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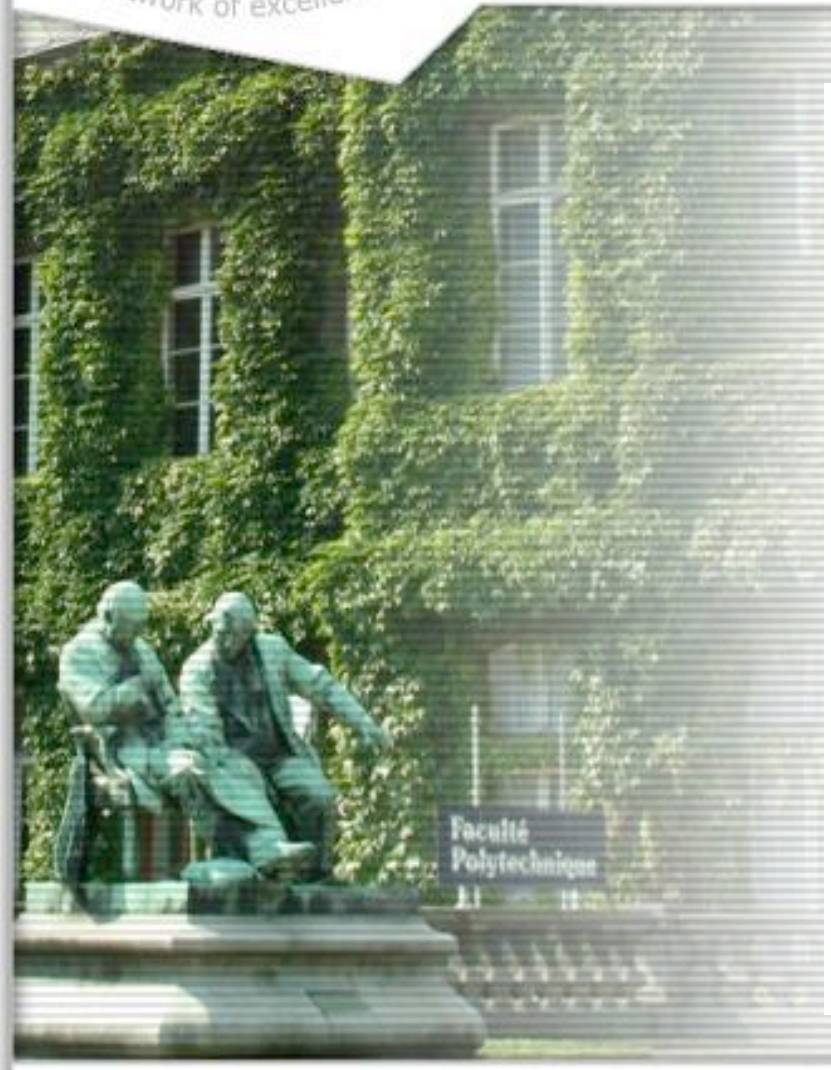

Gestural control of audio systems and digital musical instruments

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eNTERFACE'05: The SIMILAR NoE Summer Workshop on Multimodal Interfaces
July 18 - August 12, 2005 - Faculté Polytechnique de Mons - Belgium
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Interactive audio systems and HCI

- highly specialized branch of HCI
- Some characteristics (Hunt & Kirk):
  - no fixed ordering to the human-computer dialogue
  - no single permitted set of options but rather a series of continuous controls
  - instant response to user's movements
  - Further practice develops increased control intimacy and thus competence of operation

Interactive audio systems and Digital Musical Instruments

- Different types of interactive audio systems
  - Interactive sound installations
  - Musical instruments
  - Dance/music interfaces
  - (Computer games)
- Digital musical instruments

  Same functions as acoustical instruments:
  - Real time control of sound
  - Dedicated to play music: importance of aesthetics

Problem in digital instrument design

- Acoustic instruments:

  Causal link between the gestures and the resulted sound

- Digital instruments:

  The natural gesture-sound link disappears

Outline

1. Historical overview
2. Digital musical instruments
3. Examples from CNRS/LMA

From sound synthesis beginnings to nowadays: some examples

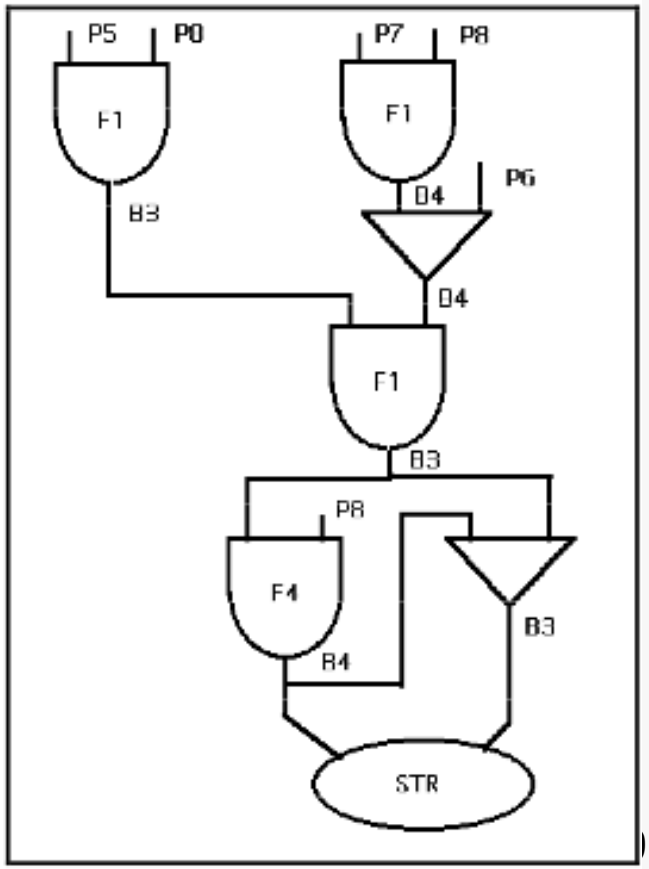
The Theremin (1920)

Computer synthesis

- Max Mathews 1957

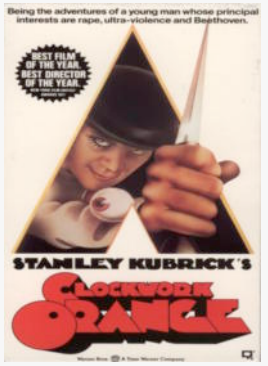
Music V : modularity

```
COM----------------------------------;
INS 0 1;
P9_HZ(W9) P6_HZ(W6) P7_HZ(W7) P8_HZ(W8)
P5_W5/4;
IOS P5 P8 B3 F1 P30;
IOS P7 P8 B4 F1 P29;
AD2 B4 P6 B4;
IOS B3 B4 B3 F1 P28;
IOS B3 P8 B4 F4 P26;COM DTE GCHE;
SB2 B3 B4 B3;
STR B3 B4 B1;END;
COM----------------------------------;
```



Analog Synths : Moog (1964)

- Theme from A Clockwork Orange (Beethoviana), Wendy Carlos 1972



Digital Synthesis, FM (John Chowning 1967, DX7 1983)

The MIDI protocol (1983)

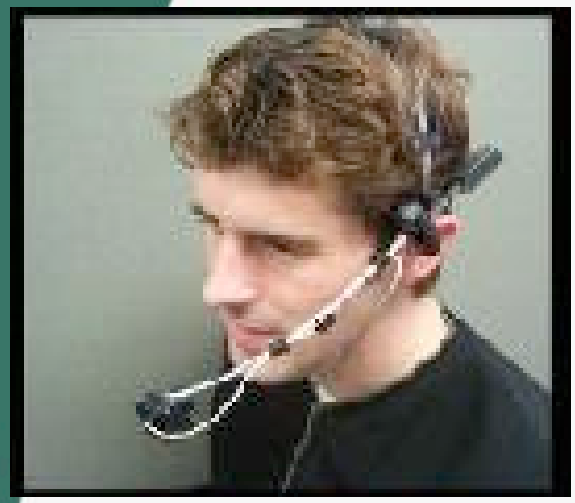
- Standard to exchange data between machines
- digital data
- Adapted to Keyboards-like interface
- Still used today, despite of its inconveniences

Don Buchla - MIDI controllers

- Thunder (1990)
- Lightning (1991)

