Gestural and Visual Approaches to Performance

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The activities at the Computer Music Lab of the CNUCE Institute[1] mainly consist of Applied Research, Education, Production. The keywords characterizing the activity of the Lab are man-machine interaction and real-time gesture control. Infrared beams and video captured image processing technologies have been taken into consideration in order to design and carry out original gesture interfaces for remote sensing (i.e. without mechanical and/or electrical links) moving objects handled by performers or direct gesture of the human body. Many interactive multimedia works have been produced and presented in various important events at national and international levels.

Research overview

Gesture, that is movement of the hands and head and posture of the mouth and eyes, plays a very important role in human communication: it can be seen as a parallel language for enriching the semantic content of speech or as an alternative way to communicate basic concepts and information between people of different cultures and mother tongues.

The milestones of tools and paradigms in man-computer communication have been punched-cards and character printers, keyboards and character screens and finally mouse and graphic screens. Due to the daily increase of the power of computer and electronics systems able to sense presence, distance, position, temperature (and so on...) of objects, a new field of investigation and implementation was started in the last few years: the recognition of human gesture.

In this direction, one the most promising areas of application is computer vision. This is due to two main causes: first, vision is for people the natural way of recognizing the gestures of other humans; second, the required hardware is simple, economic and standard enough, i.e. ordinary video cameras and digitizer cards. Whatever the technology used, the whole problem consists of two main steps. Such as in speech recognition where the main steps are from acoustic-signal to words and from sequences-of-words to semantics, in gesture recognition the main steps are:

- recognition of figures (hands, face) in terms of shape and position in space;
- dynamics, i.e. changing of shapes in time, trajectories, detection of starting and ending points of trajectories;
- semantics of gesture.

In contemporary electronic music, the synchronization between musicians and computers, and the possibility of affecting with gesture the synthesized music in order to regain human feeling and sensitivity during the live performance, is greatly taken into consideration. Besides MIDI controllers such as keyboard, drum-pads, pitch-to-midi converters, which issue messages for controlling digital sound machines, and devices such as the Dataglove used in Virtual Reality applications, many researchers active in the field of computer music, realized special devices and systems able to detect as much as possible information from the movements of human body. At the Computer Music Lab of CNUCE, the author focused his attention for designing and developing original man-machine interfaces taking into consideration sensors and technologies typically used in robotics: infra-red beams and real time analysis of video captured images. As

1. The CNUCE Institute was founded in 1965 as Computing Center for the University of Pisa; later it was attached to the National Council of Research (C.N.R.) of Italy and at the moment it has a staff of about eighty people active in the laboratories of logic programming, computer network, satellite flight control, data bases, parallel computing, structural engineering, remote sensing, computer graphics and computer music.

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stated above, the basic idea consists of remote sensing, (i.e. without mechanical and/or electrical links) moving objects handled by performers and/or remote sensing gesture of the human body. Some original gesture recognition devices and systems are here described.

Two different technologies have been used for developing gesture recognition devices: infra-red beams with which the Twin Towers device has been implemented, and video captured image analysis used for implementing the Imaginary Piano and the PAGe (Painting by Aerial Gesture) system.

Infrared and Video-based systems

After some previous experiences, a system for recognizing shape, position and rotation of the hands has been developed. The performer moves his/her hands in a video-camera capture area, the camera sends the signal to a video digitizer card plugged into a computer and the computer processes the mapped figures of the performer's hands and produces data concerning x-y positions, shape (posture) and the angle of rotation of both the hands. Data extracted from the image analysis every frame are used for controlling real-time interactive computer music and computer graphics performances. With this system, a number of applications have been implemented. The most important are:

- The Twin Towers device, based on the infrared technology, detects height and angular positions of the hands.
- The Imaginary Piano where the hands of a pianist play in the air with no real keyboard;
- The PAGe (Painting by Aerial Gesture) system where the hands of a performer paint in the air images projected onto a large video screen.

In order to put at work the power of the algorithmic composition and the gestural control approach for real time interactive performances, a special language called Real-Time Concurrent PascalMusic (RTCPM) [1][2] has been developed in the last years. As an evolution of the RTCPM language a new language named GALileo which includes visual programming, algorithmic composition and signal processing facilities, has been designed and is now under development.

