Virtual Graffiti: Three-Dimensional Paint Tools for Conceptual Modeling in Upfront

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This chapter describes several limitations present in current 3-D programs used for conceptual design and then introduces a new three-dimensional paint tool, as implemented in a beta version ofAlias Upfront, that attempts to deal with some of those limitations.

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3-D conceptual designing on a computer has always been regarded as a difficult task. Many programs require working in two-dimensions and only seeing the result later in three-dimensions. Only recently has designing in three-dimensions been enabled with programs such as Alias Upfront, FormZ, and Modelshop.

These programs create objects primarily from three-dimensional polygons. While this approach can yield excellent results, complete reliance on polygons for conceptual design could be viewed as having three disadvantages:

1. Polygons have distinct, hard edges which leave little room for a variety of visual interpretations.

2. Much of the desired information in a conceptual sketch may be symbolic, gestural or diagrammatic in nature - not easily represented by polygons.

3. Polygons are time-consuming to create, change, and, when the number is great, render.

Polygons have distinct, hard edges, which leave little room for a variety of visual interpretations.

The necessity for ambiguity in conceptual design rendering has been noted by many authors. My favorite quote on the subject is from Leonardo da Vinci:

"...Look into the stains of walls, or ashes of fire, or clouds, or mud or like places, in which, if you consider them well, you may find really marvelous ideas."

Hopefully at least in architectural design, indistinctness will result in something else than "monstrous things", but the final point is well taken - "by indistinct things the mind is stimulated to new inventions" - a very appropriate situation for conceptual design.

Hand-drawn sketches have personal expressiveness, a sense of scale, and a subtlety of edge and texture. Polygons have hard edges and tend to have simple geometries lacking tentativeness in their visual appearance. The placement of polygones is the result of very specific decisions and the resulting "hard-line" drawing seems to represent a final solution that is resistive to playful change and alternative interpretations. This tendency is reinforced by geometric polygon generation tools which require the user select a specific tool and then go through a required series of actions which result in a precise representation - a representation that is probably much more specific the initial intention (Figure 1).

Much of the desired information in a conceptual sketch may be symbolic, gestural or diagrammatic in nature - not easily represented by polygons

When making a "back of the napkin" type of sketch we often draw a rough three-dimensional concept with relatively few surfaces, then embellish that drawing by sketching in more detail on the surfaces. That sketching may
represent actual physical detail, or it may be more diagrammatic in nature, suggesting physical or visual relationships which may later become form. An important aspect of this type of sketching is that it has a looseness that can suggest without being overly specific. Although these gestures can be represented with polygons, it is usually difficult to do so (Figure 2).

**Figure 1:** Existing tools tend to create hard-edged, specific geometries which resist playful change and alternative interpretations

Although the tools can at times suggest design possibilities, at other times they become like a tortuous passage that must be navigated before anything is created. Something that could be sketched in seconds may require several minutes of detailed construction—naturally this can greatly inhibit the quick explorations that characterize conceptual design. The result can be using a 3-D design tool more for representing the completed design rather than being involved in conceptual design.

The ability to change polygon representation varies from program to program, but can be quite time-consuming if much detail is being changed. Things that could quickly be changed in a sketch, such as a window or door, could take so much time as to be prohibitive, especially when the designer wants to try several possibilities. Again these difficulties may result in the tool not being used for conceptual design where it is desirable to make quick and frequent changes.

Rendering time increases with the number of polygons. Although simple scenes can render in a few seconds, complex scenes may require several minutes. As rendering times increase, the likelihood for use in conceptual design decreases since the spontaneity available from sketching becomes more important that the advantages of a 3-D model (Figure 3).

**Figure 2:** Sketch by Alvar Aalto: freehand conceptual sketching often contains symbolic, gestural or diagrammatic information which is difficult to represent with polygons

**Figure 3:** Complex three-dimensional models can be cumbersome to create, change and render

Polygons are time-consuming to create, change, and, when the number is great, render.

The creating of polygon representations often requires a number of decisions about which tools to use and how they are to be employed.
as underlays for further drawing, or brought into
paint programs for further development. In fact,
this has often been a good way to deal with the
problem. Unfortunately, of course, the resulting
drawing is fixed in the 2-D world, and sketched
concepts cannot be transferred to other views or
used in animation. A possible second approach
would be to somehow sketch, using paint tools
provided by the 3-D modeler, directly onto the
model surfaces in three-dimensions on the screen,
then capturing those bit map images on the
surfaces in three-dimensions so that they could
be seen and further modified by sketching in
any other view. This approach would combine
the best of both traditional 3-D and paint worlds.

