Dance-Music Interface based on Ultrasound Sensors and Computers

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ABSTRACT

This work presents the development of an interface between dance and music. The proposed system allows the interaction among movements and positions of a dancer or dance group and a piece of computer music played live.

The signals from the sensors are acquired by an IBM compatible PC and are interpreted by a software developed in C language. This software analyses the signals and decides which MIDI messages to be issued to the music generating devices. The dancer can control such parameters as volume, velocity, pan, program change, among others.

The sensors are based on ultrasound signal processing techniques and the final system has the capacity of detecting a particular position in a 3-D space of 5x5x2.5 cubic meters, with a resolution of 0.4mm.

INTRODUCTION

The use of informatics and electronics engineering in order to create new expression tolls is a growing research area, allowing dancers and musicians a degree of interaction during live performances.

Some dance groups or companies already use dance-music interfaces based on several sensors connected to computers in order to alter musical parameters on the fly. One of this groups is Troika Ranch (URL at the end of this paper), a New York City based performance group that makes use of sets of sensors worn on the body of dancers or placed at the stage. These sensors transmit information about the dancer's actions to a computer that runs a software that interprets the information received and allows the control of music and different types of media in real time, including lights and video. Their sensors are developed by a company named New Micros and are based on 68HC11 microcontrolers.

Another performance company is Cassiel, from Scotland (URL at the end of this paper). They produce performance projects using custom-built music systems. They make use of infrared transmitters built into baton-like wands, a systems called Lightning II. From the position coordinates gathered by tracking the infrared transmitters in the wands, the system performs an analysis of the performer's gestures and allows user defined relationships between gestures and potential musical responses.

In Brazil, at UNICAMP (Manzolli 1995), it is being developed a project called Luvas de Pelica, where a glover interface allows the production of music by the interaction of hand gestures and sound events. The system uses piezo electric transducers and mercury switches that sense contrasts of movements.

The interface proposed in this paper is based on different transducers, in our case ultrasound sensors. The processing of ultrasound signals is a very accurate position determining system, allowing an actual position resolution of tenths of millimeters within a limited space.

DESCRIPTION OF THE INTERFACE

The interface is based on a IBM compatible microcomputer (PC). In our prototype at UFPR, a 286 computer receives and analyses the signals from the sensors. A software was designed to interpret the incoming signals and decide which MIDI message (Boom 1987) to issue.

In order to produce MIDI messages straight from the PC without using a sound card, it was decided to use the computer's modified serial port, through the substitution of the UART clock, replacing the original crystal by a 1MHz or multiple frequency crystal. This allows the production of the serial transmission rate of 31.250 bits/s ± 1%. A custom-built cable was made to connect the serial port of the PC (DB25 port) to any MIDI compatible device, containing resistors and a diode to keep the current levels compatible to the MIDI Standard (because the serial port of the IBM PC is originally a RS 232 standard compatible port). Figure 1 shows the custom-built cable.

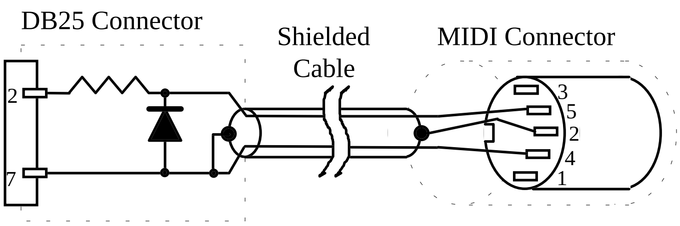

Figure 1: Custom-built MIDI cable

The next step was to connect the PC to a MIDI device or another computer that was able to receive MIDI signals. It was decided to use a Macintosh computer running the software MAX (Opcode Systems Inc 1991), due to its inherent capacity of dealing with algorithms. This scheme can be seen in figure 2.

