Geometric objects in Blender 2.32

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Geometric objects model in Blender

The aim of this document is to inspect the way that Blender 2.32 stores the information for modeling static scenes. I am not an expert on Blender (I have been using Blender for about 3 months) , so I don't claim to know all the intrinsics of Blender. Although I have written this as class notes for a beginners course, I suspect that it would be also useful for intermediate users. My intention is to give some light on the following questions:

1. How does Blender stores geometric objects? That is, what is the *model* it uses?
2. Which objects can be modeled using Blender? (i.e. which is *domain* of the representation model?)
3. What are we modifying when we edit the geometry of an object? Why sometimes it is not possible to choose some menu options?
4. Which is the logic sequence of operations one must follow to change an specific characteristic of an object? For example, how can I change the color of a single face of an object?

Let us have a look at what Blender offers for modeling geometric objects:

- Meshes, that have faces, edges and vertices.
- NURBS Curves and Surfaces (that can be converted into meshes).
- Other geometric objects: metaballs, ...

==> Those are the **geometric objects in Blender** (i.e. elements that have geometry that can be visualized).

- Groups and hierarchies of objects.
- Copies and references (*links*) of objects.
- Objects (and sometimes, faces) have materials and textures associated to them.
- Meshes that deform objects (*lattices*) and skeletons attached to them (*armatures*).
- Light focuses *(lamps)* , cameras, scenes, ...

These elements do not have a visible geometry, but they modify the shape/aspect/organization of geometric objects.

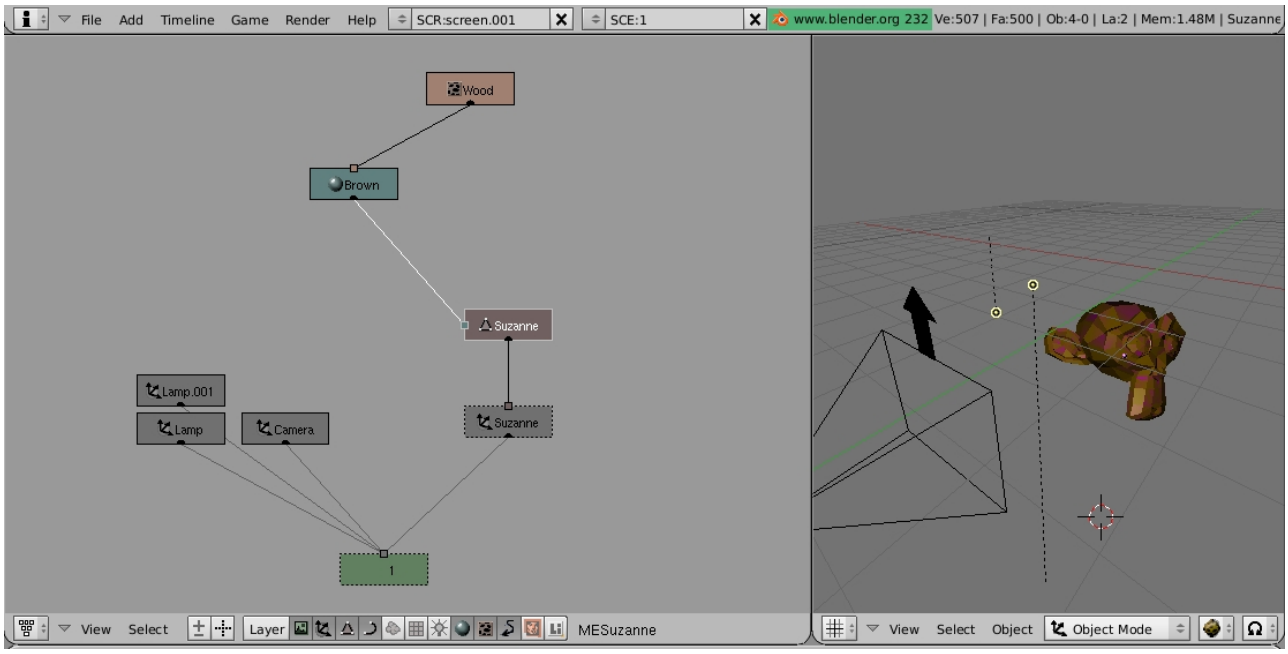
So, how does Blender manage all this information? How is it stored into memory and organized?
Hint: here and there Blender messages and options refer to *datablocks.*

The conceptual model in Blender

The data structures Blender uses the Object Oriented paradigm. To explore the data structures that constitute our scene model, use the *OOPS Schematic* view. Simply choose  in one of your views to activate it.

Note: the OOPS is only a view, not an editor. That means that you can't modify or erase things, change links, etc. in the OOPS Schematic view (in fact, the only thing I was able to modify in this view was the datablock names by pressing KEYN). But you can select objects and parts using this view (sometimes, this is very useful).

Below there is a caption showing two views of a simple scene made of a monkey head (named Suzanne) with a color (Brown) and a texture (Wood) associated, two lamps and a camera. On the left, the OOPS Schematic view of the scene, on the right, the 3D view.



So, a *DATABLOCK* is an instance of a class.

First, notice that there are datablocks of the class Object and class Mesh. And there are many others classes: Lamp, camera, material, texture, ...

An OBJECT in Blender is:
An entity *(datablock)* of the class Object.
+ a pointer to some geometry (Mesh, NURBS or metaball ...). In other words, a link to a geometric datablock.
+ a matrix that stores a linear geometric transformation (i.e. a translation, a scale and a rotation in 3D).
+ optionally: pointers to other entities (*datablocks*), such as materials.

