TJHSST Computer Systems Lab Senior Research Project
Interactive Geometry in 3D
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Abstract

The goal of this project is to write a program that allows its user to create and manipulate a complex system of geometric objects in space. From a few basic object types, very interesting and useful constructions can be built. This could be useful for education, mathematical or scientific research or visualization, or just for fun.

Keywords: Euclidean geometry, human-computer interaction, educational computing, scientific visualization

1 Type of research

This project is primarily applied research, combining well-established techniques in new ways to create a useful product.

2 Background and review of current literature and research

For a while there has been software for computer assisted design (CAD), which utilizes a few basic shapes and techniques such as snapping and numeric entry to create precise, polished diagrams of a product that can then be used in its manufacturing.

A similar sort of program is used for 3D modeling, in which the user constructs polygon meshes in three dimensions: freehand; with snapping; and numerically. My program aims to be more focused on geometric objects and dynamic preservation of their relationships as some are manipulated. The leading example of this is a commercial program called The Geometer's Sketchpad. However, its interface is rather clunky, and it is limited to two dimensions. However, the fact that it is possible to build primitive 3D constructions in it illustrates the power behind the idea of geometric construction. The basic philosophy for the user interface of my program comes from the modeling program Blender and the text editor VI.

A somewhat different and interesting approach is taken by the SKETCH project of Zeleznik, Herndon and Hughes of Brown University from the mid-1990's, and the commercial program SketchUp. With these programs, the goal is quick, informal visualization of a scene from the user's imagination, much like a pencil-and-paper sketch in three dimensions. SKETCH is particularly noteworthy for making extensive use of mouse gestures for determining how to interpret the drawn lines. My program will aim for a simultaneous use of mouse and keyboard for maximum flexibility and efficiency.

3 Procedures and Methodology

Once the basic code for a geometry heirarchy, display, and user interaction is in place, the user will be able to make simple constructions involving points, lines and possibly circles, in two dimensions. This would make for good proof-of-concept visuals, especially when animated.

Visual feedback will generally be sufficient to see if the program is working as expected; for instance, does a point of intersection between two lines show up in the correct place?

The next stage will be to add the third dimension. The main challenge at this point will be developing the user interface, and fine-tuning the graphics code so that things can be seen clearly.

The final stage for this year, which will add the most practical use for the program, will be developing more sophisticated components such as a locus that can trace the path of some other object in the scene, and be updated in real time. This would enable uses such as graphing and visualizations of complex three-dimensional objects.

4 Expected Results

Since this is a primarily interactive program, its best demonstration will be to use it. When this is not possible, screenshots and animations of its features will suffice. There is a good deal more work that could continue to be done on the program once it gains the described features, to make it more user-friendly, more functional and better looking. A side project could be to create a variety of constructions using it, for illustrating various mathematical concepts.

More interesting future features would be to add embedded scripting support for advanced scene manipulation, or even integration with a physics engine for more realistic animation possibilities.