A Touch-Sensitive Input Device

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INTRODUCTION

In computer music systems there is a continuing problem of finding techniques which allow suitable physical gestures to be used to express musical ideas. This is especially true in performance. This situation exists due to a lack of appropriate input transducers. Conventional computer input devices (such as sliders, joysticks, tablets, and keyboards) are being used to increased advantage (for example, Buxton, Reeves, Fedorkow, Smith, and Baecker, 1980). However, additional research is required to design new devices which lend themselves to the articulate expression of musical gestures. The "sequential drum" of Mathews (Mathews and Abbott, 1981) is one example of work in this area. The proximity sensors used in performance by Chadabe (1980) and the motion sensors used by Pinzarrone (1977) are two other examples. In the remainder of this paper we discuss yet another input device which has been developed as part of the research of the SSSP. The device is a touch-sensitive tablet which is intended to be able to be used as a pointing device, for adjusting performance parameters, and as a percussion - like input device. While the device was designed with music applications in mind, it is far more general in application.

FUNCTIONAL OVERVIEW

The basis of the tablet is a flat surface measuring 30 by 42 c.m. The surface is capable of sensing the point of contact of a finger with a resolution of 64 (horizontal) by 32 (vertical) evenly spaced units. Only one point of contact at a time can be dealt with. The device measures the capacitance at the point of contact and calculates a six-bit digit of proportional magnitude. Since capacitance is determined by the surface area covered at

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the point of contact, this six-bit digit can be thought of as analogous to pressure (based on the observation that the harder you push, the more surface area your finger covers). This Z value is then transmitted to the host computer, along with the X and Y values identifying the position of the point of contact.

IMPLEMENTATION OVERVIEW

The overall architecture of the device is shown in Figure 1. Here we see that the tablet is made up of four basic modules.

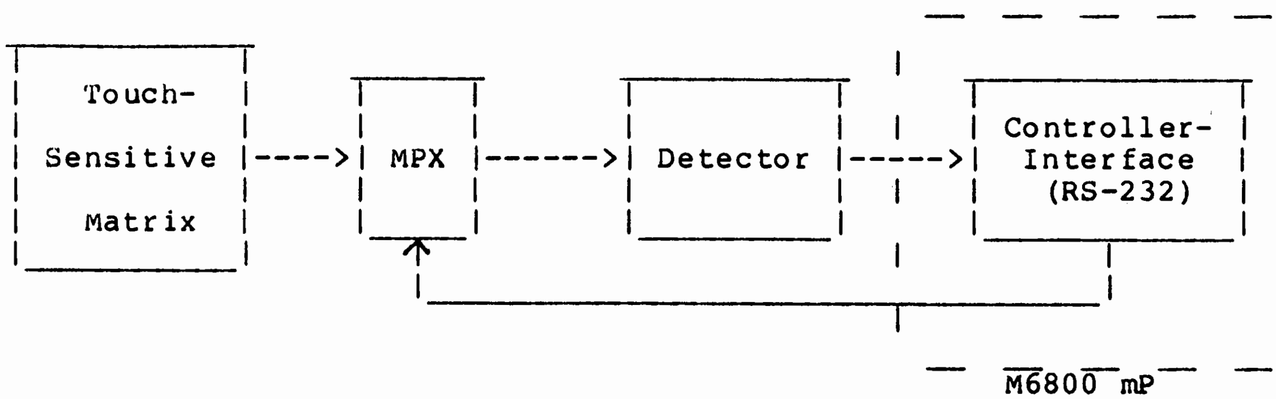

Figure 1. Tablet Block Diagram

The "Touch-Sensitive Matrix" is a printed circuit board etched with a matrix of vertical (64) and horizontal (32) conductive strips. At the edges of this array of strips are multiplexers and capacitance sensors, which are under the control of the microprocessor. Periodically, the microprocessor scans the entire tablet, reading the capacitance of each strip. The values obtained are compared to a set of reference values measured and stored upon start-up. Further processing takes note of strips which show capacitance increased beyond a threshold. Because a finger tip invariably covers several adjacent strips in both the X and Y directions, the controlling software then selects the point of highest capactance in the largest group of strips as the point of contact. A point of contact for X and Y is computed in this manner. The sum of excess capacitances for all contacted strips surrounding the contact point is scaled to a six bit number and used to indicate the pressure.