When you change between *object mode* and *edit mode* (with the TAB KEY)**, you are choosing what to edit, either the object datablock or the geometry datablock linked to it**. So, although you can scale an object either in object mode or in edit mode (by selecting all its vertices), in the first case you are changing the values stored in the linear transformation matrix, and in the second case you are moving/scaling/rotating all the points individually.
Objects have a reference point, its *center,* that can be used as application point for rotating and scaling, and it is viewed as a single point either in edit and object modes; it is selectable only in object mode. The linear transformation matrix can be numerically changed by pressing KEYN in the object mode.

A MATERIAL in Blender is a datablock of the class Material with:
Colors (basic, specular, mirror)
+ other properties (attributes): alpha, specularity, translucency, etc.
+ optionally: a pointer to a material datablock (or better said, a set of pointers to material datablocks).

When you copy an object with "Duplicate" (SHIFTD), both the object and the mesh datablock are copied. But when you make a linked duplication (ALT-D), only the object datablock is duplicated, so the old and new objects share the same mesh datablock. This is very useful for modeling symmetric parts of an scene. For example, a mirrored instance of an object can be created in this way by a linked duplication and scaling one of the objects by a factor of -1 in one of the axis directions.

You can inspect what kind of datablocks exist by toggling the buttons in the OOPS view :

Those are: Scene, Object, Mesh, Curve/NURBS /Font, Metaball, Lattice, Lamp, Material, Texture, IPO, Image, Library.

Parent linking

There is a different kind of links: the *parent links*. An object can be the parent of another, wich in its turn can have some children, and so on, resulting in a hierarchy (or tree) scheme, very useful for organizing everything. These parent links, although of a different kind than the pointers between objects and meshes, for example, are also displayed as black arrows between datablocks in the OOPS view.

You can select several objects linked by these relations with "select->grouped->children" or "select->grouped-> parent", etc. The more interesting thing is that when you move/translate/rotate an object (in object mode, of course) all its children and descendents change in the same way. To get this, Blender modifies the linear transformation matrices of the children objects in the appropriate way. Thus, if you have a hand parent linked to an arm, when you rotate the arm the hand moves accordingly.

Parent links can also be set between objects and lamps, for example (think on the headlights of a car, or on the flame of a candle). There is a special bject, called *empty,* with no geometry associated, that can be used as a node of this parent link tree (for example, as the root node of the tree).

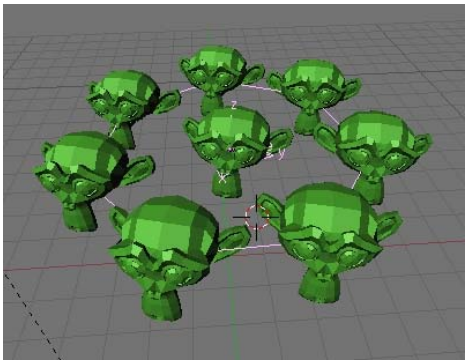
Finally, remark that there is also the *layer* notion, an very useful attribute of the entities that can be used for an optimal organization of our scene.

To experiment with pointers and hierarchies I have created a Blender scene of a tree, arbre.blend. Download it, open it with blender and play with it.

Meshes in Blender

- Meshes are a set of vertices, edges and faces.
- Faces can only be are triangular or quadrangular (3 or 4 vertices only). Vertices in a quadrangular face may not lie in a plane (the viewer triangulates it when z-buffering).
- Blender allows separate edges and faces, even angling.
- Thus, objects can be non-manifold, allowing more than 2 faces converge in an edge, any number of edge loops ending in the same vertex.
- Since boolean operations are not defined for non-manifolds, it is the user's responsibility to select well defined closed objects for operating. Otherwise, an unpredictable result can be obtained (sometimes Blender crashes).
- Vertex subsets in a mesh can be grouped. Very useful for selecting subparts of objects.
- The material attribute (a pointer) is individual for each face, with a double index method. That is, the object has a table of pointers to materials, and each face points to elements of that table.
  - However, vertices can have individual colors (see the *vertex paint mode*...)
- A vertex can have a link to a children (*vertex parenting*). I have read somewhere that this is used for animation.

A *duplivert* is composed of two mesh objects parent link related, with the *duplivert* flag selected in the parent object. The mesh of the parent is not displayed; instead, a copy of the child mesh is placed in every vertex of the parent mesh.



The Blender mesh editor

- It is a powerful and well done tool. Mainly, because you can UNDO and REDO almost all the operations (the number of undo/redo steps can be configured in the user preferences).
- Edition is performed at vertex level. To select an edge, just select the two endpoints; to select a face, select its 3 or 4 vertices.
- There is a number of basic operations to move, add and delete vertices, edges and faces, as well as tools to merge vertices, shift normal faces, etc.
- Other higher level operations include:
  - Face subdivision (subdividing edges and neighboring faces if necessary)
  - Loop face subdivision
  - Smooth subdivision
  - Extrusions (of any group of faces, vertices or edges)
  - 2 proportional edition modes (OKEY)

Interesting experiments (exercises for the reader):

1. Try several extrusions of faces, edges and vertices and deduce how does Blender performs it (which new entities are created and how are linked to the old part of the mesh). Create some non-manifold objects and dangling edges/faces.
2. Copy objects with *duplicate, duplicate linked* and see the difference in the OOPS view.
3. Join two different objects (CTRL-J) and also two duplicate linked objects and look at the results.
4. Separate part of a mesh (automatically or selecting some vertices).
5. Copy pointers (*make links,* CTRL-C).
6. Create and delete pointers (*copy attributes*, etc.)
7. Change the color of a single face in a mesh object. Apply a texture to two faces of the same mesh.
8. Create hierarchies (*make parent, clear parent*) and see how parent links are showed in the OOPS view.
9. Use *Make single user* to duplicate shared datablocks.
10. Use the OOPS view to select objects. Use KEYN in this view to rename datablocks.
11. Create a duplivert.
