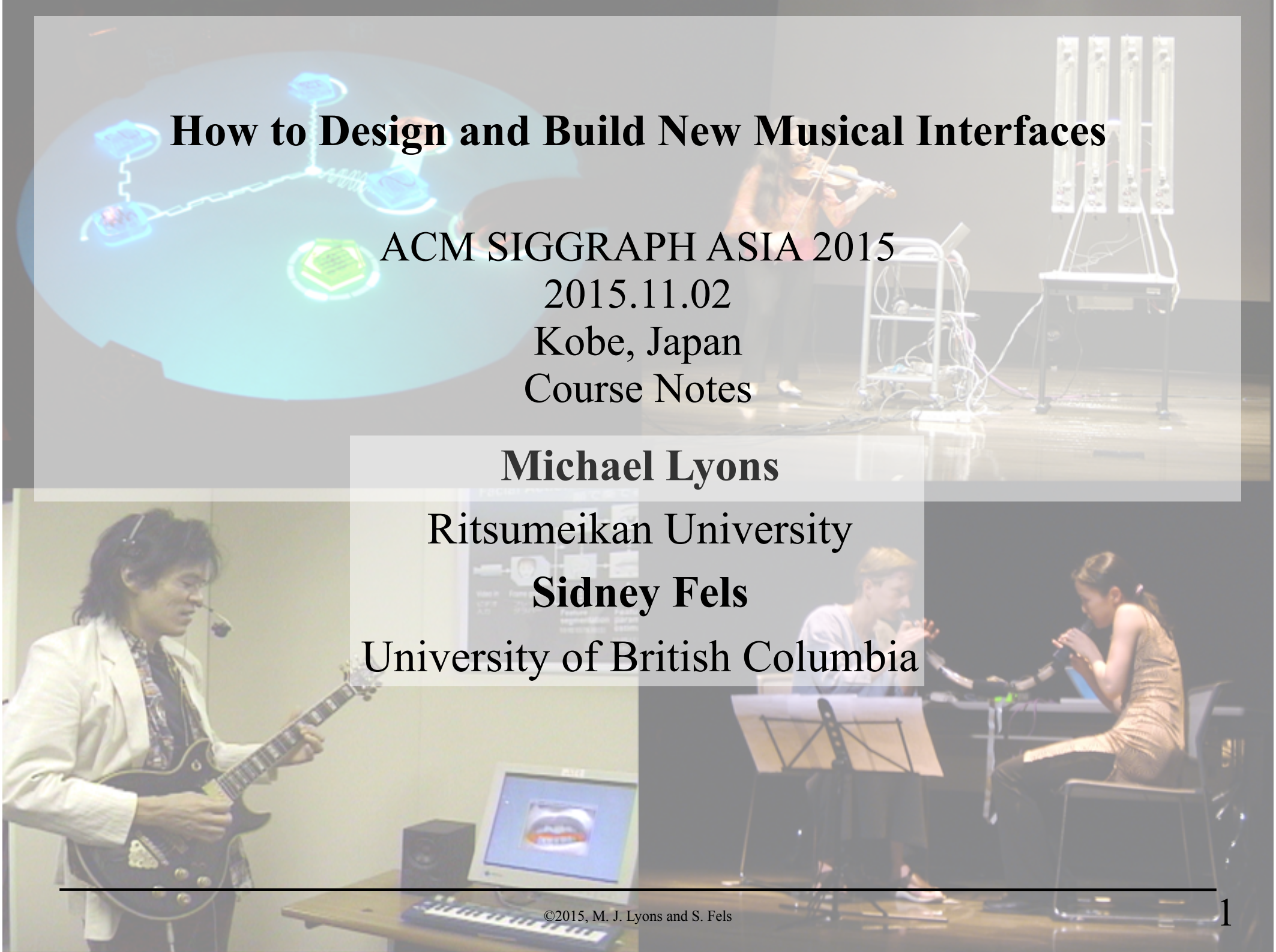


How to Design and Build New Musical Interfaces

ACM SIGGRAPH ASIA 2015
2015.11.02
Kobe, Japan
Course Notes

Michael Lyons
Ritsumeikan University
Sidney Fels
University of British Columbia

Since its beginning in 2001 as a CHI workshop in Seattle,
NIME brings together scientists, engineers, designers and artists
around New Interfaces for Musical Expression.

Laptop Performance

A NIME Performance

What is NIME about?