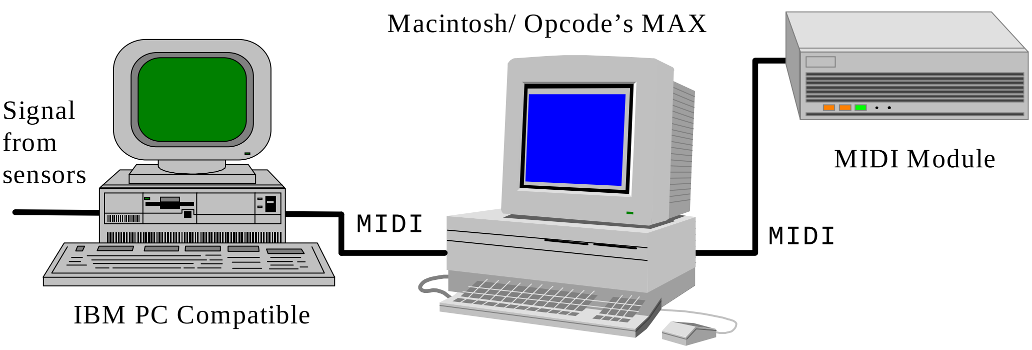

Figure 2: Suggested music generating scheme to be used in the shows.

The software running on the PC was written in C language, and its basic job is to evaluate the position of the ultrasound sensors and other sensors connected to the system. A timer defines when the signals of the sensors must be read, after that the correct MIDI message associated to the sensor is sent. The MIDI messages generated by the software can be either a sequence of notes or a control to a MIDI device. These messages are sent to the software MAX running in the Macintosh, as seem in figure 2.

The fluxogram of the software that performs the interface between sensors and MIDI devices is presented in figure 3.

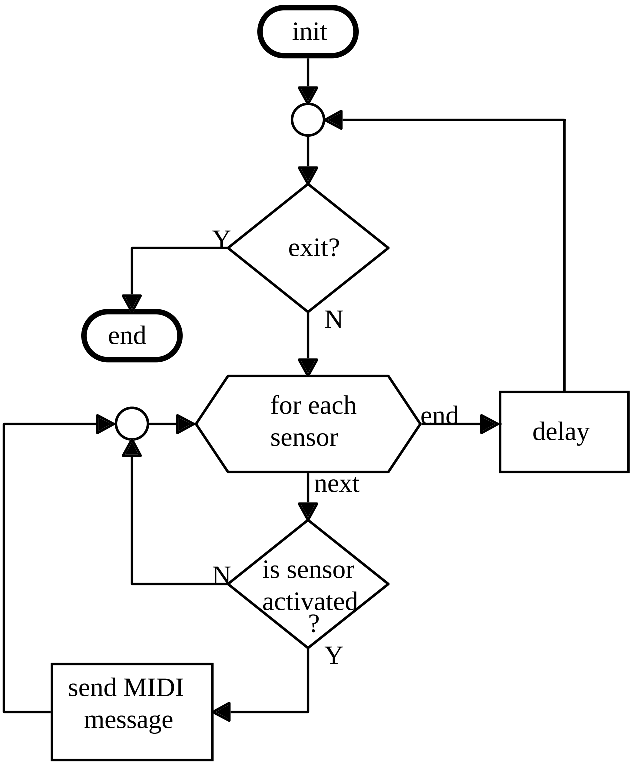

Figure 3: Fluxogram of the software running on the PC.

The system is based mainly on ultrasound sensors developed at UFPR and described in the next section.

DESCRIPTION OF THE POSITION ACQUISITION SYSTEM

The interface proposed in this paper is based on a position signal acquisition and analysis system for a 3D limited space, that uses the processing of ultrasound signals (Cai & Regtien 1993). The processing of ultrasound signals is a low complexity and low cost system when compared to other positioning signal acquisition techniques, such as artificial vision or electromagnetic field measurement systems.

The resulting proposed acquisition systems is composed of three modules: (a) a reference circuit that defines the coordinate system and limits the range of spatial capture of the position signal. It is composed of three ultrasound receptors whose positions define the coordinate systems axes, (b) an ultrasound transmitter that defines the point or points that should be measured and (c) the processing module, composed of one microcomputer that analyses the data that comes from the reference system and defines the coordinates of each point. The acquisition system is shown in figure 4.