« The hands » , Michel Waiswisz

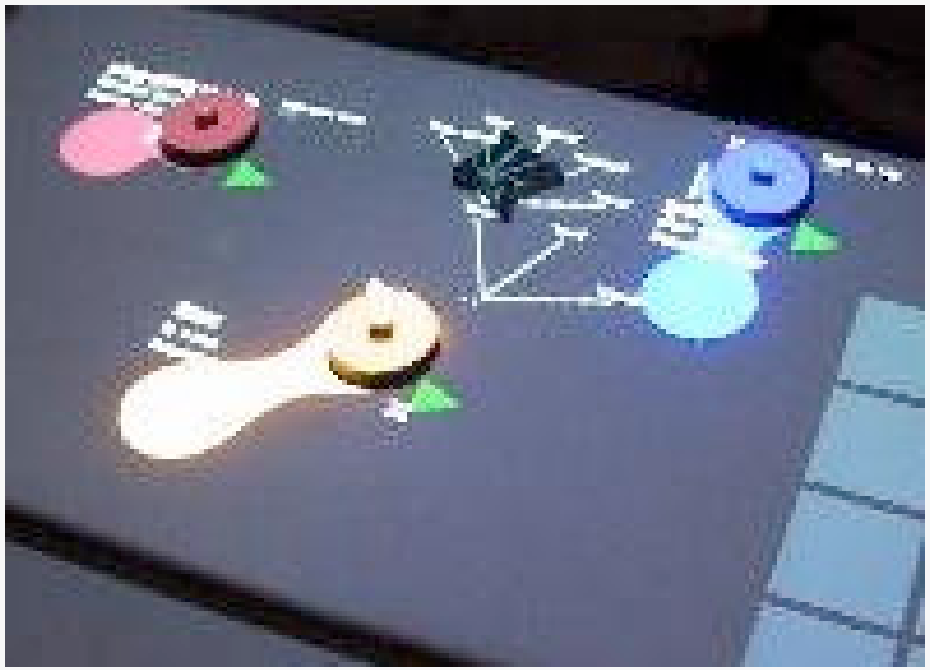
Mouthesizer, M. Lyons



bioelectric sensors
Atau Tanaka

Tangible interfaces

Audio Pad



Digital musical instruments

musician - instrument relationships

Gesture
Action

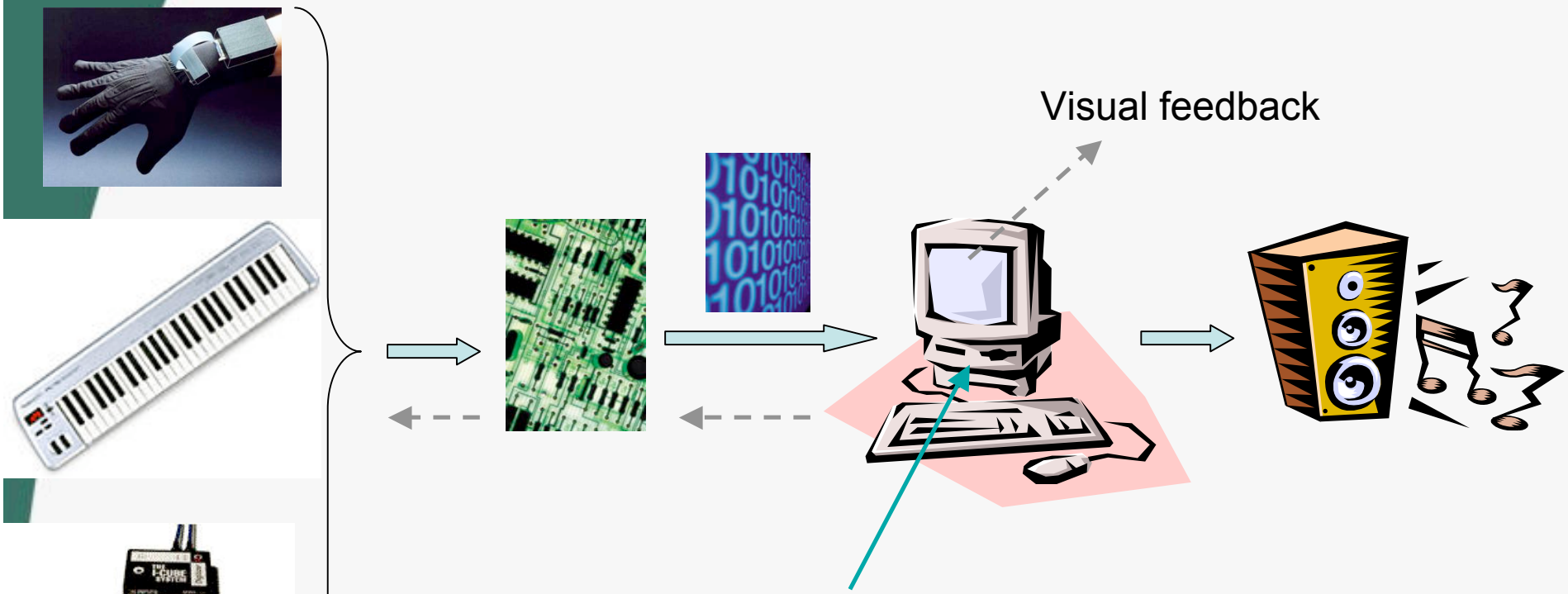
Feedbacks
Perception

Musician

Instrument

action - perception loop

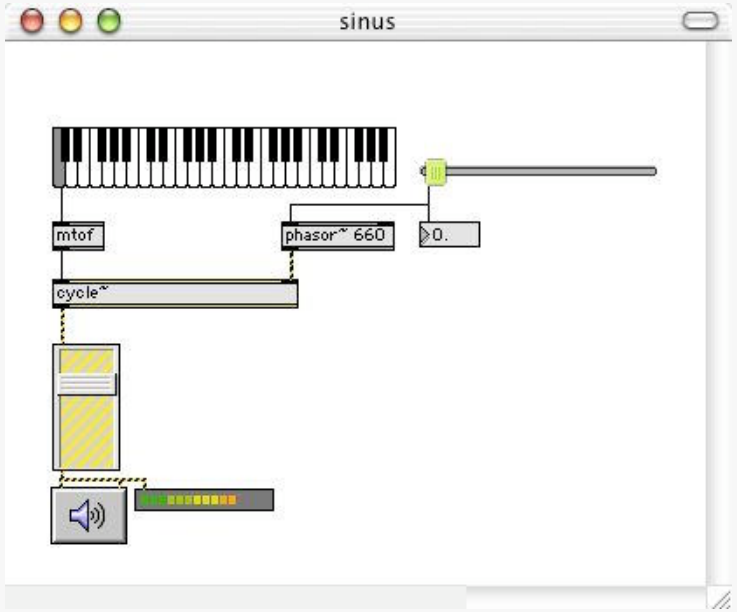
Digital musical instruments



- Sound processes
- Mapping : link between gesture and sound

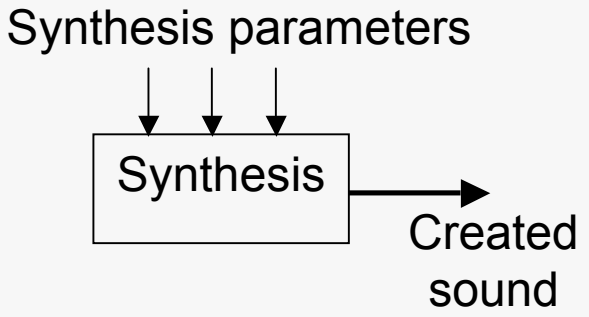
Hardware / Software

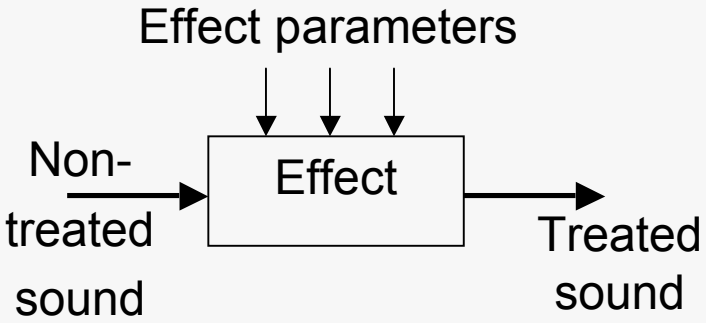
- Controllers: hardware (sensors)
- Data management / Sound production:
  - Programmers:
    Max/MSP, Pure Data
  - Low end users:
    standalones, plug-ins,
    virtual instruments



Sound processes

- Synthesis methods
  - Wave table synthesis
  - Additive synthesis
  - Subtractive synthesis
  - FM and non-linear distortion
  - Granular synthesis
  - Physical models





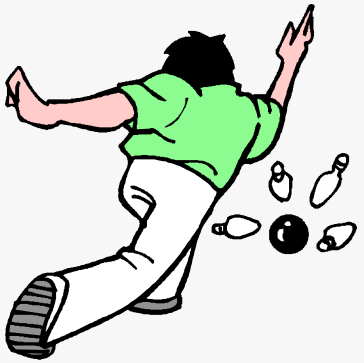
- Digital audio effects

  Act on : dynamic, time, pitch, space, timbre (envelope, phase, spectrum)

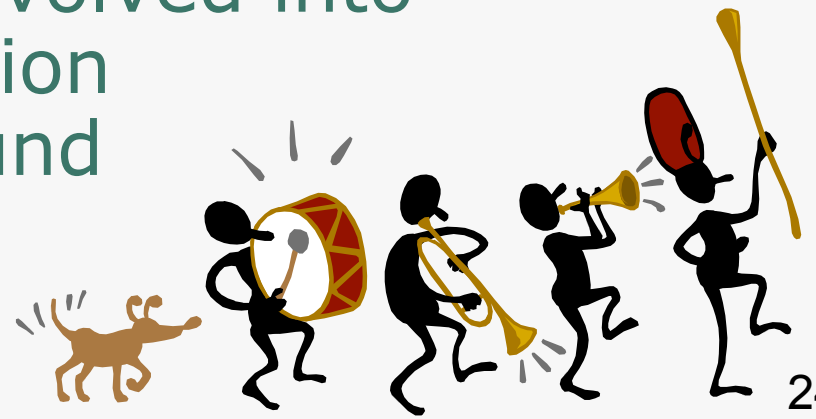
Gesture in digital musical instruments

Instrumental gesture

- Gesture is « all corporal behaviours associated to our muscular activity » [Cadoz, 1999].



