INTERNATIONAL SYMPOSIUM ON MUSICAL ACOUSTICS

10 -14 September, 2001
Perugia, ITALY

Promoted by

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A DATA STREAMING BASED CONTROLLER FOR REAL-TIME COMPUTER GENERATED MUSIC

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Abstract

We here describe some modalities for controlling interactive computer music by means of human gesture and movements. Attention is focused on the experiences carried out in our departments describing some of the systems developed as Twin Towers, PAGe and SMI. In the second part of the paper an overview on data streaming features is given, in order to characterise system functionalities and performances.

INTRODUCTION

In the last decade a lot of interactive audio environments have been built in the field of computer music for capturing and analysing performer's movements in real time in order to achieve powerful control on sound synthesis [1][2]. In this way the lack of visual feedback during computer music performance have been partly filled out re-introducing the role of the performer, which is part of the visual feedback to sound, always present in classical concerts.

From gesture acquisition up to the audio level, a data stream is processed and transferred among different sub-systems: format and kind of data processing are important parameters for the system performance definition. For that data stream must be carefully examined in detail.

Data stream which corresponds to gesture must then be related in some way into music. This is the well known problem of mapping data representing gesture into the musical result, which involves creative and artistic aspects.

INTERACTIVE DIGITAL AUDIO ENVIRONMENTS

In the last few years we focused attention on designing and developing original wireless interfaces, taking into consideration the technologies of infrared beams and of real-time analysis of video captured images [3]. The basic idea consists of remote sensing human body gesture so that the human body itself becomes a natural and powerful expressive interface able to give feeling to artistic performances based on computer generated real-time electroacoustic music and computer graphics.

As previously stated, many other systems based on the similar technologies have been built all over the world. Digital Dance system [4], for instance, uses up to 16 bend sensors taped on the dancer body, a microprocessor for processing sensor data and a radio transmitter/receiver for transferring them toward a MIDI interface. This system is used for interactive dance, where one or more performers dance and control the music at the same time.

Eyesweb, a system developed at DIST, Genoa University [5] uses one or more video cameras to achieve real time analysis of body movement and gesture. Such information can be used to control and generate sound, music and visual media, and to control actuators. Another goal is to develop model of interaction and to understand affect and expressive contents of gesture.

Twin Towers is the best known gesture detector developed in our labs at CNR, Pisa, in which pairs of infrared rectangles projected up from a base unit are played by a human performer who moves his hands through the beams (see figure 1).

The changing orientation of the performer's hands relative to the device can be calculated from the reflection of the beams back to the base. This results in a controller with (in the simplest case) six degrees of freedom for each pair: the height, side rotation, and front rotation of the hand. When the timing of gestures is included, many more possibilities arise: for example, the speed of motion through the beams could be used as a control parameter as well.

A new Twin Tower version is currently under development in our labs with on board microprocessor for pre-processing sensor data with calibration, linearization and other *ad hoc* routines. The system meets the standalone specifications and is equipped with a MIDI OUT port, in order to easily connect to any MIDI compatible device.

Fig. 1 – Twin Towers Infrared System.

Handel is a video detection based system in which a performer moves his hands through the active video area. The system performs Fourier analyses of hand images to detect different postures (fist, splayed fingers, etc.) used as inputs for the two following interactive graphics and sound synthesis algorithms.

Painting by Aerial Gesture (PAGe) tracks the hand motions and generates colour graphics on a large screen behind the performer. Algorithmic computer music is generated at the same time under the influence of the hand movements to accompany the graphics.

The Imaginary Piano is a system for tracking hands motion in a video field, to interpret these as a piano player gestures. The software translates the detection into control parameters for an algorithmic composition process sounding through piano samples. The effect is of someone playing on an invisible piano.

The ultimate interactive system developed is SMI, under the auspices of "MOSART" network (Music Orchestration Systems in Algorithmic Research and Technology, a EC IHP Project [6]), during the time Gabriele Boschi spent in Århus at DAIMI-DIEM (Denmark), presented at the MOSART Spring Meeting [7].