The Problem:

- Digital Technology & computers are involved in nearly all forms of contemporary music

- But the computer is not a musical instrument

The "Office Gesture"

Laptop Battle Tokyo
Superdeluxe Roppongi
11/2008

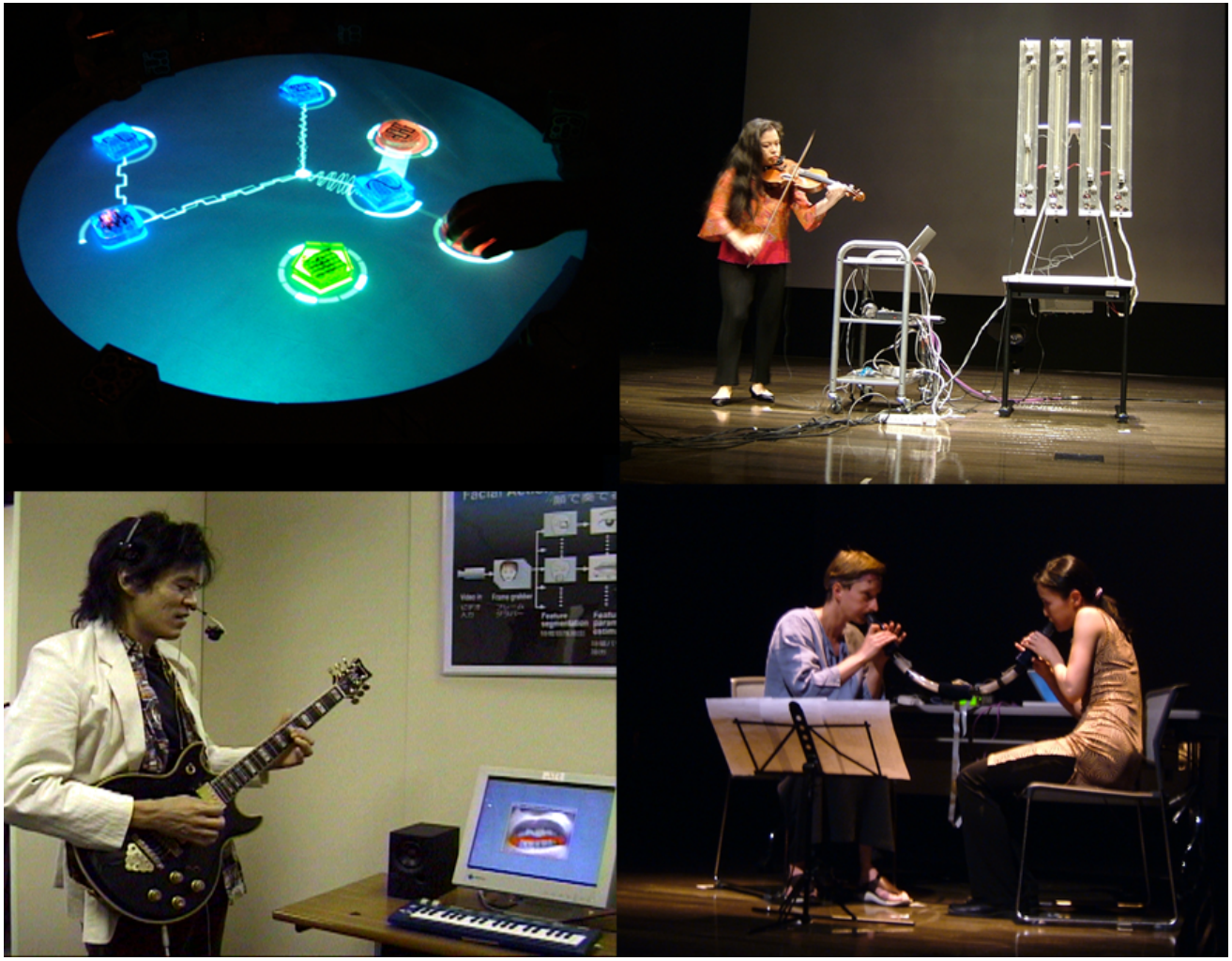
BY: sml!

How to Play the Computer?

- Computers offer a wide range of sound and music creation opportunities
- How can we create new interfaces to play computers in a way that is appropriate to human brains & bodies?

How to Play the Computer?