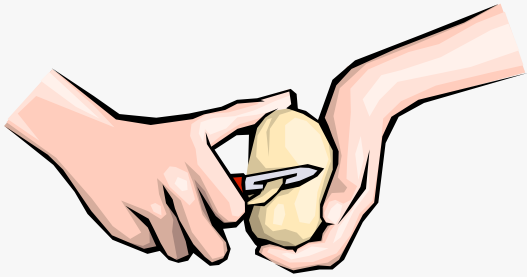
- *Instrumental gestures* : gestures that are involved into creation or modulation of the produced sound



Gestures of musicians

- action - perception loop :

  Learning and perfection
- Current tools : action -> result
- Instrument : action <=> result
  - strong synchronicity of gestures
  - Learning time



Gesture typology

- Excitation gestures: give the energy that is need to produce sound
- Modification gestures: modify a sound during its lifetime
- Selection gestures

Others : preparatory gestures

Controllers' typology

- Direct acquisition
  - Haptic
    - Invasive
    - non invasive
  - non haptic
- Indirect acquisition
- Hybrid systems






Type of gestural controllers

- Imitation of acoustical instruments

- Alternative controllers

Compare controllers

taxonomy

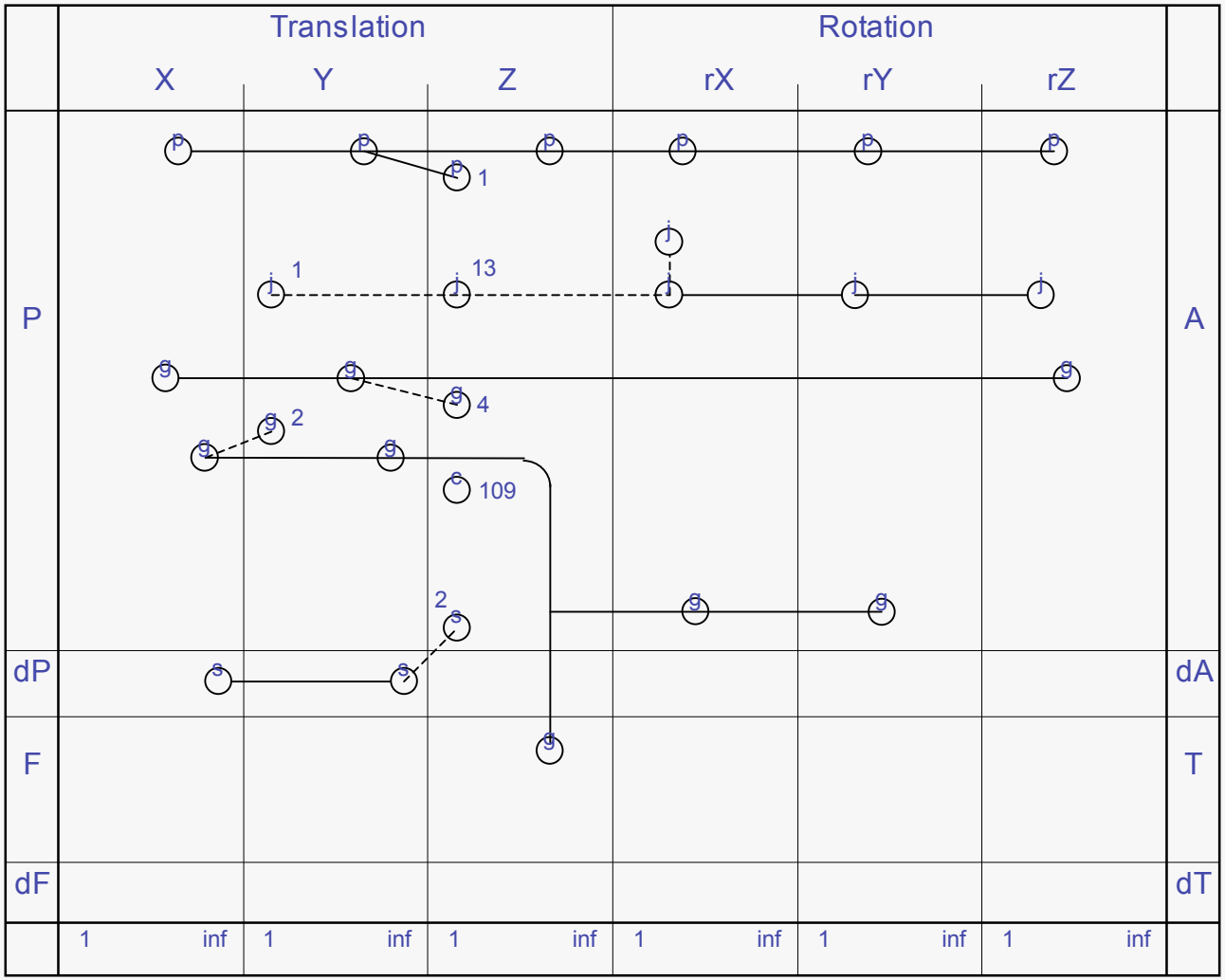
s : USB mouse

c : QWERTY kbd

j : joystick (Saitek Cyborg 3D Gold)

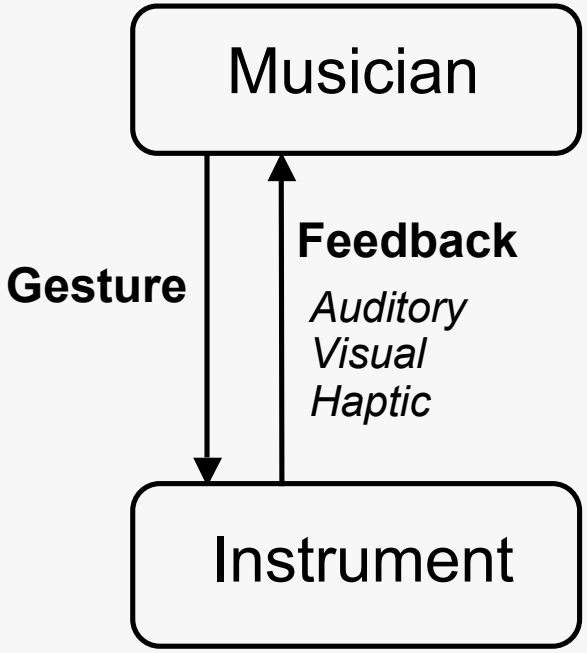
g : graphical tablet (Wacom Intuos 2)

p : Pointing Fingers (1 finger)

