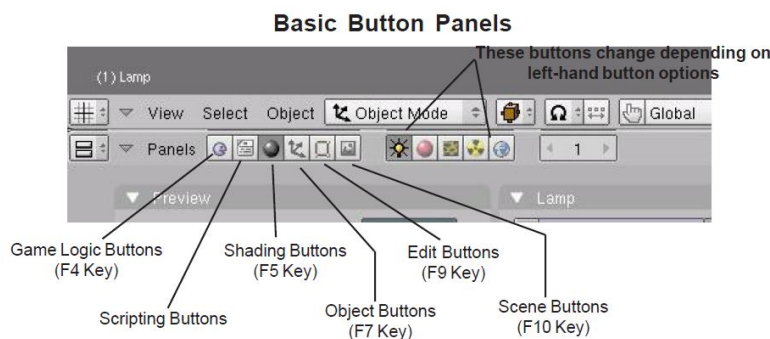
Blender accepts .DXF and VRML(.wrl) files. Just use the OPEN option from the file menu to insert these types of files into an already existing scene. When inserting other Blender files or objects into another scene, use the APPEND option from the file menu and select the appropriate options. Multiple objects can be selected with Shift-Right mouse button.

Springs/Screw-

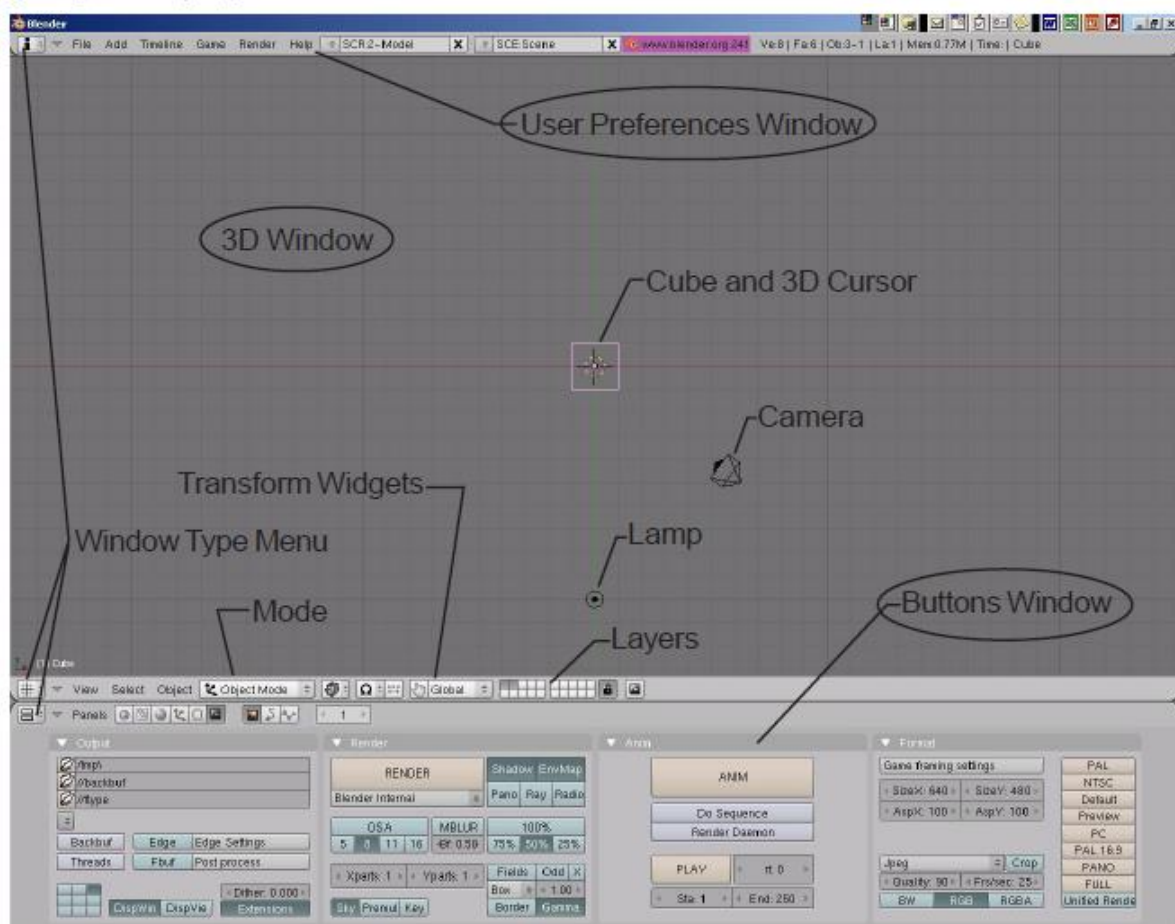
Blender can create these objects in the edit buttons. You need a profile of the object, the cursor at the center of revolution, and 2 vertices to show the length of the revolution. The profile and the length vertices need to be in the same object. All vertices need to be selected when performing the operation. You will also need to be in the front view.