This tutorial is about progress in new interfaces for making music

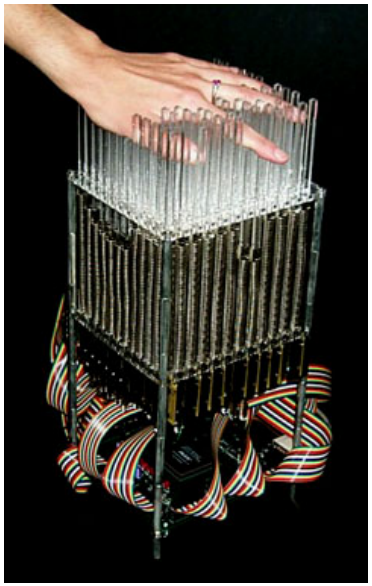


Key Objectives/Messages

1. Provide a framework for understanding the current research on new musical interface technology
2. Introduce the theory & practice of NIME
3. Point to further knowledge resources
4. Get to know some of the people & work of NIME
5. Suggest how to begin creating new musical interfaces for a lifetime of challenge & enjoyment

A Brief History of NIME

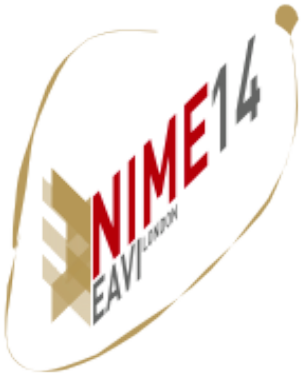
"New Interfaces for Musical Expression"
First organized as a workshop of ACM CHI'2001
Experience Music Project - Seattle, April, 2001
Lectures/Discussions/Demos/Performances



A Brief History of NIME

NIME-02 - Media Lab Europe, Dublin in May 2002

conference-scale event with similar format to the NIME-01 workshop



NIME-16
Griffith University
Brisbane, Australia
July 11-15, 2016

NIME Themes

- Novel controllers & interfaces
- Performance & composition with new interfaces
- Interfaces for collaborative performance
- Real-time gestural control of music
- Interfaces for musical novices & education
- Cognition in Musical Interface Design
- Haptic & force feedback in musical control
- Artistic, cultural, and social impact

Course structure

- Part I - 9:00 - 10:30 (90 minutes)
  - Module 1: So you want to build a NIME…
  - Module 2: Visual Interfaces
  - Module 3: Design & Aesthetics of NIME
- Discussion 10:30-10:45 (15 minutes)
- Break 10:45-11:00 (15 minutes)
- Part II - 11:00-12:30 (90 minutes)
  - Module 4: NIME after NIME
  - Module 5: NIME Theory
  - Module 6: NIME Education
  - Concluding Remarks
- Discussion 12:30-12:45 (15 minutes)

Module 1: How to build a New Musical Interface

Six step procedure

Sensors

Mapping

Synthesis

Demonstration

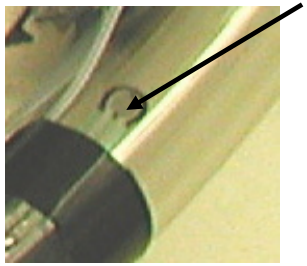
Six steps to build a NIME

1. Choose control space
2. Choose sonic space
3. Design mapping between control and sound output
4. Assemble with hardware and software
5. Compose and practice
6. Repeat