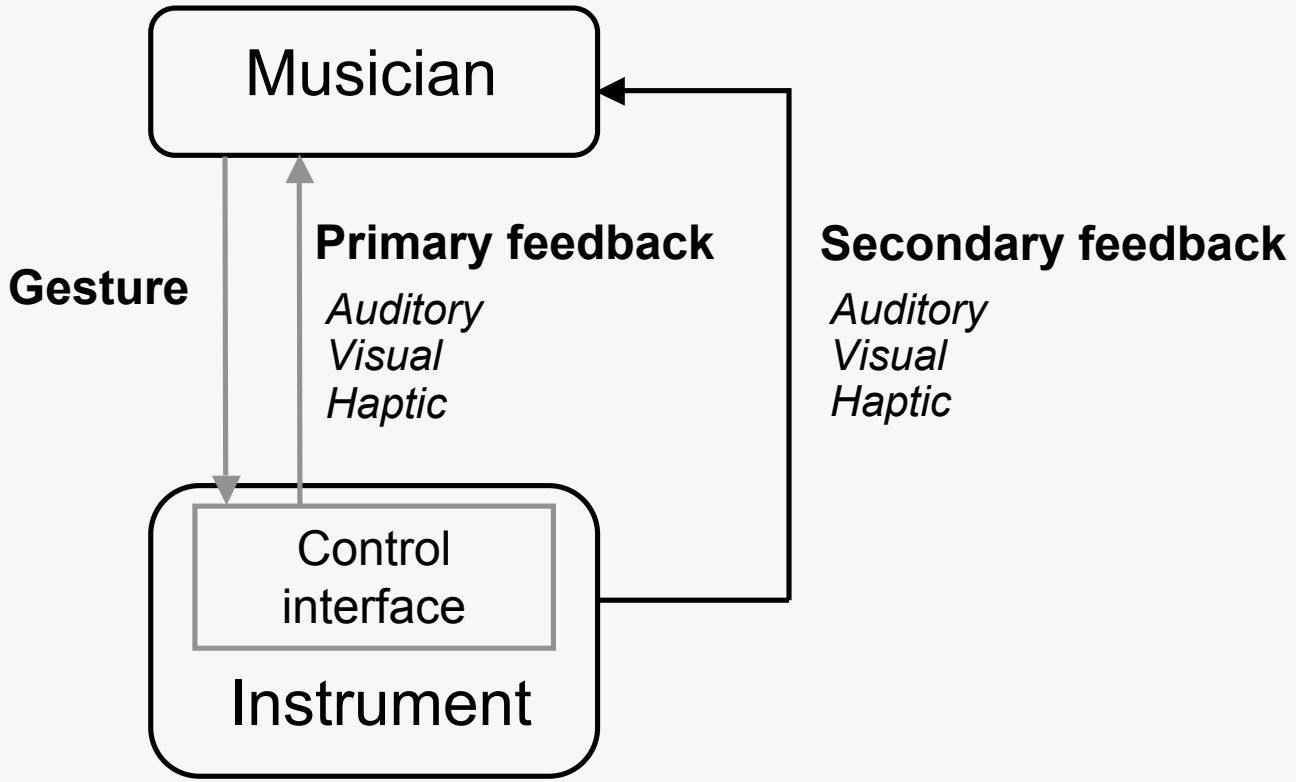


Feedbacks

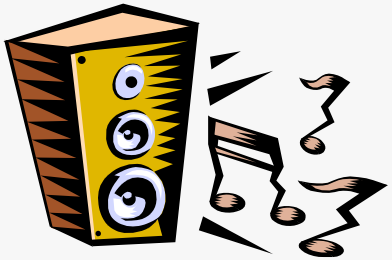
Feedbacks


Musician
Gesture
Feedback
Auditory
Visual
Haptic
Instrument

Feedbacks


Musician
Gesture
Primary feedback
Auditory
Visual
Haptic
Secondary feedback
Auditory
Visual
Haptic
Control interface
Instrument

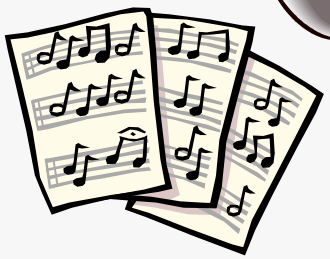
Auditory feedback



Visual feedback

Beginner : look at his gestures

Other musicians



Scores

Audience

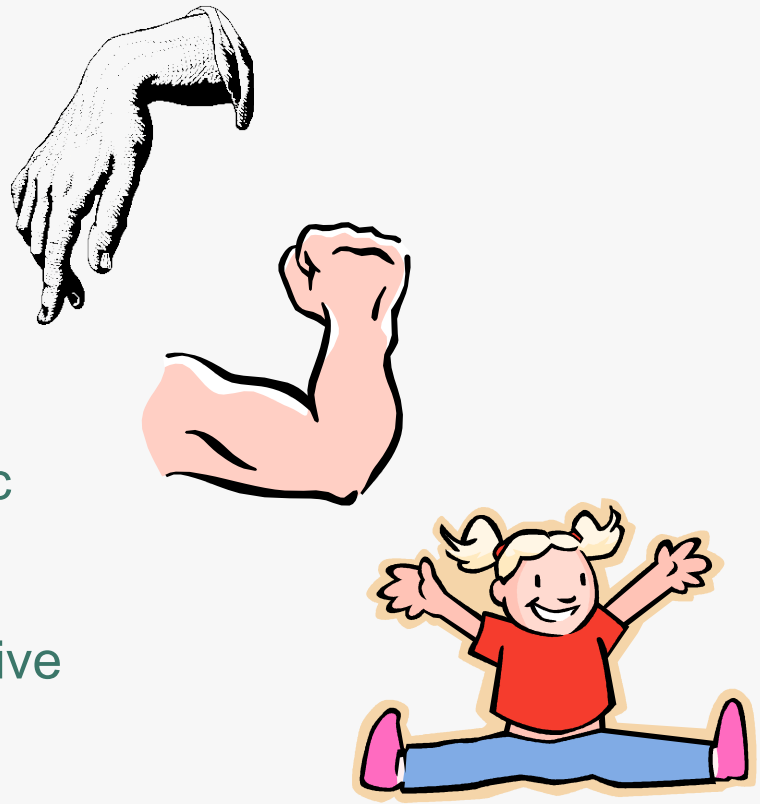
Secondary feedback:

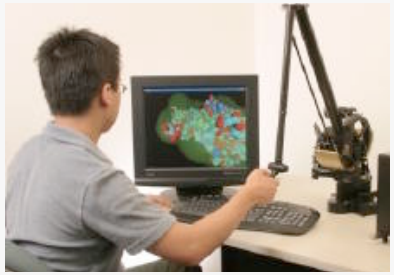
- Video
- Graphical interfaces

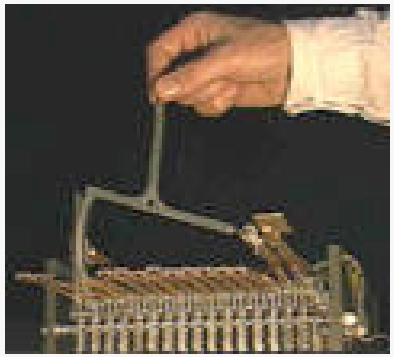
Haptic feedback

« A gesture is characterized by the indissociable interweaving of its motor function and its perceptive function » [Gibet 1988]

- Tactile
- Kinaesthetic
- Proprioceptive

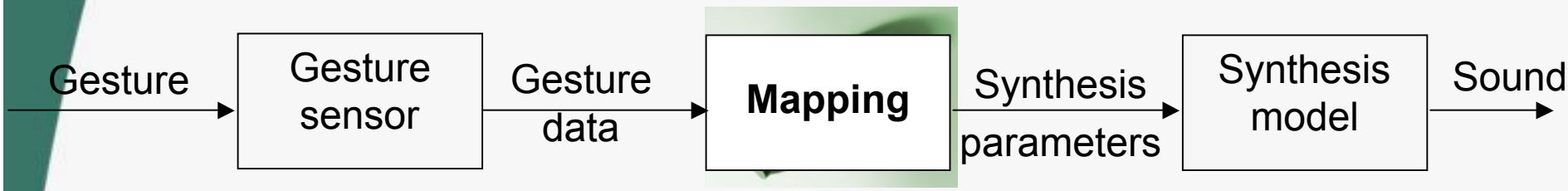




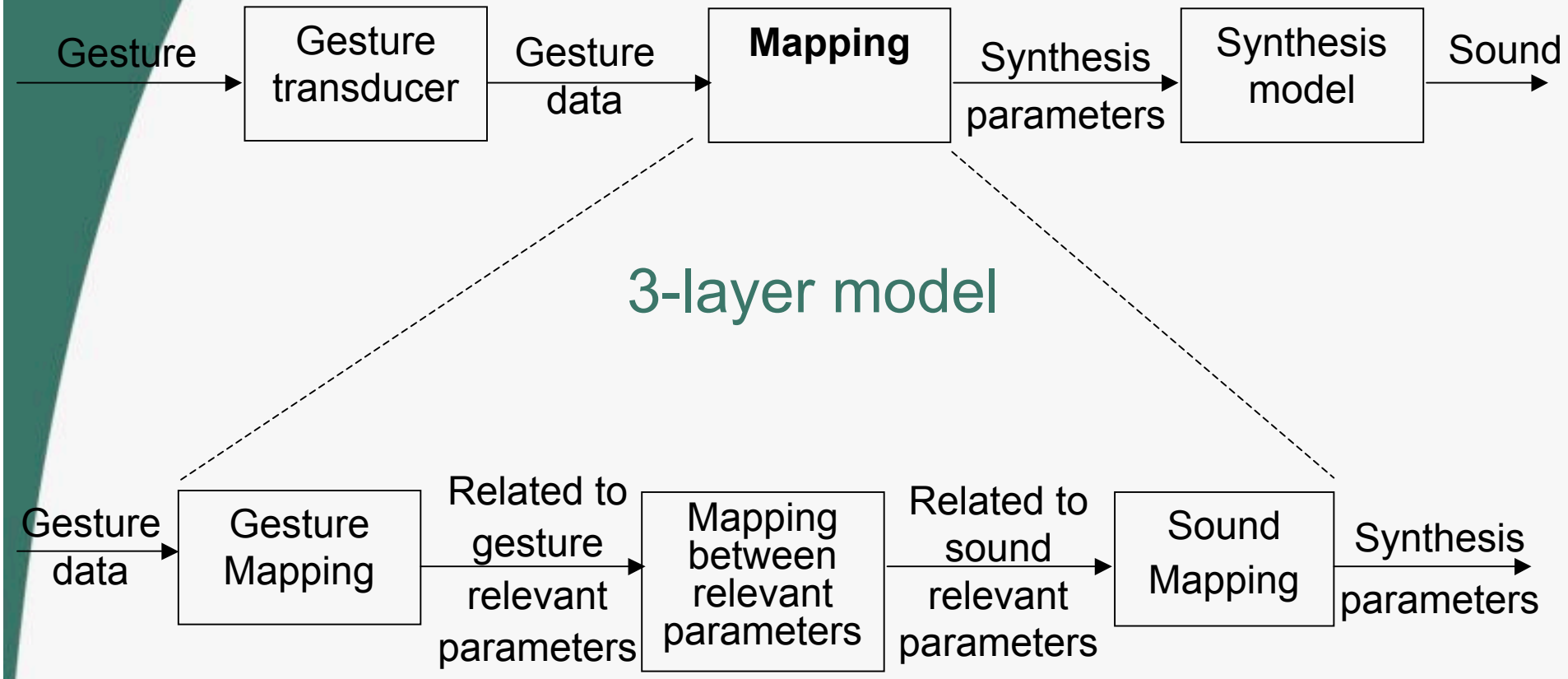


Mapping: link between gesture and sound

Mapping


Gesture
Gesture sensor
Gesture data
Mapping
Synthesis parameters
Synthesis model
Sound