SMI PROJECT

SMI is a configurable MIDI interface for converting analog and discrete signals into MIDI messages. Gestures, movement and actions executed by the performer or by people visiting the art installation are captured by different kind of sensors (light, traction, temperature, pressure, touch, rotation etc) and then translated into data stream for a generic sound processor or synthesizer. Figure 2 shows the SMI prototype (the white box) connected to 6 different kind of sensors, to the MIDI and to the power supply cables.

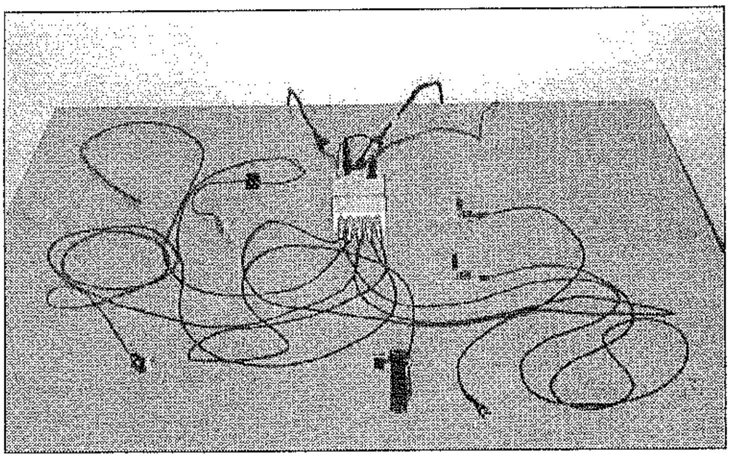

Fig. 2 – The Smart MIDI Interface (SMI) prototype.

SMI is used as a gesture tracking system for live performances, where one or more players can control sound synthesis through sensors connected to the interface; in this case the whole system can be considered as an user definable musical instrument.

In addition SMI can be used in a

museum or in Art installations where sensors are placed close to paintings and sculptures. When a person passes by a sculpture, places his hand or touch an artistic object specific sound synthesis effects can be generated.

More in detail the SMI consists of a µcontroller, with on board AD converter, which translates and processes analog voltages (generated by sensors) into MIDI messages, using configurable routines such as auto-calibration, linearization, inversion and resolution leveling. The interface is equipped with 5 analog inputs (i.e. analog voltages are sampled and quantized with 10 bit resolution) and 5 digital inputs (i.e. analog voltages are sampled and quantized with 1 bit resolution). SMI also has 5 MIDI controlled digital outputs for controlling any kind of actuator through a relay.

Win32 software for configuring SMI through MIDI IN port has been also developed, and once the desired configuration is loaded, SMI can operate in standalone mode, i.e. settings are automatically reload after power-up or reset. Configuration can change many MIDI parameters (for instance the interface MIDI channel, the base digital inputs MIDI channels, the types of MIDI messages etc.) as well as control and set up all the different procedures on analog signals (auto-calibration, linearization, inversion etc.). A screen capture of the *SMIprogrammer* application is shown in figure 3: check boxes, radio buttons and edit boxes, feature an intuitive and easy to use graphical interface.

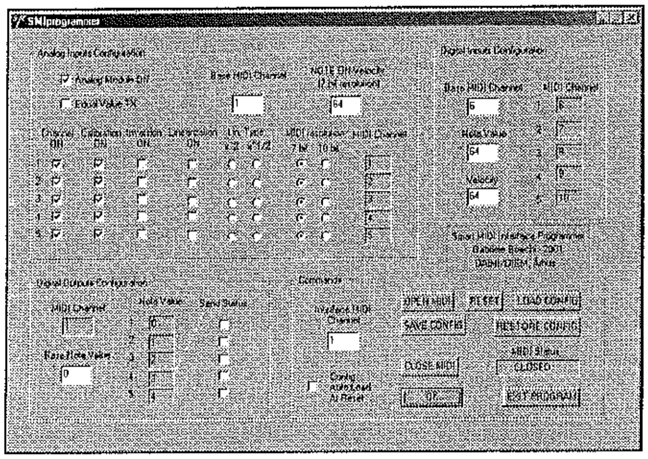

Fig. 3 – SMIprogrammer Win32 application for configuring the interface.