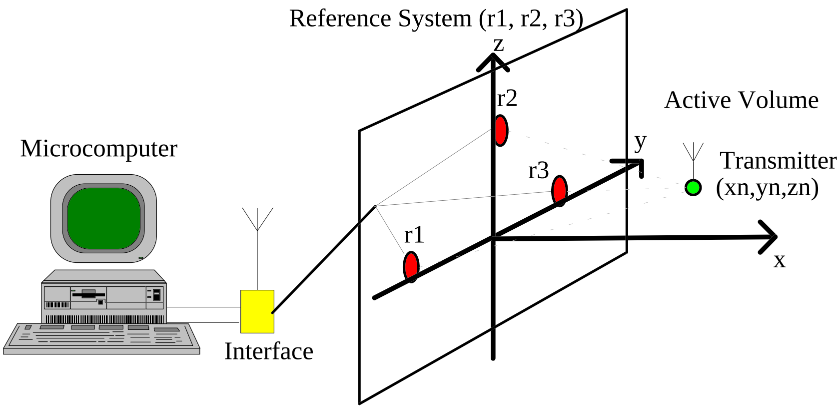

Figure 4: Position acquisition system.

The processing done in order to obtain the position signal samples is based on the ultrasound wave time-of-flight (Auer & Lamar 1994). The distance between the point (ultrasound transmitter) and each of the three receptors that are part of the reference system are quantified in 16 bits, so each sample of the acquired signal has 48 bits (x,y,z).

The volume covered by the system is defined by the ultrasound transmitter power and by the sensibility of the receptors. A prototype has been designed to cover a volume of approximately 5x5x2.5 cubic meters. The theoretical system resolution within this volume is 0.076 mm. The prototype presented an actual resolution of 0.4 mm. The sample rate for such volume is 68Hz, and defines the maximum frequency of displacement that can be detected. The resulting sample rate is sufficient for the acquisition of human movements. The intrinsic directionality of ultrasound waves was overcome by the use of redundant receivers and transmitters.

In order to minimize the physical dimensions of the equipment connected to the dancers an integrated circuit (IC) was implemented. The CMOS IC was designed with the software OCEAN (Groeneveld & Stravers 1993) using Sea-of-Gates structures, see figure 5. It allows the use of up to eight sensors at the same time.