The Twin Towers

The Twin Towers gets information from positions and movements of the hands for controlling interactive computer music. It consists of two sets of four sensing elements which create two zones of the space (the vertical edges of two square-based parallelepipeds, or towers) where an object (i.e. a hand) can be detected in terms of height and front and side rotations with respect to a reference frame. Physically the Twin Towers device consists of a tablet of 20x50 cm held in a horizontal position at 70 cm circa from the ground by a stand very similar to a music stand: control electronics is on board, and a cable with power and signal wires, connects it to a power supplier and to the computer. An object placed in front of them, reflects on the transmitters the light coming from the transmitter diode and its distance from the reference plane is measured in terms of quantity of the reflected light. For detecting the mere distance of the hand from the tablet, a single transmitter-receiver couple could be enough; but for detecting more information such as rotations and different kinds of movements, it is necessary to measure the irradiance regarding separate portions of the hand. For that, we consider the palm as a square divided in four parts, each one seen by a separate photo transistor. The whole system so implement a sort of double aerial 3-D joy-stick.

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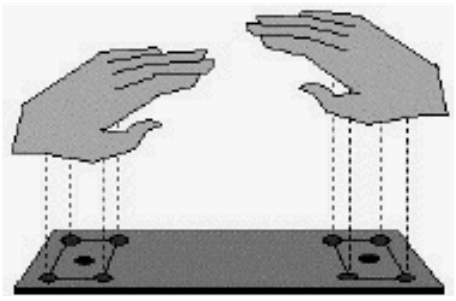

Fig. 1. Left. Twin Towers control. Fig. 2. Right. The author at the Twin Towers.

In the Electronic Music community, the Twin Towers has been compared with the theremin. However, the Twin Towers can be considered as a general purpose gesture recognition device and it is not difficult to think that it can easily simulate even the functionalities of the Theremin. In may 1998 L. Tarabella gave a concert in duo with Lydia Kavina, the most famous thereminist today, in Colletta di Castelbianco. The video below shows a short excerpt of *MarsLight*, a performance on the Twin Towers.

Fig. 3. Video available in the original CD-Rom version. Excerpt of *MarsLight*.

The Imaginary piano

The Imaginary piano consists of a real-time image-analysis of video-captured system: here, the interaction "tools" are, of course, the mere bare hands of a pianist. The pianist is sitting as usual on a piano chair and has in front nothing but the camera few meters away pointed on his hands.

Fig. 4. The author at the Imaginary piano.

There exist an imaginary line at the height where usually the keyboard lays: when a finger, or a hand, crosses that line downward, a specific message (actually a Note On MIDI message) is issued; "where" the line is crossed states the key number, "how fast" the line is crossed, states the velocity.

This application should be considered an original performance rather than an original instrument due to the inaccuracy of gesture when striking the right key.

Fig. 5. Video available in the original CD-Rom version. Excerpt of *Press anyway*, for Imaginary piano.

PAGe system (Painting by Aerial Gesture)

In this application, positions and movements of a performer's hands are recognized in an wide vertical x-y area: the performer acts as a painter who uses his hands for selecting colours and nuances of colour and for actually drawing a picture. Movements are performed in the air and the resulting picture is projected on a large video-screen. An UV lamp is placed very close to the performer and whatever white colored element is shown is interpreted by the computer as a drawing brush; the left hand is always used as a real time control for nuances and others.

This systems comes after two previous prototype systems: the first one, named "Shine Hands", was designed and developed by Paolo Carosi and used for composing the multimedia work *Memorie della Pelle*; the second one, named "Aerial Painting Hands" (APH), has been implemented by Dr. Giuseppe Scapellato and used for composing the works *Orizzonte degli eventi* and *Piazze della Memoria*.

The PAGe system has been completely redesigned by the author and developed by Dr. Davide Filidei as the subject of his thesis at the Computer Science faculty, University of Pisa.

These systems and works have been inspired by artist Marco Cardini who also performs them on stage: Cardini, after the experience of the italian artist Lucio Fontana who, during years 1993 and 1994 suggested the idea of a system able to give the possibility of "...painting in the air..." and to introduce a new dimension to painting: time.

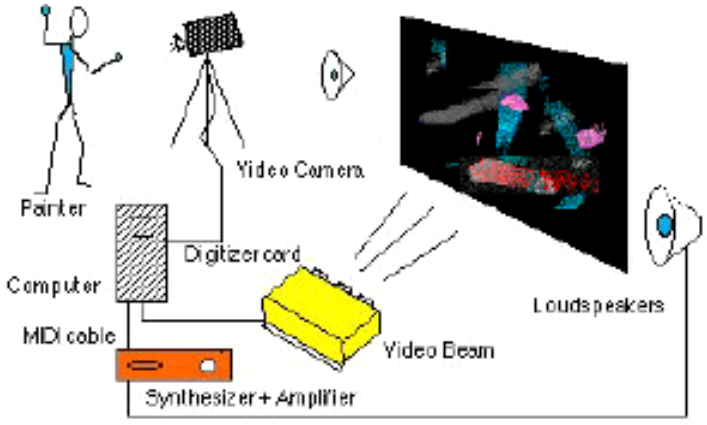

Fig. 6. The PAGe system.

