# DO-IT: Deformable Objects as Input Tools

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## ABSTRACT
Standard input tools such as the mouse and keyboard do not provide users with a direct and intuitive means of 3-D shape manipulation. This study proposes a new concept of interface system for 3-D shape deformation using a deformable real object as an input tool. By deforming the tool with bare hands with a tactile feedback, users can manipulate a 3-D shape modeled and displayed on a computer screen directly and intuitively. A PC-based prototype system with a cubical input tool made of electrically conductive polyurethane foam demonstrates the effectiveness and promise of the concept.

**KEYWORDS:** Human interface, 3-D input tool, computer graphics, computer-aided design, free-form deformation

## INTRODUCTION
In present computer systems, standard input tools such as a mouse and a keyboard are normally used for 3-D geometric shape manipulations as well as for 2-D ones. For highly 3-D shape deformations, e.g., twisting the whole shape while bending it, however, these tools are not appropriate because they often require some combination of indirect operations and do not provide users with direct and intuitive facilities. To solve the problem, we propose the use of deformable objects as input tools (DO-IT) for direct and intuitive 3-D shape deformation [1].

## BASIC CONCEPT
Figure 1 shows the basic concept of the DO-IT system. An objective shape to be manipulated is modeled and displayed on a computer screen, and a virtual control volume to deform the shape is also defined. Then a deformable real object is prepared as an input tool whose shape should be the same as, or at least close to, the control volume so that users can easily understand the correspondence between them. The deformation of the tool can be electrically measured by fabrication of a tool consisting of electrically conductive elastic material ,or attaching sensors, e.g., strain

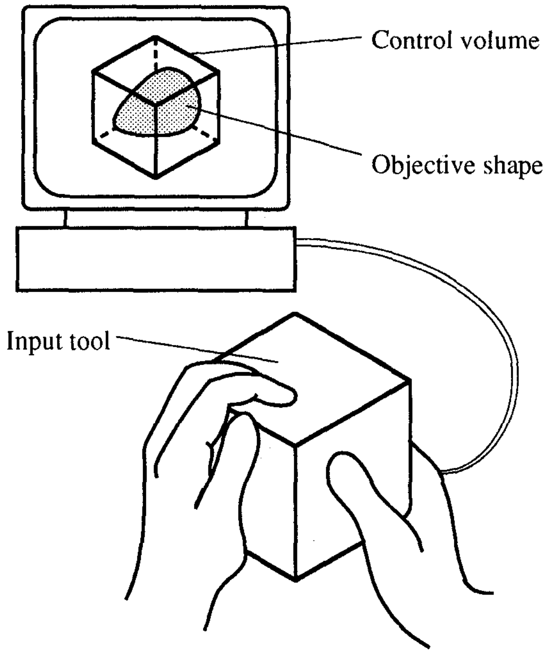



Figure 1. Basic concept of DO-IT system

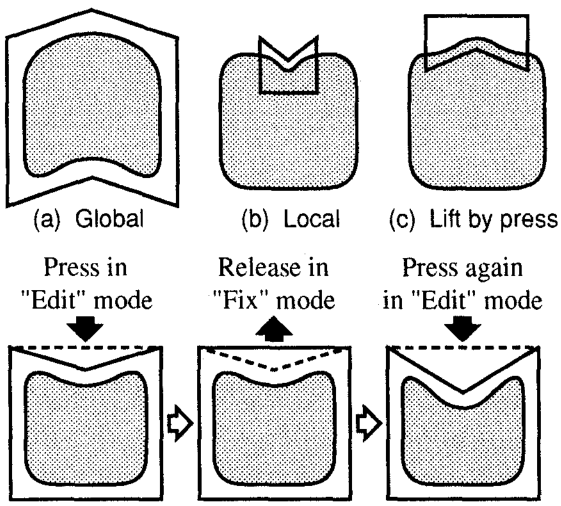
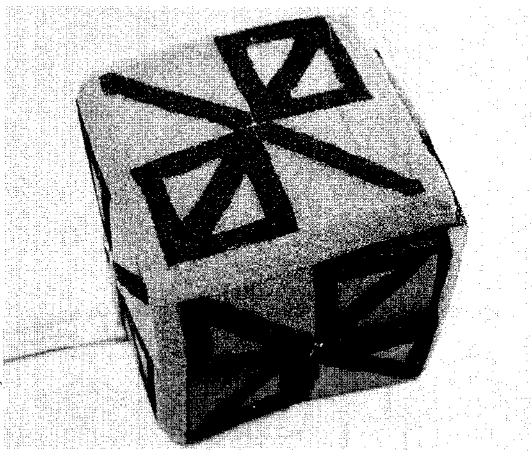