As the final step in each scan of the tablet, data is formatted and transmitted to the host, using a standard 9600 baud RS-232 serial link. Because of the amount of processing required, the tablet is scanned only about twenty times per second; this rate is adequate for tracking hand movements, but it is too slow to be completely satisfactory as an input device for a percussive instrument.

The current version has been implemented using 49 integrated circuits. Included in this is a Motorola M6800 microprocessor which was used to implement the controller-interface module. This was realized using 1968 bytes of ROM.

EXAMPLES OF USE

To date, the tablet has been used by two programs. The first is a test program to demonstrate its sensing potential. It simply maps the three coordinates transmitted by the tablet into parameters of an FM sound being generated by the SSSP synthesizer (Buxton, Fogels, Fedorkow & Sasaki & Smith, 1978). Pressure determines volume (no contact results in silence), vertical position determines pitch, and horizontal position controls timbre (by determining the index of modulation of the FM instrument). The mapping is totally arbitrary. What is important is that the device can reliably sense pressure, and position of single points of contact, as well as track these parameters as the hand slides across the surface. In this example we have used the tablet as a position sensing device, using the absolute values of the coordinates for control purposes.

Our second software effort was to integrate the tablet into the _conduct_ program (Buxton _et al_, 1980), which is the main performance system of the SSSP. Here the tablet can be used in two ways. First, it can be used as a triggering device. Thus, striking the tablet can be used to initiate events, whether they be single notes or scores. As such, the beginnings of a percussion-like interface is provided. The second use of the touch-tablet is as an alternative to sliders or the mouse for adjusting performance parameters through the control of groups. In this case the tablet can be used as a motion sensitive device, where hand motion in the horizontal and vertical domains can be independently used to increment or decrement the parameters associated with a particular group. Alternatively, the magnitude of the change of parameter values can be made proportional to the magnitude of the distance of the point of contact from the centre of the tablet. Again, the control is two dimensional, working in both the horizontal and vertical domains. Both methods of group control "delta modulate" the parameters associated with the groups in question. The two techniques have different characteristics, however. The first emulates the function of a "mouse" and a tracker-ball. The second lends itself well to combination with the triggering ability of the device. Used in combination, the tablet can be used to initiate an event, and have the properties of that event (such as duration, loudness, pitch, spectral content, _etc_.) controlled by where the device was hit to cause the trigger. In so doing, the full potential of the device as a percussion instrument is greatly augmented.

CONCLUSIONS

The tablet described has clear limitations. First, the positional resolution is low, and would need to be increased for it to reach its potential as a general purpose device. It is not yet good enough, for example, to be used as a drawing device where pressure controls line thickness. Basing the design on capacitance sensing is one of the factors in this limited resolution. This also results in some variability in the pressure sensitivity. Clearly other technologies such as measuring conductance or optical techniques need to be investigated. Timing is another area where the resolution suffers. While percussion like gestures can be used effectively to trigger events, a percussionist would be frustrated by the slight lag in response and the inter-event time resolution. Such devices in the future must be designed so that the scanning can be carried out with about 5 ms of resolution. Transmission from the transducer through to the synthesis device must be traversed in about 5 ms. Finally, the most severe limitation is the device's inability to sense and track more than one point of contact at a time. A "polyphonic" version of such a tablet, one that can independently sense position and pressure for several simultaneous points of contact, would definately be welcome. However, in spite of these limitations, the tablet functions well in its present application and bodes well for the future.

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