Fig. 7. Marco Cardini performing *Memorie della Pelle*.

Fig. 8. Video available in the original CD-Rom version. Excerpt of *Memorie della Pelle*, for PAGe system.

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By freezing real-time produced images, Cardini also realizes paintings properly printed using ink-jet wide printers.

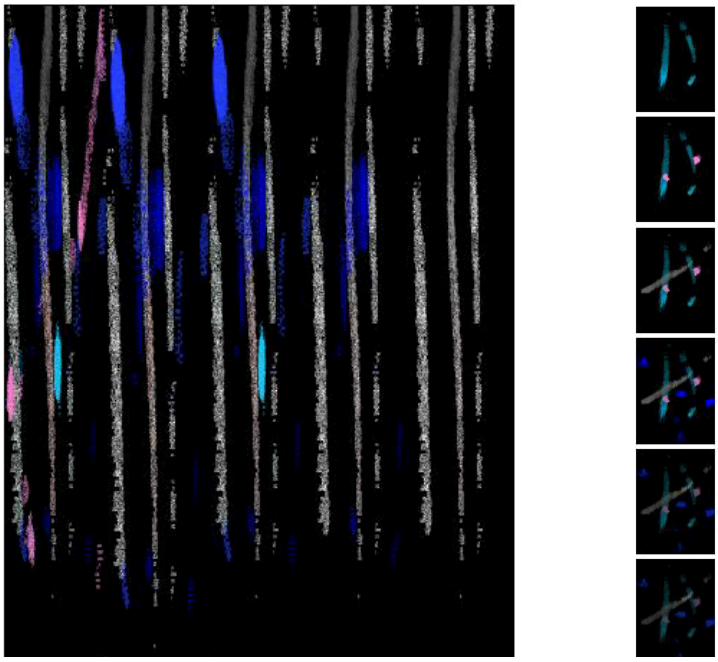

Fig. 9. *Cascata di Pixel.*

The GALileo language

I recently designed a new language named Galileo which includes graphical facilities and inherits from RTCPM [3] [4], an algorithmic approach to composition and to interactive performance.

Depending on the number of active objects and on the length of code describing the functionality of each object, a composition can range from a pure algorithmic to a MAX-like patch approach. In the first case a movement is characterized by few long-code process-elements and few links; in the second case a movement is characterized by many short-code process-elements and many links [7]. It also gives the possibility to define Csound-like instruments to be executed in real time on the computer in use.

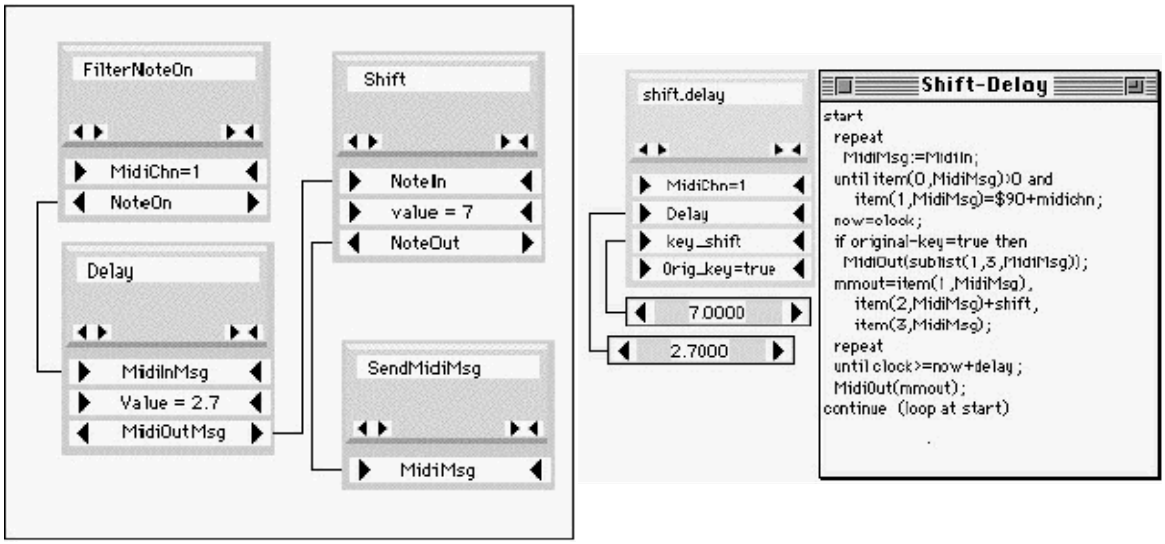

Fig. 10. Two windows from GALileo.

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