Multiple Viewports-

There are several tutorials to help with this operation. Results are great! To create multiple viewports, move your cursor over the edge of the viewport (to start, you only have the drawing window and the button window move your cursor to the break between them). Right click on the break and select split area. Blender will break the area that you brought the cursor from



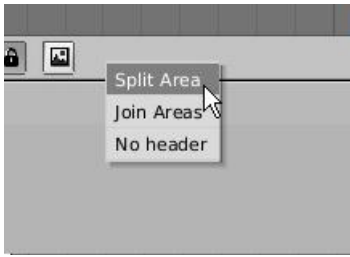
Blender Interface



You are looking down at a scene consisting of a cube, lamp and a camera (top view). The cube is a basic mesh object to give you something to look at, a lamp to illuminate the scene, and a camera to show the scene. Older versions of Blender may open with different scenes (a plane instead of a cube and a light), but the idea stays the same. The 3D cursor in the middle of the cube is used to locate where new items will be placed. It can be moved around on the screen by clicking the Left Mouse Button (LMB). Along with familiar pull-down menus like other programs, you have a viewport along the bottom that changes every time you select a different button. This "Buttons Window" can be changed around, but for now, let's keep it where it's at.

Creating Viewports (also called windows)

Most times, you need more than one 3D window to work with since you're trying to locate objects in three dimensions. Most rendering and animations programs allow for multiple viewports along with graphical views of various data. Blender allows the same. Remember that Blender starts with 3 viewports that are set to User Preferences, 3D Window and the Buttons Window. You can change the size of any of these windows by using the LMB and dragging on the line between



the viewports. You will notice the arrow pointer changes to a double headed arrow while over the line.

In order to split the screen and create another viewport, while the cursor is over the line, Right Click (RMB) and select “Split Area”. Drag the line to a desired location and size. By moving the mouse to either side of the viewport line, you select the side to split. Joining viewports together works the same way. There’s no limit to the number of times you can split your windows. I like to traditionally work with 2 views like the example shown below. I use the left view to flip between my principle views (top, front, side) and the right view for camera view and animation tracks (which we’ll discuss later).

Class Exercise 1 - Viewports

Graphics Functions

1. The primitive functions (low-level objects)
e.g. points, line segments, polygons, pixels, text and various types of curves and surfaces

Class Exercise 2- Creating Objects

2. Primitives – ‘what’
Attributes – ‘how’ (the way the primitives appear)
Attribute functions (e.g. colour, pattern, typeface)
3. Description of the synthetic camera
Viewing functions (specify various views)
4. A set of transformation functions
(rotation, scaling and translation – matrix transformations)
5. A set of input functions (deal with devices such as keyboards, mice and data tablets)
6. Control functions enable us to communicate with the window system (for a multiprocessing multiwindow environment)
7. Inquiry functions

- Geometric primitives (line segments, polygons, curves and surfaces)
- Raster primitives (arrays of pixels) – lack geometric properties

Class Exercise 3- Basic Editing Exercise

Polygons – a series of connected lines to be displayed correctly: it must be simple, convex and flat.

Convex – all points on any line segment are inside the object

Text (various fonts)

Stroke text – constructed as other graphic primitives use vertices to define line segments or curves that outline each character (transformations may applied – retaining its detail and appearance).

Raster text – simple and fast – Characters are defined as rectangles of bits – bit blocks (bit-block-transfer (bitblt) operation). Replicate or duplicate pixels to increase the size of raster characters (larger characters of blocky appearance).

Curved Objects

Can approximate a curved surface by a mesh of convex polygons – a tessellation

Colour

most interesting aspect

Three colour theory

Additive colour model (three primary colours mixed); red, green and blue - RGB

Colour gamut – range of colours

Viewing

which objects should appear on the screen

default viewing conditions exist

viewing rectangle of clipping rectangle (objects inside the rectangle are in the image; objects outside are clipped out and are not displayed)

orthographic view – orthographic projection ('sees' only those objects in the volume specified by viewing volume). Unlike a real camera, the orthographic projection can include objects behind the camera.

Matrix Modes

model view and projection matrices

Control Functions

Interaction with the Window System

Window or screen window – a rectangular area of the display, the screen of a CRT

Aspect Ratio and Viewports

aspect ratio of a rectangle is the ration of the rectangle's width to its height
distortion – a consequence of the default mode of operation, in which the entire clipping rectangle is mapped to the display window.

Viewport – a rectangular area of the display window. By default, it is the entire window, but it can be set to any smaller size in pixels

Class Exercise 2- Boolean Editing