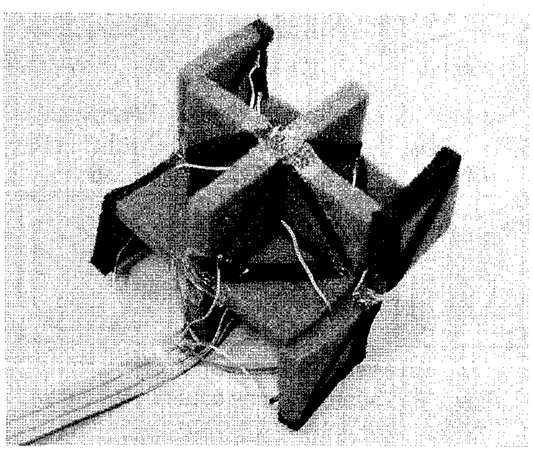

Figure 2. Deformation by control volume

gauges, on the surface and/or the inside of the tool. The measured deformation of the input tool is processed and used to manipulate the objective shape in a computer. With this interface system, users can deform the objective shape on a computer screen by performing direct and intuitive operations on the input tool with bare hands aided by tactile feedback, such as pressing, bending, twisting, and combinations of them.

This is a free-form deformation-oriented [2] approach. Even with an input tool of relatively simple shape, such as a cube, practical shape manipulation can be achieved by adequately controlling the relative size, position, and orientation of the control volume to the objective shape (Figure 2(a)(b)). Even though it may be somewhat difficult to stretch the input tool, such deformation as lifting the surface of the shape can also be realized by pressing the other sides of the surface (Figure 2(c)). Since the input tool is elastic, the deformation of the objective shape will be removed when users release the tool. By switching an effect of input tool deformation on the objective shape on (the shape is editable) or off (the shape is fixed), deformation of the shape can be maintained and accumulated (Figure 2(d)). In these shape manipulations, a control volume is used as a 3-D shape editing cursor.



(a) Appearance



(b) Inside structure
Figure 3. Cubical input tool

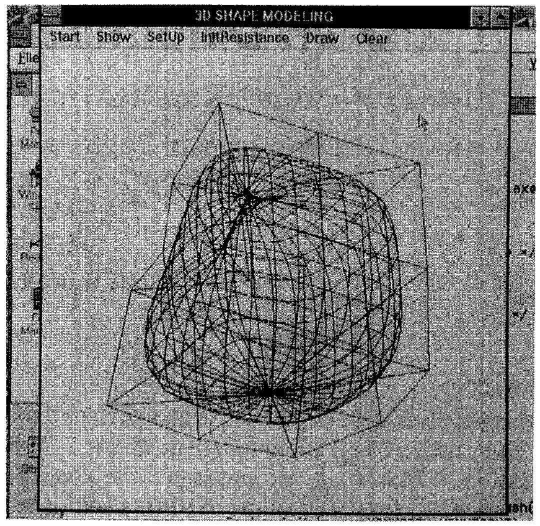



Figure 4. Screen of DO-IT system

## PROTOTYPE SYSTEM IMPLEMENTATION

We have implemented a PC-based prototype of the DO-IT system with a cubical input tool. Figure 3 shows the appearance and inside structure of the actual tool made of polyurethane foam (elastic and electrically nonconductive; gray portion in the photograph). Pieces of electrically conductive polyurethane foam (black portion in the photograph) are embedded on the surface and the inside of the cube. These pieces are used as sensors to measure length by electrical resistance. Resistances of all sensors are input into PC through an A/D converter. Based on the measured sensor lengths (calculated from resistance) of the input tool, control volume deformation can be calculated, which then determines the resulting objective shape deformation. Figure 4 shows the control volume and the objective shape displayed on the prototype system screen.

## CONCLUSIONS

In this short note, we proposed a new concept of interface for direct and intuitive 3-D shape manipulations using deformable objects as input tools, and the prototype system demonstrated the effectiveness and promise of the concept. Some features of our basic concept have not been fully implemented in the PC-based prototype yet, and we are currently working on a 3-D graphics workstation version with full features and improved performance.

## ACKNOWLEDGEMENTS

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