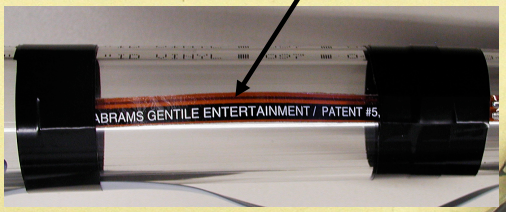
Priority of 1 and 2 can vary

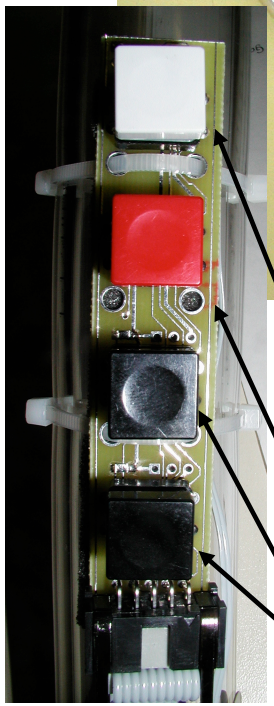
An example: Tooka *(Fels et al., 2004)*

Vibrato



Pitch Bend

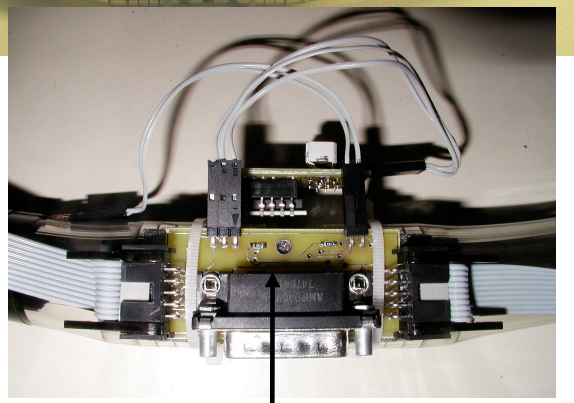




Octave

Sustain

Pitch



Volume

mapping with PureData

sound synthesis

Pick your control space

- Plethora of sensors available to measure:
  - motion of body parts
    - position, rotation, velocity and acceleration
  - translation and rotation (torque) forces
    - isometric and isotonic sensors
  - pressure
  - airflow
  - proximity
  - temperature
  - neurophysiological signals
    - heart rate
    - galvanic skin response
    - brain waves
    - muscle activities
  - light levels
  - and more…

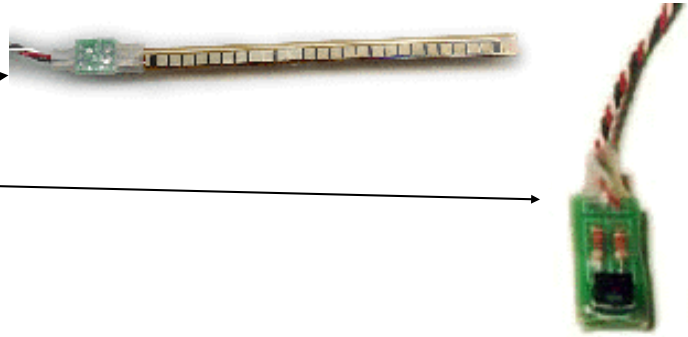
Physical property sensors

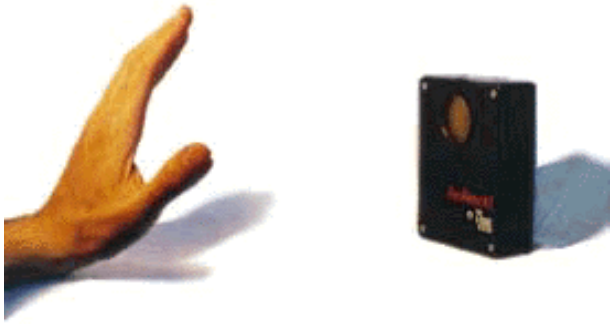
- Piezoelectric Sensors
- Force Sensing Resistors
- Accelerometer (Analog Devices ADXL50)
- Biopotential Sensors
- Microphones
- Photodetectors
- CCDs and CMOS cameras
- Electric Field Sensors
- RFID
- Magnetic trackers (Polhemus, Ascension)
- and more…

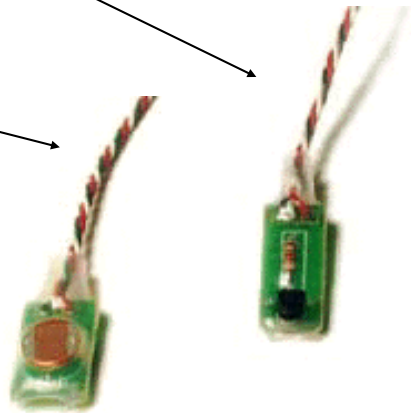
What can I measure?

Human Action Oriented Sensors

- Here's a few:
  - Bend - piezo-resistive
  - Close - IR reflection, 1-7"
  - FarReach - ultrasonic (50Hz update)
  - Flash - phototransistor
  - Gforce - piezo-electric single axis accelerometer
  - Hot - zener effect (thermocouple)
    - -40 to 100deg C
  - Light - photo-resistive



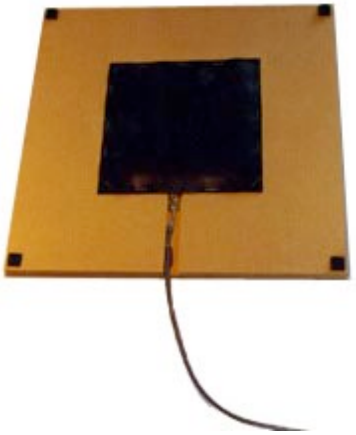




How do I measure that?