Modularity in the Mapping



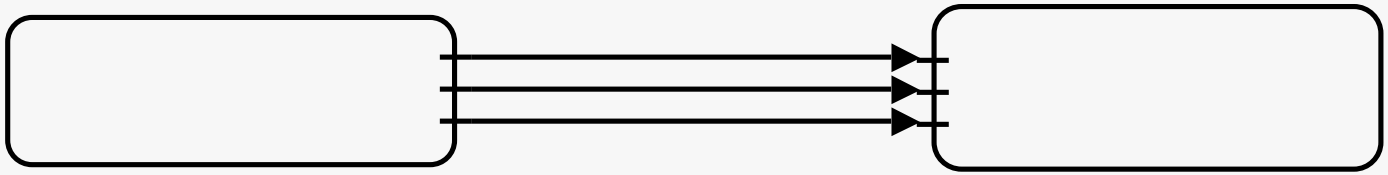
Relevant parameters

Mapping Attributes (1/3)

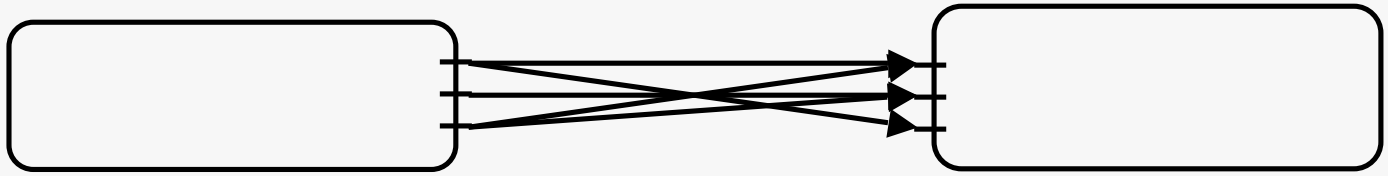
- Explicit
  - Mathematical functions
- Implicit (black box)
  - Statistical tests
  - Neural networks
  - Maximum estimation in a data basis

Mapping Attributes (2/3)

- Simple
  - "One to one"



- Complex
  - "Many to many"
  - output = combination between several inputs



Mapping Attributes (3/3)

- Static
  - s(t) = F(e(t))
- Dynamic
  - s(t) = F(e(t),e(t-1), …)
  - Mechanical systems
  - Genetic algorithms

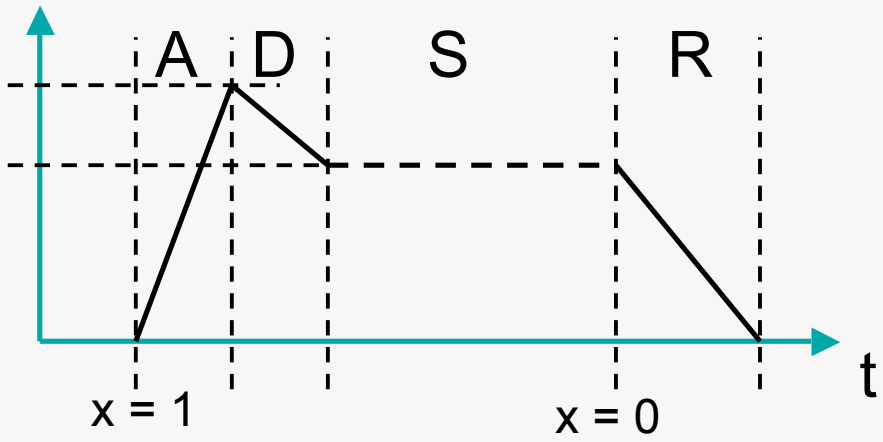
Managing data

About control data

- Temporal data : x(t)
- Sampling rate
  - Audio: 44100 Hz (CD standard)
  - Control: between 50 and 1000 Hz, best: > 100 Hz (10 ms)
- Latency time
  - Interval between an action and the response of the system to this action
  - Best: > 10 ms for musical control

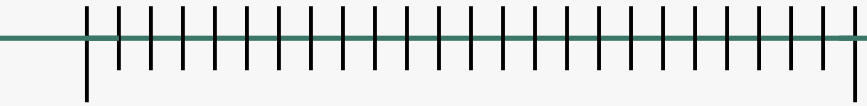
Data types

- Discontinuous
  - Trigger
  - x = 0 or 1
  - Example: triggering of temporal envelopes
    ADSR (Attack, Decay, Sustain, Release)



Data types

- Discontinuous
  - Trigger
  - x = 0 or 1
  - Example: triggering of temporal envelopes
- Continuous
  - Limits : variation scales
  - Resolution (example : MIDI data -> 7 bits = 128 values)
  - Lists and matrixes



x min x max

Simple data transformations

- Changing scales
- Use tables
- Division into several areas
- Time transformations:
  - Delays
  - Smoothing

Presets

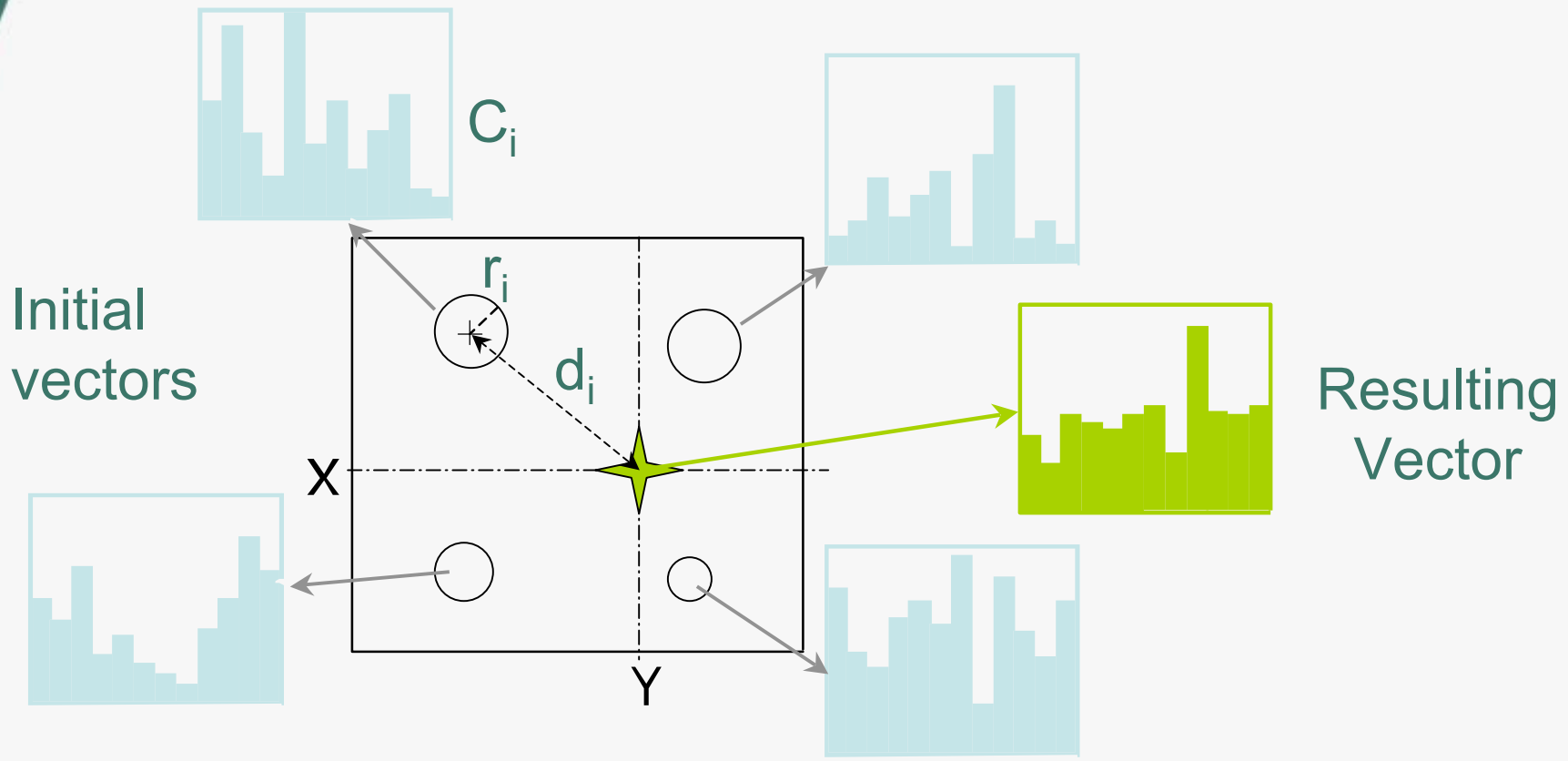
- Storing parameters values
  - All parameters cannot be controlled simultaneously
  - Fix some parameters to constant values
- Choice of presets:
  - Selection gesture
  - Modulation gesture: interpolation

