# Inexpensive Non-Sensor Based Augmented Reality Modeling of Curves and Surfaces in Physical Space

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## Abstract

*Previous works in modeling of curves and surfaces in augmented reality (AR) space has used expensive sensors such as magnetic sensors. In this work, we propose an augmented reality system where a user can model interesting surfaces with her hands, and without expensive sensing systems. The system uses computer vision based methods for the tracking of the user's head and hand position. Using a glove and the tracking system, the user can draw smooth lines or surfaces with her hands in a physical space. Also the user can intuitively modify the lines or surface created by pushing or pulling at the control points of the lines or curve in a tangible manner.*

## 1. Introduction

Creating 3D surfaces has many important applications in a variety of fields such as engineering, automobile and the film industry. Systems such as Teddy [1] allow the automatic construction of 3D polygonal surface from a 2D silhouette drawn by the user. Teddy's physical user interface was based upon 2D input devices such as standard mouse or tablet. Sachs built a system called 3-Draw [2] for sketching 3D drawings using a tracked stylus. The results were viewed on the standard monitor. Butterworth constructed 3DM [3] an immersive system that places the user in the modeling space through the use of head-mounted display. The user is allowed to "fly" around the virtual world to observe the 3D model. However, she can get disoriented moving about the virtual workspace. Schkolne [4] constructed a system that allows 3D surface drawing in augmented reality. The use of semi-immersive environment aids the user in spatial understanding of the 3D model without getting disoriented. Expensive magnetic trackers are used to for tracking purposes as the hand traces out a surface in 3D. Tongs with magnetic trackers and sensors are used to move the curve drawn. Piekarski et al [5] uses a vision-based system for the tracking of gloved hand in an indoor VR application.

The disadvantage of the previous systems is that they require expensive tracking systems and sensors (such as magnetic trackers). In this system, the emphasis will be on drawing 3D curves and surfaces in augmented reality using a method that does not require expensive sensors.

## 2. Overview of Interaction

The way the user interacts with the virtual models is through control points. In computer graphics, manipulating the control points of curve and surfaces will change its behavior. Thus, in this system a very intuitive manner for curve and surface design was proposed, which is through the user's index finger. By adopting a 'finger pointing' gesture (index finger pointing out of clench fist but with thumb brought close to the index finger), the user indicates that he wishes to add control points; the control point is placed at the position of the user's index finger tip. In 2-D graphics modeling packages, when the user wishes to modify the shape of the surface or curve, she does so by changing the position of the control points. In this system, the user interacts with the control points by entering into the "modify object" mode. Then adopting an open palm hand gesture, a virtual selector is attached to the index finger. Now, using her hands the user can push or pull the control points.

An artist when making a drawing is typically seen holding a palette where he could used to mix his paints and stores the most recently used colors. In this system, the metaphor of the artist with the palette is used. The palette serves as a control panel, making use of the palette the user can change the color of the virtual object, rotate the virtual object as though the virtual object was sitting on a lazy susan and erase the object.

## 3. Design and Implementation Issues

In the system, the most fundamental consideration is that of registration. The work done by Schkolne [4] uses VR tracking equipment to aid in the registration of the head and hand position. In our system, we propose to



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make use of public domain vision techniques developed by Kato and Billinghurst [6] to track the head and hand position.

The adding of the control points by the user is determined by where the user's hand is, and further more the control point is modeled in the world space (world coordinate system). This requires the knowledge of the user's hand position with respect to the world coordinate system.

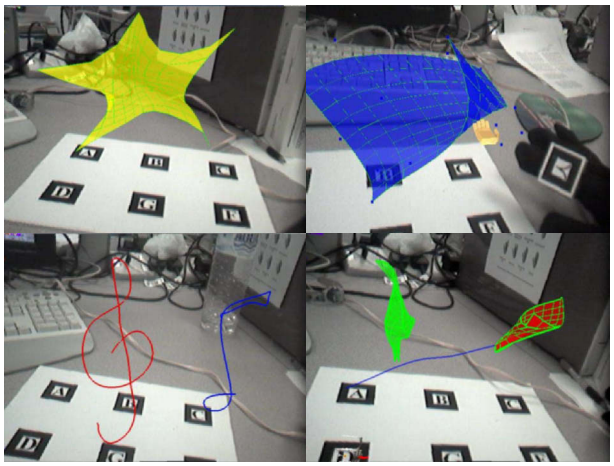

**Figure 1. Drawing curves / surfaces with finger**

The challenge in this part of the design is to have a tangible way for which the user can generate the control points for the surface he or she wants. The approach taken was that the user had to first generate the control points for a curve by using his finger tip to add the control points. Subsequently, the user can 'pull' the set of control points in any direction he wants, while this is being done the original set of control points generated at the beginning for the curve, will be duplicated along the direction of pull.

The kind of interaction provided for control points includes the selection and re-positioning of the control points. As the control points are stored in a linked list changing of the coordinates of the control points is easily achieved, as all that is required is to update the coordinates of the particular member of the linked list.

## 4. Results

The following will show some of the results that a user can achieve to create interesting and innovative curves and surfaces. The user moves her hand over the table and traces out a curve or surface in three-dimensional space (Figure 2). Placing control points using the tip of her finger draws the curve or surface. A painter's palette gives further control to the user by allowing her to rotate, erase and shade the 3D surface drawn with different colors.

The user can toggle between drawing 3D curves and surfaces**.** This enables the user to choose the mode he deem suitable for his usage. After drawing, the curve or surface can be 'pulled' into different shapes to allow the user to fine-tune his drawing (Figure 2).

## 5. Conclusion

To date, work done in this field of augmented reality modeling is limited as due to the high cost and difficulty faced in designing user interaction. The contribution of this work is to offer a low cost alternative for augmented reality modeling as current such applications use costly magnetic trackers typical of that of full immersion VR systems. Another obvious advantage of our system is that it can be easily scalable at minimum additional cost.

In this project, a proto-type system of a low cost augmented reality-modeling program was developed. The interface allows the user to create and interact with the virtual curves and surfaces in a very tangible manner.

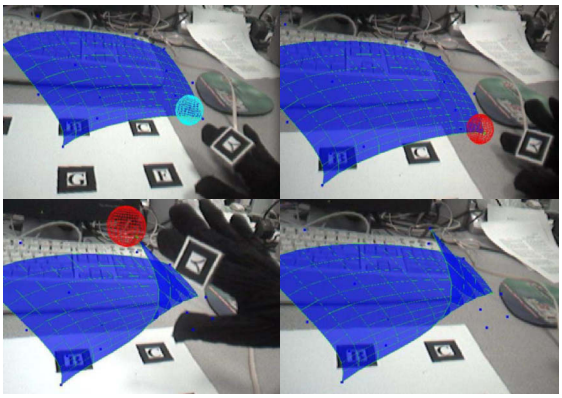

**Figure 2. Interacting with the surface to change its shape**

## 6. References

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[6] www.hitl.washington.edu/projects/shared_space/

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