SMI MIDI OUT port can be directly connected to any MIDI compatible/standard device, such as synthesizers (for direct synthesis) or computers (for algorithmic composition). MAX MSP environment for Macintosh has been used for a demo-performance.

DATA STREAMING FEATURES

The goal of describing data streaming features is to charaterize the information path from the sensors until the destination device; in our system, data stream structure can be modeled as shown in figure 4.

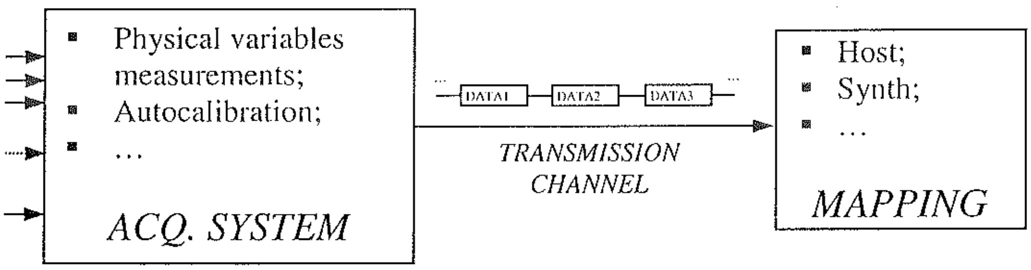

Fig.4 – General Data Streaming Structure.

Generally speaking, acquiring systems capture physical quantities from the external world and translate them into digital data stream. Sampling frequency and resolution are the well known parameters which characterise the quality of the system.

The cinema's 25 frames per second are enough to satisfy the Shannon condition on sampling rate on almost the daily life movements, but in case of a fast rotating movement aliasing problems arise. This data streaming rate can even be too low for controlling sound synthesis, i.e. noise can be heard at audio level: the problem is usually solved with oversampling techniques.

Many books discuss in detail the theory of reconstructing sampled analog signals [8][9]; here we only say that the type of interpolation or filter must be chosen considering the destination of the control signal (micro-level or macro-level), the desired precision (limited by the used resolution), the maximum time latency and so on.

SMI uses 10 or 7 bit resolution, which is usually enough for controlling sound parameters, i.e. quantization error cannot be heard, but in some cases (the pitch, for example) 10 bit they are not enough. Once again the solution is achieved with an oversampling approach.

Calibration is an important feature in tracking systems for normalizing the different sensors responses within the whole working range. This operation should be performed with the maximum resolution available (i.e. implemented on board), thus avoiding algebraic and quantization error increase, because of the standard data length adopted in transmission channel supporting data stream (7-8 bit with RS232, MIDI...). Channel is also characterized by the maximum transfer speed (bandwidth), the noise immunity, the maximum cable length etc. If we use MIDI its own limitations about bandwidth and flexibility are well known [10]. The new serial standard USB can be instead used where high transfer rate and high flexibility are required.

Data related to gesture, processed by the controller, are received by the host computer or synthesizer and then mapped with specific strategies into the synthesis parameters. For every tracking system a physical gesture space is defined and each position is linked to a particular event or control on the interpretation side.

CONCLUSIONS

So far we have examined the technical aspects of tracking systems and data flow. Hence on we could try to formalize some aspects on mapping; however this is not the appropriate place since it does not involve technical aspects any more but, rather, the artistic side of the matter.

Systems developed in our labs and above described have been used world-wide for composing and performing multimedia concerts. With SMI the aim is to start with the fascinating world of interactive artistic installations.

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