Interpolation between parameters

Continuous transition between presets

- 1D interpolation
  - Go to one preset to another using a continuous parameter
  - $S(x) = A.x + B.(1-x)$ with $x \in [0 ; 1]$
- 2D interpolation

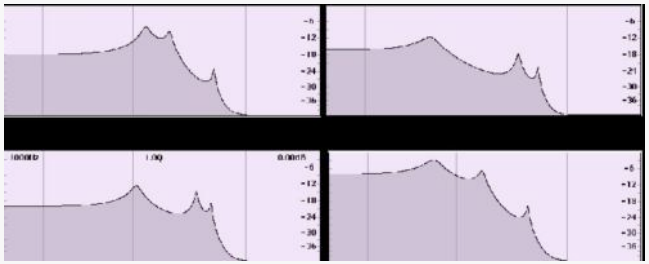
Principle of 2D interpolation



Digital musical instruments: some examples developed at CNRS/LMA

The Voicer

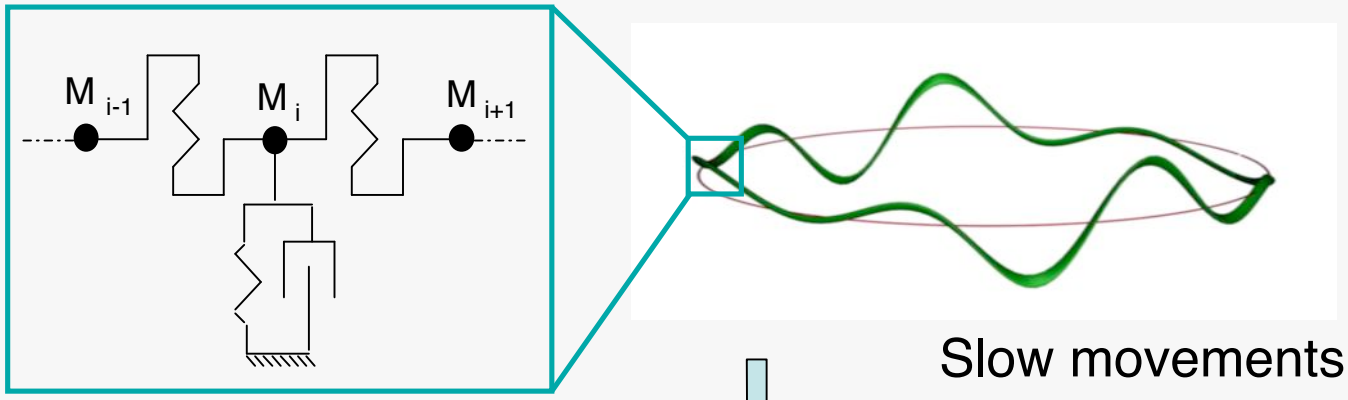
Interpolation between vowels



Circular control of pitch

The Voicer

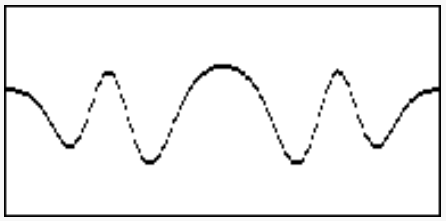
Scanned synthesis



Slow movements

Control parameters:

String parameters

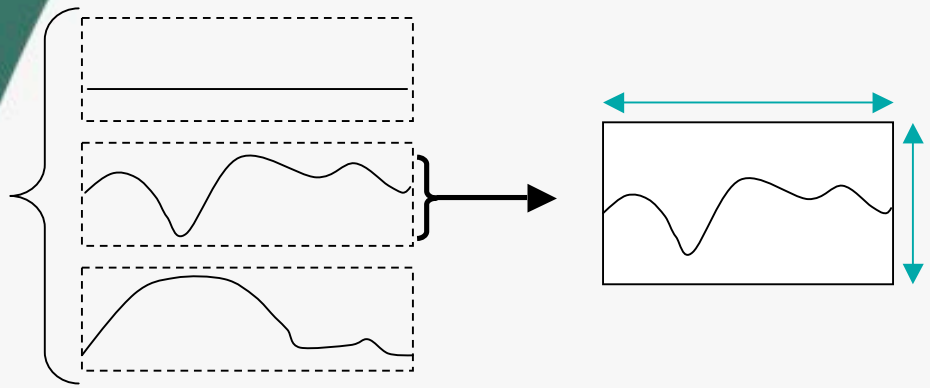


String shape: wavetable

Scanning frequency

scanning → Sound

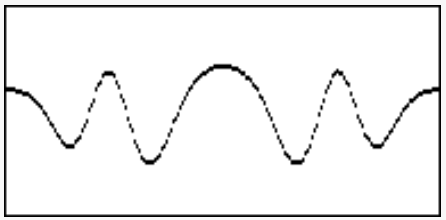
Scanned synthesis



Curves manipulated by metaparameters

Control parameters:

String parameters

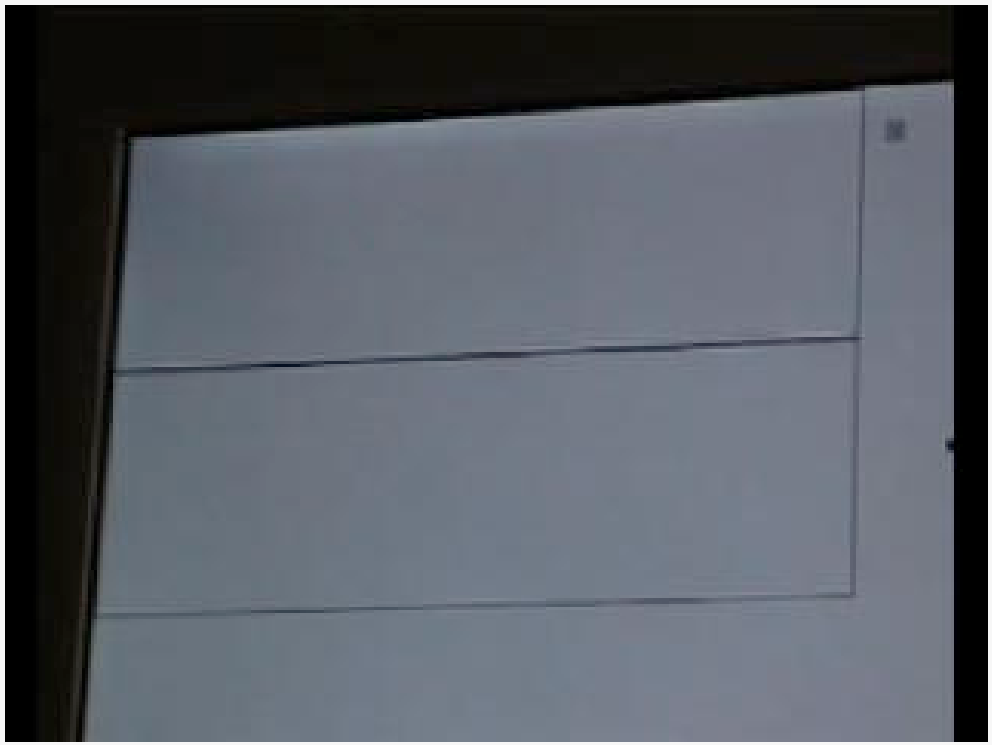


String shape: wavetable

Scanning frequency

Sound

Scanned Synthesis: graphical interface

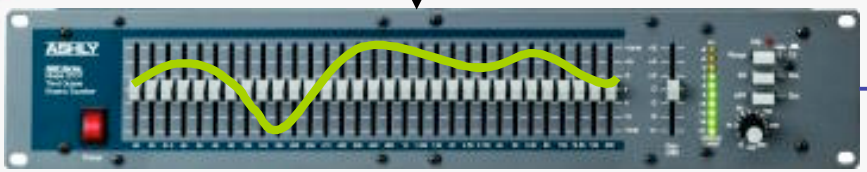


Scan gloves

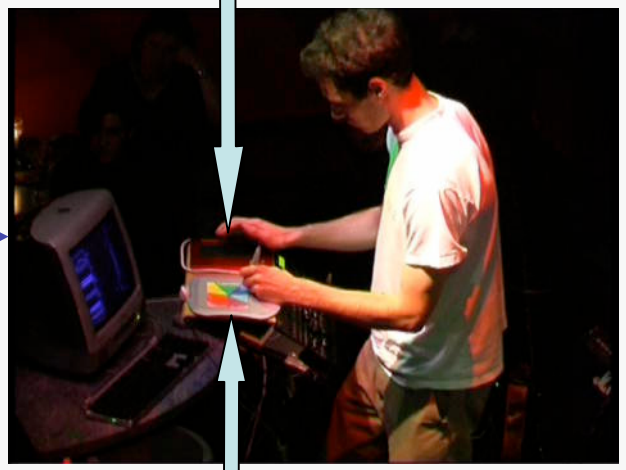
- Scanned Synthesis controlled with gloves