This 3-D paint capability, nicknamed “virtual
graffiti,” is now possible with beta versions of
Upfront Version 2.0. The implementation
provides three capabilities:

Traditional paint tools adapted for three dimensions

In the new version of Upfront, a paint toolbox
provides standard paint tools. The rectangle and
circle tools are adapted to 3-D sketching in that
they automatically sense the three-dimensional
orientation of the surface being drawn upon and
paint in perspective on that surface rather than
making a figure that is in the plane of the flat
screen. The drawing action is the same as with
standard paint rectangle and circle tools except
that the figure is drawn in perspective. Gridding
and ruling, if turned on, take place in three-
dimensions with respect to the surface being
drawn upon (Figures 4 and 5).

Ability to capture a sketch made on any 3-D surface

A sketch on any surface can be captured on that
surface and becomes a part of that surface in
any view, even during animation. The operation
is a true bit map operation so that the ambiguity
and looseness in the original sketch is preserved
in all views. It is possible to create and modify
any sketch in any view. (A complementary set
of draw tools is also provided for cases where a
more hard line effect is desired). Unlike a sketch,
in which detail on a surface responds only to
the view in which it was created, a 3-D sketch
can be changed and altered through many views
so that it responds to what is seen in many
situations (Figures 6 and 7). The drawing is made
just as it would be in any sketch or paint program
except that the adapted rectangle and circle tools
help to draw those figures in the correct
dimensional planes. Surfaces with any three-
dimensional orientation may be drawn upon
(Figures 8, 9, and 10).

It is important to distinguish this capability from
conventional image and texture mapping which
applies a 2-D image to a 3-D surface. In the
case of “virtual graffiti” the surface is sketched
up directly in 3-D, just as with regular sketching.
(This is a rather interesting transformation since
the projection of bit map pixels are all different
sizes and shapes on the three-dimensional surface
upon which they are drawn).
Capturing a background image on a 3-D surface

The 3-D paint tools also capture background images, to allow conventional image-mapping. In this case the image is “captured” from a background rather than being sketched by hand. Examples of background images are scanned photographs, scanned concept sketches of plans or facades, and images created in paint, draw or video programs (Figures 11, 12, 13, 14 and 15).
An especially interesting outcome of this approach is the ability to pull a photograph "back into" three-dimensions: Upfront already has the ability to match the perspective of a scanned photograph background and "digitize over" surfaces in that image. It is possible with the new tools to capture the areas of bit map underlying those digitized surfaces, and then take new viewpoints which show the photograph as it would be seen if the camera had been located somewhere else. This allows going beyond designing "over" a photograph by allowing designing "inside" a photograph. Naturally the effect is limited to the information present in the original photograph, though multiple photographs can be used to develop a more complete representation. It is even possible to animate movement within the resulting projected photograph (Figures 16, 17, 18 and 19).
Summary

This chapter has described a new tool developed for three-dimensional conceptual design wherein each polygon in the drawing has the potential for becoming a three-dimensional sketch which can literally be drawn or modified in any view. This tool brings many of the advantages of the sketch world provided by paint programs into the world of 3-D polygon representation in a way that is a natural extension of the 3-D polygon sketch capabilities of a program such as Upfront. Since it gives 3-D expression to sketching, it facilitates more personal variation in three-dimensional representation.

For some types of conceptual three-dimensional design, a model with great visual complexity could consist of only a few tens of polygons with attached 3-D painted and scanned images. The majority of the designing might take place as the designer worked with the 3-D paint tools to change the images on the polygons, rather than the polygons themselves.

3-D paint is not expected to be the solution to the problems of conceptual design on the computer, but just progress towards that goal. It still requires that polygons be created upon
which to draw, and is often best used for representing things which have relatively little depth. Nonetheless it builds upon present methods and brings an important computer-aided sketching tool from 2-D into 3-D, making a contribution toward a three-dimensional drawing environment that is suitable for conceptual design. It introduces a new element for the designer's toolbox - the three dimensional sketch - that does not diminish existing methods, but augments and complements them.