A Multipurpose Array of Tactile Rods for Interactive eXpression

Contacts
Dan Overholt
Egon Pasztor
Ali Mazalek
Media Laboratory
Massachusetts Institute
of Technology
dano@media.mit.edu

Introduction

The MATRIX (Multipurpose Array of Tactile Rods for Interactive eXpression) is a device that offers real-time control of a deformable surface, enabling the manipulation of a wide range of audiovisual effects. The interface functions as a versatile controller that can be adapted to many different tasks in a variety of application domains. It was first used as a new type of musical instrument in the Emonator project.[1] New domains are now being explored in areas such as real-time graphics animation, sculptural design and rendering, still and moving image modification, and the control of physical simulations.

The Interface and Technology

The human hand has shaped and produced many amazing things over the centuries. It is one of the most nimble and dexterous tools at our disposal. One of the goals of the MATRIX project was to create an interface that would make the most of our skill with our hands. The result was a human-computer interface that can extract useful information from a gesture, exploiting the senses of touch and kinesthesia. It allows a computer to respond in real time to the form of a 3D surface, and captures the shape and movement of the hand at high resolution, taking advantage of the skills we have developed through a lifetime of interaction with the physical world.

The MATRIX interface consists of 144 rods which move vertically in a 12 by 12 grid, and are held up by springs at rest. The device uses this bed of rods to provide a large number of continuous control points, thereby improving the communication bandwidth with the computer. The deformation of the surface is determined using opto-electronics, and a FPGA (Field Programmable Gate Array). A technique called quadrature encoding is used to derive the current rod positions. All resulting positions are sent to the computer at a frame rate of 30 Hz, letting the system respond quickly and smoothly to a users input.

Visual Applications

The surface of the MATRIX can be used as a controller for any real-time graphics application where dynamic user input is required. Its responsive model of the hand provides a much richer method of control than a mouse, joystick, or keyboard. For example, the animation of ocean waves is traditionally done using a combination of physical simulation and careful positioning of isolated control points. Using the MATRIX, the motion of a user's hand can be mapped directly to the underlying forces in a wave simulation. The user would then have the experience of interactively creating the simulated ocean swells. This technique can also be applied to many other physical simulations for things that behave as particle systems, such as wind flow or the rippling of cloth.

Currently the MATRIX is being used as an input device for real-time graphics animation, image manipulation, and physical simulation. Figure 2 shows several examples of different tasks using the MATRIX. The upper left shows the rods of the device as perceived by the computer. These rods are interpreted as a shaded surface, which is shown on the upper right. This same surface can be used to deform virtual objects or images, such as the picture of the dog on the lower left. The surface can also be interpreted as an array of wind forces in a simulation of a grassy plain, as shown in the final image. As the user moves their hand, the blades of grass bend back and forth in response to the virtual winds.

In addition to these applications, the MATRIX is being used for the dynamic control of colored lights. The transparent acrylic rods serve as light guides for four computer controlled ColorKinetics C-30 lights[2] placed beneath the device. Colors and patterns of light are synchronized to the movement of the rods based on different mappings. For example, the average value and rate information of each quadrant of rods can be used to determine the color and intensity of each light.

Future Extensions

We are beginning to use the MATRIX for real-time processing of an incoming video stream using effects such as stretching, morphing, and other visual deformations. In the future, we plan to investigate using the interface to sculpt complete 3D objects by allowing users to change the orientation of the object in space and shape each of its sides individually.

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See also: www.media.mit.edu/~dano/matrix/

References

1. Overholt, D. (2000). The emonator: a novel musical instrument. MIT Media Laboratory master's thesis, 2000.
2. ColorKinetics lights: URL: www.colorkinetics.com/