Filtering String

Sound input: noise, samples, …



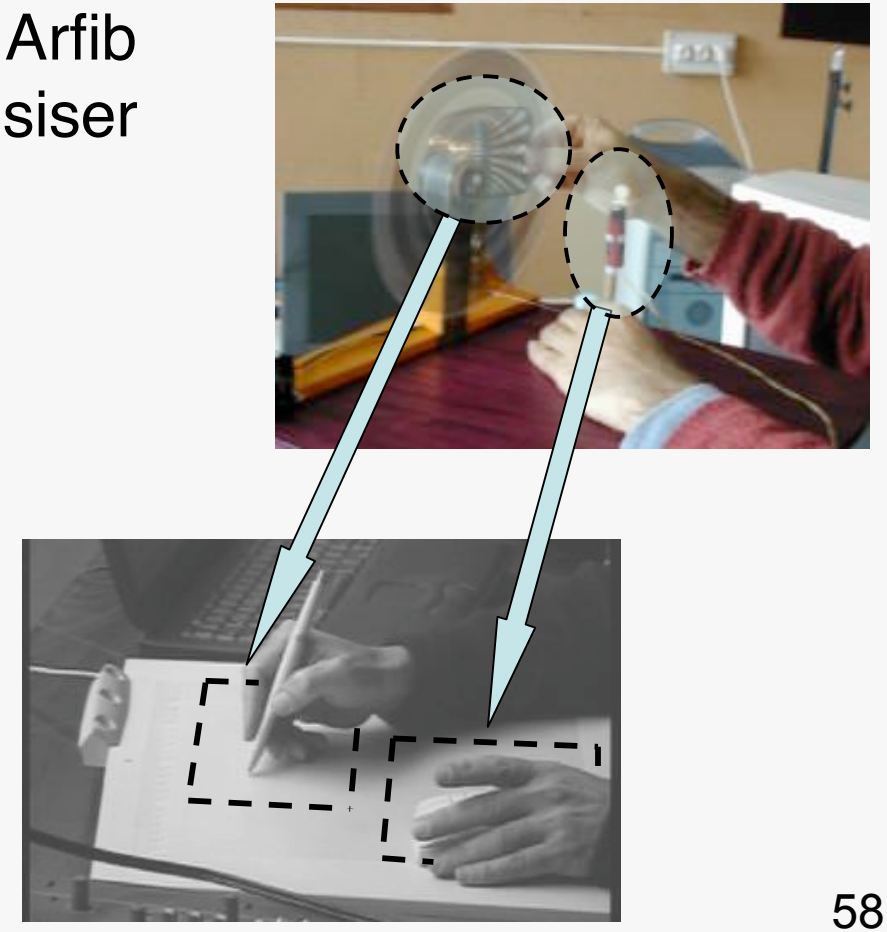
Forces on the string



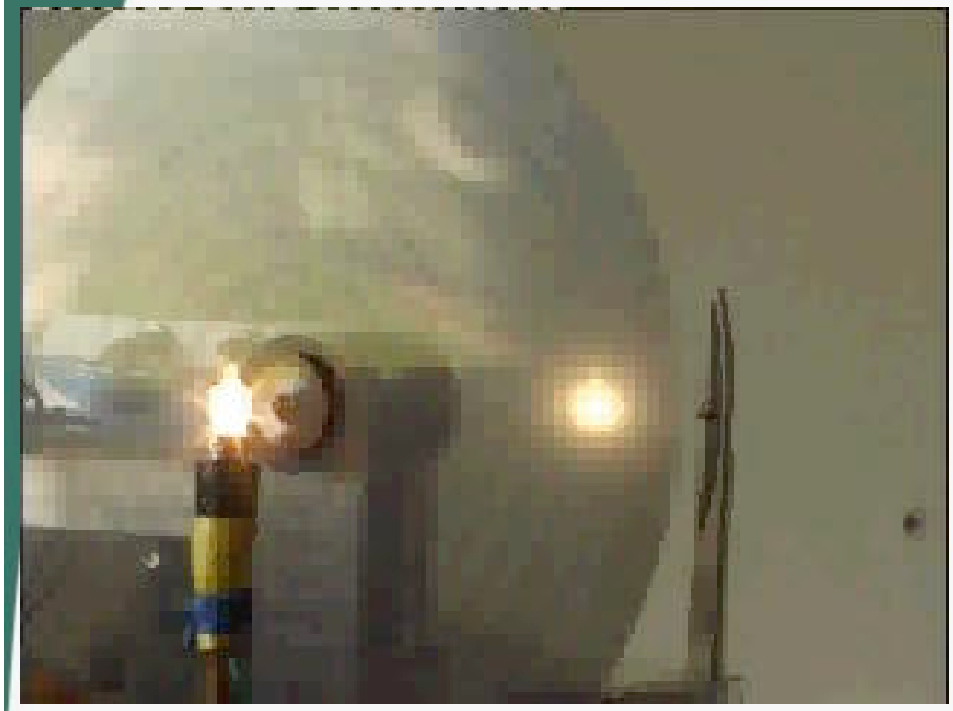
Physical parameters of the string

Photosonic Emulator

Emulator created by Daniel Arfib from the Photosonic Synthesiser of Jacques Dudon

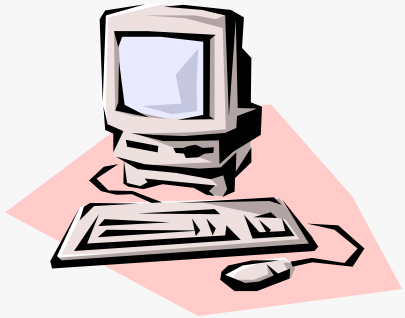


Photosonic Emulator



Graphical interfaces in the control of sound processes

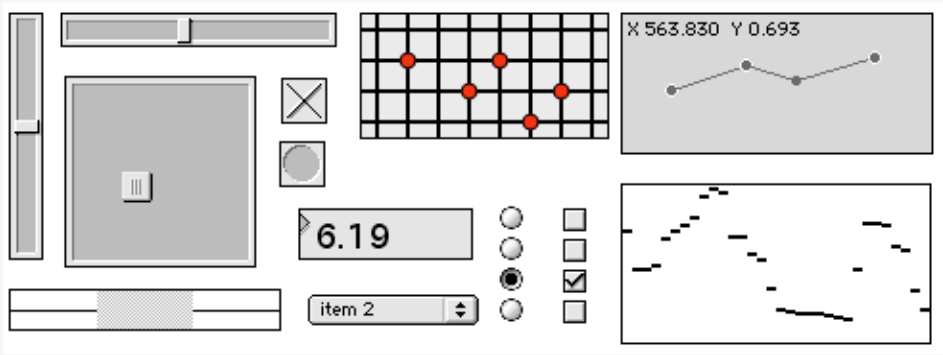
Graphical interfaces

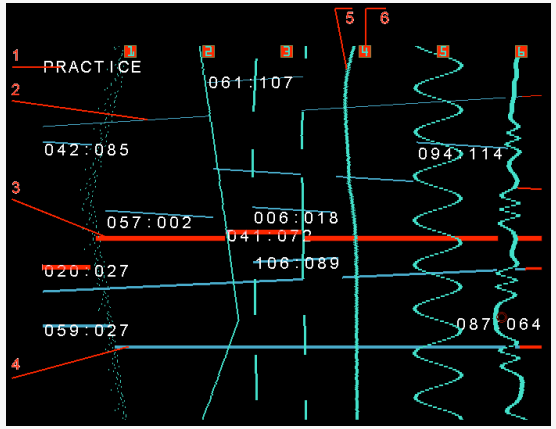


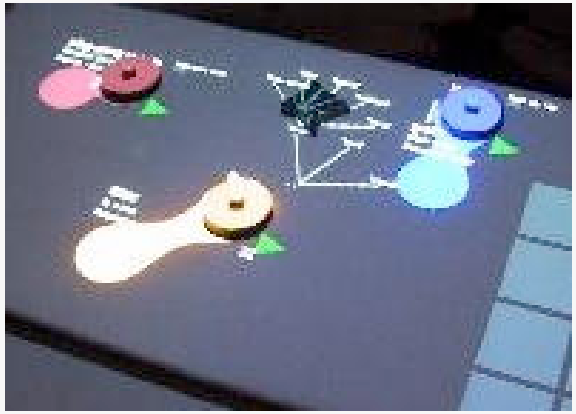
- Implemented in most computers
- Current interfaces:
  not suitable for sound process control
  - Only one hand involved
  - Actions performed
    one after the other
- Post-WIMP interaction