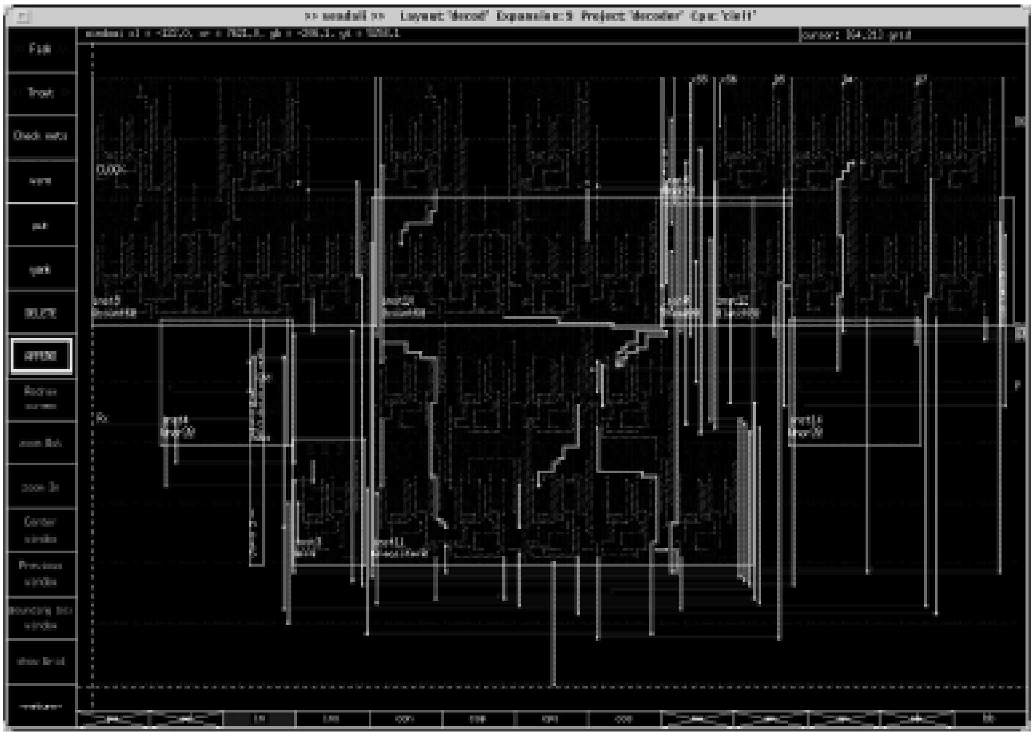

Figure 5: Layout of the decoder integrated circuit designed for the system.

DESCRIPTION OF THE PROTOTYPE

A prototype was developed with different kinds of sensors, e.g., light sensors acting as switches or linear ones, pressure sensors and ultrasound ones. The signals from the linear sensors were acquired through an acquisition board (Leonel, Groger & Bonfim 1995) that is able to handle 8 multiplexed signals. Others were connected straight to the PC's parallel port, in case the sensors represented switch like options light/no light, pressure/ no pressure.

The software was adjusted to issue NOTE ON and CONTROL CHANGE messages. A general MIDI sound Module (Roland sound canvas) was used instead of MAX. Some notes were selected and also algorithms to generate “arpeggios” with random notes.

The ultrasound sensors were controlled through a Fuzzy Inference System (The Math Works Inc. 1995), shown in figure 6. It allows the system to map positions with some degree of liberty in order to make the interface more user friendly. It was used mainly to control volume changes and PAN messages.

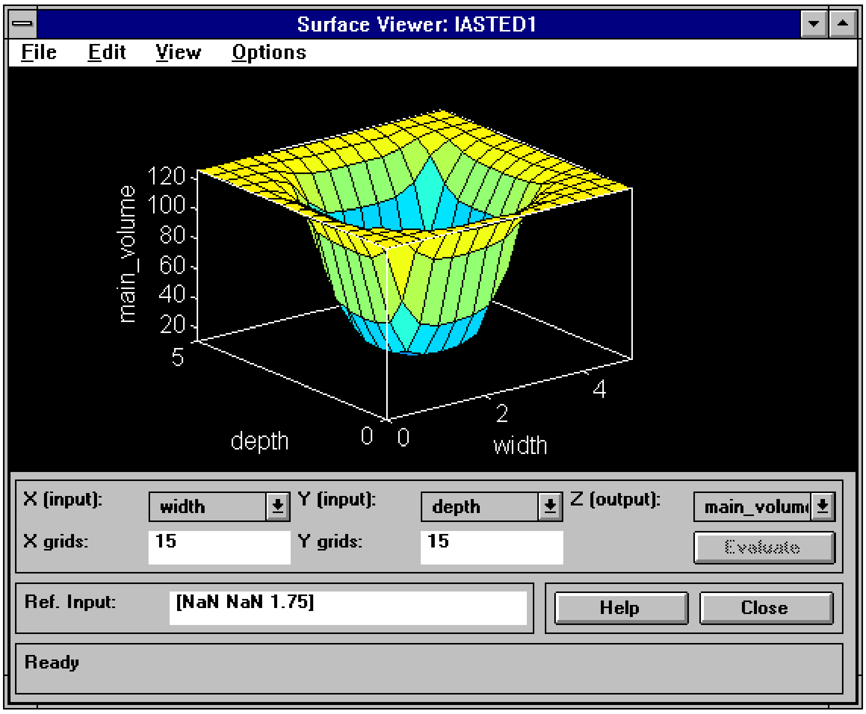

Figure 6: Fuzzy control of volume based on mapping the dancer position.

CONCLUSIONS AND FUTURE WORK

It was presented an interface between dance and music based on ultrasound sensors. The interface was developed aiming the production of an expression tool to be used by dancers and choreographers, flexible enough to be adapted to different dance and music styles, according to the users preferences. It produces basically MIDI messages in response to movements and positions of a dancer or dancers on the stage.

It is schedule a presentation of the final system with the Dance Group of UFPR for the second semester of 1996, as well as its use as tools for other choreographers interested in it.

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