SUMMARY

The goal of this project is to implement a meta-sketching layer to lie on top of Mental Canvas, a sketched-based 3D design system I have previously been working on. This system would incorporate the sketch organization, annotation, labeling, and search ideas I developed last semester. The output of this project will be a prototype toolkit and user interface that accommodates general purpose meta-sketching operations (such as tagging, grouping, and annotation) as well as more specific applications that make use of these primitives (such as sketch search and various types of sketch space visualization). The user interface for this project will be derived from the multi-resolution interface I previously developed. 3D Mental Canvas worlds will be embedded in this organizational space in such a way that the meta-sketching environment naturally complements the 3D sketch collages.

With this project, I hope to continue combining my interests in computer science generally, computer graphics and vision more specifically, and additionally in cognitive science, visual art, and architecture. I hope to motivate my design decisions from the perspective of the psychology of human perception, and from some understanding of tools that would be useful to artists and architects.

DETAILS

The present project is one component of a larger research thread in the Yale Graphics Lab that aims to develop techniques for conceptual level 3D modeling and design. One layer of this research involves creating systems for sketch-based 3D architectural modeling. I have previously worked on implementing of a tool for this layer called Mental Canvas. This system takes a qualitatively different approach to 3D representation from current standard computer aided design systems. Rather than using a conventional “top-down” approach, defining large masses in 3D and then refining and decorating these masses, Mental Canvas develops designs as the synthesis of 2D sketches arranged by the user on planes in a 3D environment. 3D form emerges by the fusion of multiple 2D views in the user's own visual system. The 2D sketches in Mental Canvas are a natural way of semantically breaking up the envisioned 3D models. These sketched views and sections consequently lend themselves especially well to organization and visualization in a meta-sketching layer of design. The present project attempts to build that layer.

This project will consist of two phases. In Phase 1, I will implement the organizational primitives and the user interface upon which meta-sketching applications can be built. In Phase 2, I will implement several prototypes of such meta-sketching applications.

Phase 1:
I will build a user interface derived from the zooming user interface I developed last semester and previously. This framework lends itself especially well to meta-sketching since it allows a multi-scale, intuitive view of the hierarchy of sketch information. I will also explore augmenting the the basic 2D layout with partial extension into 3D space. Specifically, I plan to examine how a bumpy 2D surface embedded in 3D space might combine the ease of navigation of 2D surfaces with the depth of information provided by three full dimensions.

In this environment I will provide a modular set of meta-sketching primitives. Each of these primitives will interface with sketch objects in a standardized way. In this way I will build up a toolkit of primitives and operations that can be used by later meta-sketching applications. The primitives created may include the following:

* **Sketched-based sketch tags**
  Users would be able to draw labels on sketches. These labels could be later used for sketch organization.

* **Sketch groups**
  A hierarchical sketch and workspace grouping system may be provided.

* **Basic sketch graph data structures**
  Simple graphs may be built up based on object tags and object groups.

* **Sketch parameter tables**
  Basic image parameters would be automatically extracted and tabulated for sketches.

* **Semantic mapping tool**
  Users would be allowed to draw with a variety of specialized 'markers' on their sketches as well as in the 3D Mental Canvas world. These markers would be matched with meaning in a translation table. Sketched symbols (such as arrows) could also be identified as carrying meaning. These markups would thus form semantic maps overlaying the syntactical sketch strokes.

* **Textual annotation**
  Architects tend to heavily interleave graphics and text in their notebooks. A special set of pens may be provided for such highly integrated textual markup.

**Phase 2:**

This phase will consist of programming applications to make use of the meta-sketching primitives. I plan to test two types of applications: sketch visualizers and sketch searchers. In both cases, the programs will use tags, symbolic annotations, semantic maps, and others of the primitives described above to organize and present sketch information in meaning full ways. There are a variety of possible applications to test:

* **Sketch parsing**
Sketch layout could be reorganized and displayed in a semantic network that describes a particular design principle such as 'paths of access' or 'lines of sight'. These networks would be built up based on the data in semantic maps.

*Parameterized sketch space visualization*
A general method for redisplaying sketches would be to position them in parameterized space according to a chosen set of features (found in their parameter tables.) The particular coordinate layout (e.g. Cartesian or radial, 2D or 3D, etc) would be up to the user's discretion. The user interface framework would be built to accommodate multiple topological layouts.

*Temporal evolution visualization*
Date of sketch creation could be used as a parameter in a parameterized visualization. Special treatment would be required for this variable since time lends itself to very specific and meaningful visualizations (e.g. time lines, movies).

*Image-based sketch search*
Users would sketch a thumbnail version of an image they are looking for and image search algorithms (perhaps crawling over sketch tag graphs) would scour the archived tags to find matches.

*Data mining sketch archives*
Data mining techniques could be used to classify and cluster sketches for more effective search, and to redisplay the sketch layout in novel ways, revealing statistical trends in the sketched designs.

**DELIVERABLES**

1) Implement a basic toolkit and user interface to support meta-sketching applications.
2) Implement prototype meta-sketching applications built upon (1).
3) Write up theory behind code and lessons learned from the implementations. In particular, use the prototype applications to determine which primitives make the best case for inclusion in a meta-sketching toolkit and what sorts of user interfaces lend themselves best to this type of work.