Graphical interfaces: examples

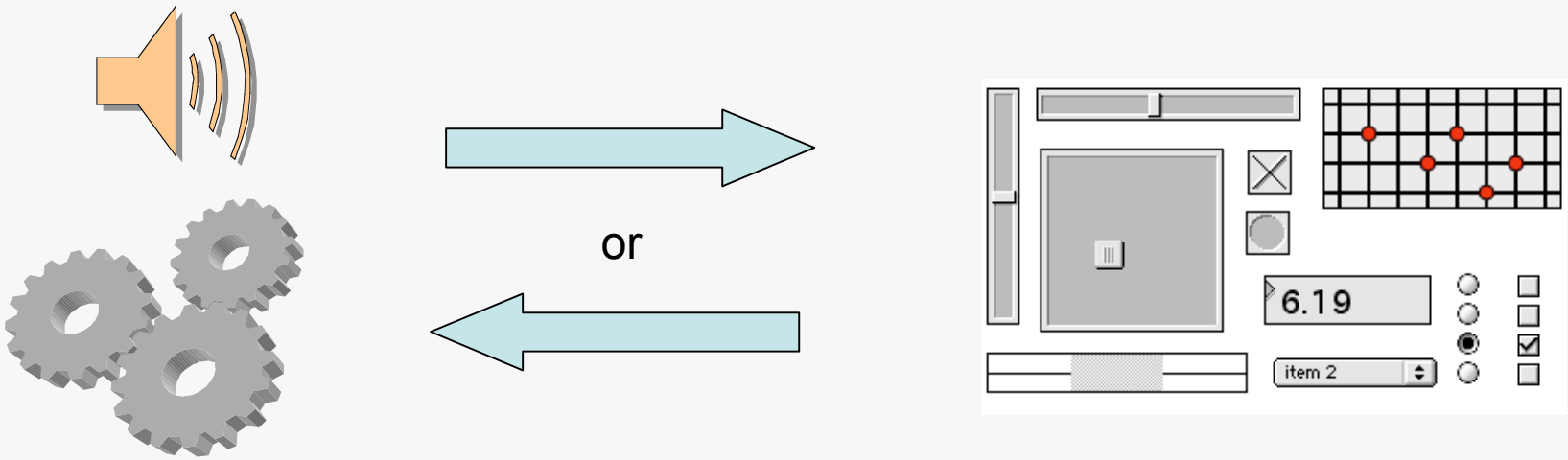
- Graphical objects
- Dynamic virtual objects
- Mixed reality
- 3D interfaces





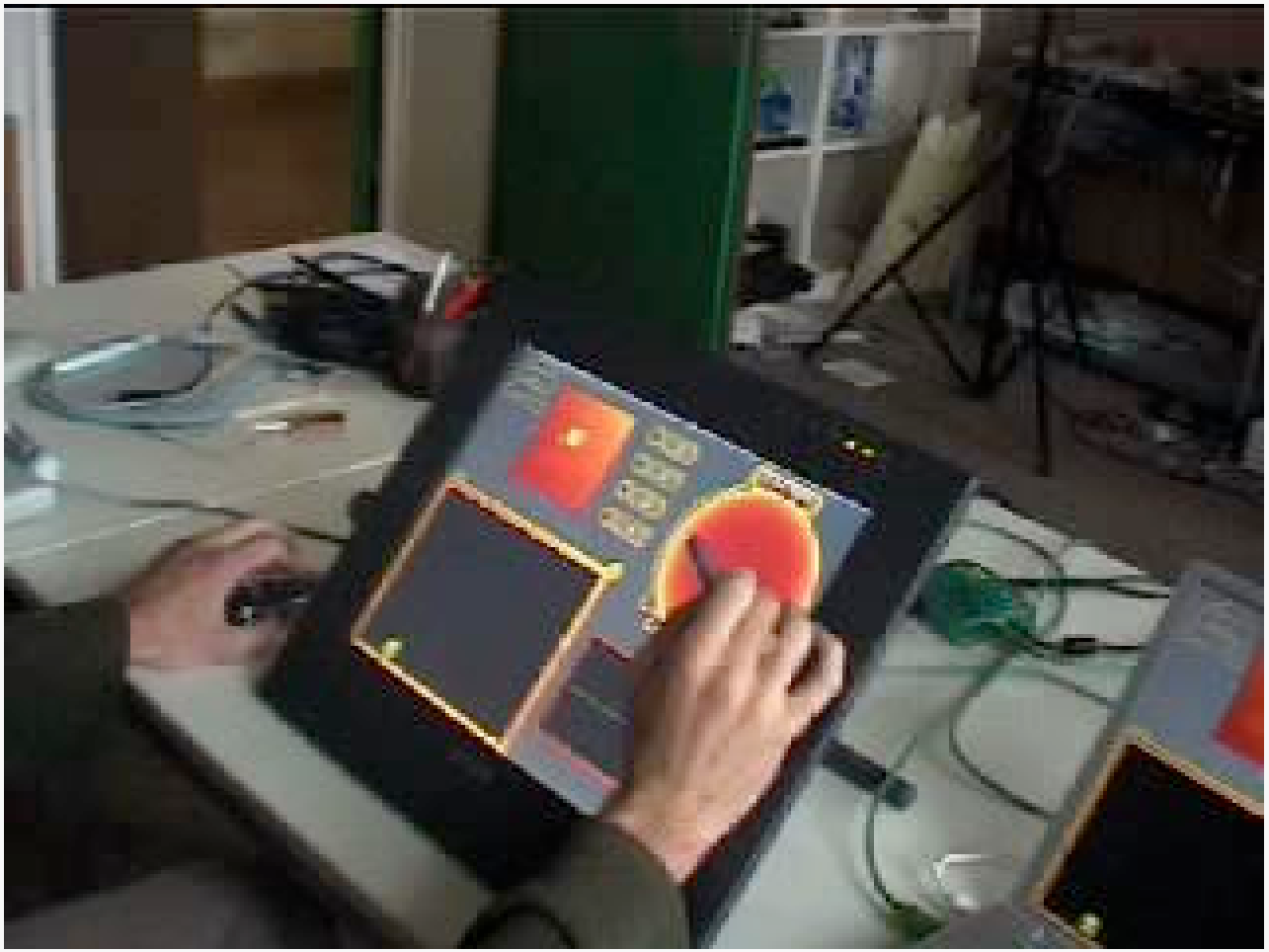


Design graphical interfaces: different strategies



1. Generic interaction techniques: independent from sound processes
2. Start from specificities of the sound process to design the graphical interface

Etheraction

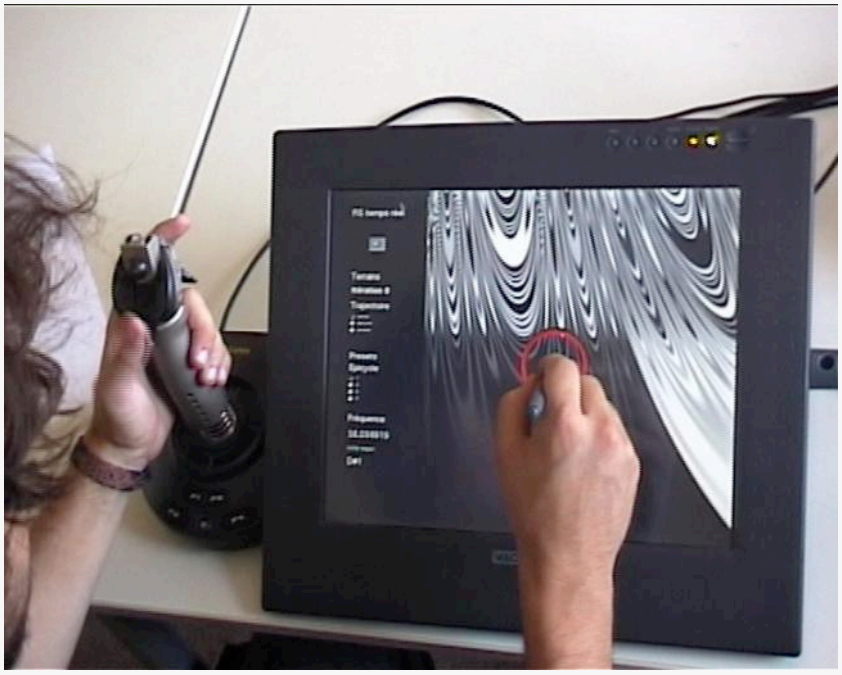


Wave terrain synthesis

A trajectory runs on a 3D terrain

different types
of trajectories

Graphical interface



Conclusion

- Digital musical instrument
  - Specific interactive system
  - Recreate the link between gesture and sound
  - Importance of the mapping
- Tomorrow instruments?
  - Use of visual and haptic feedbacks
  - Up to you to create them …

Thanks for your attention

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http://www.jmcouturier.com