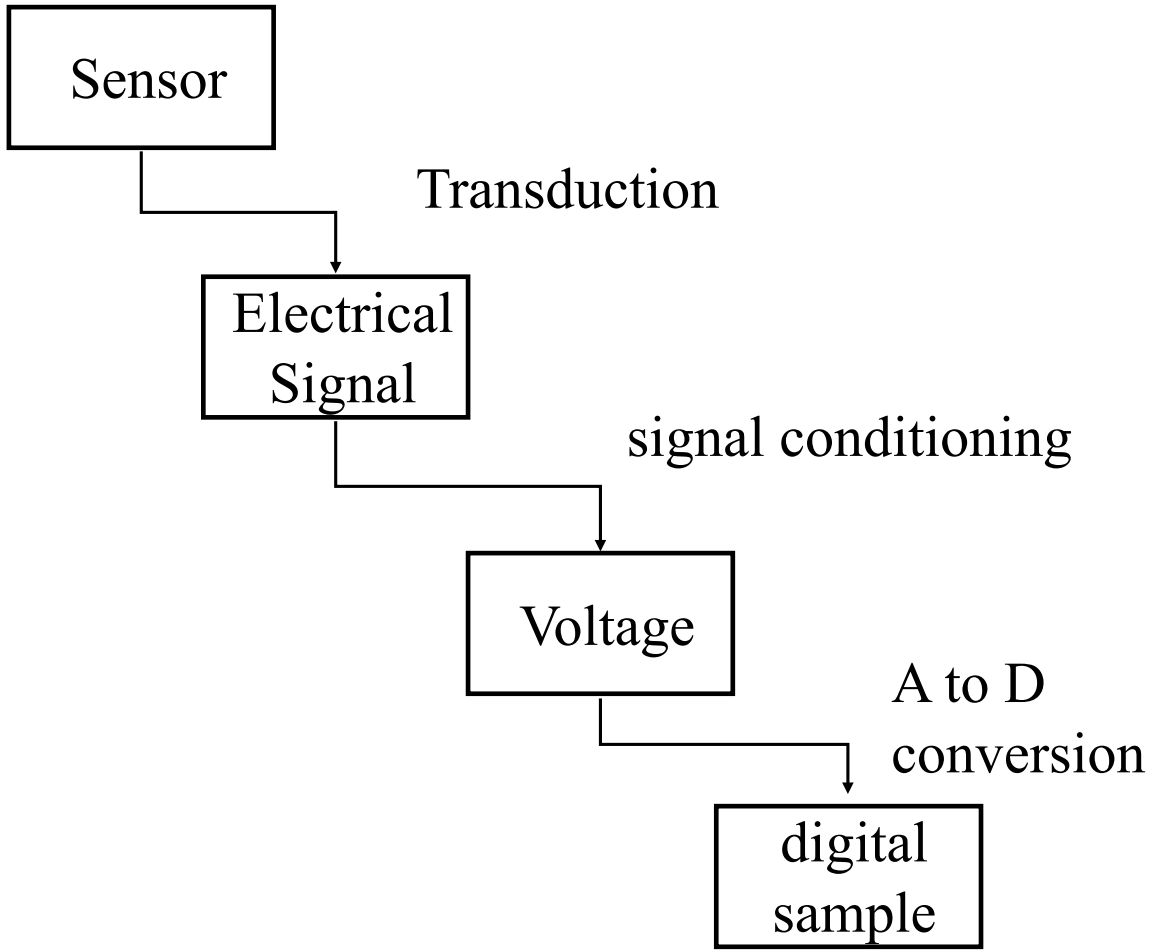
Human Action Oriented Sensors

- Reach - EMF disturbance
- Slide - resistive
- TapTile - Force sensitive resistor
- Tilt
  - electrolytic, single axis (-70-+70 deg)
- Touch - 0 travel FSR
- TouchGlove
  - several touch sensors
- TouchStrip
  - long touch sensor
- Turn
  - potentiometer



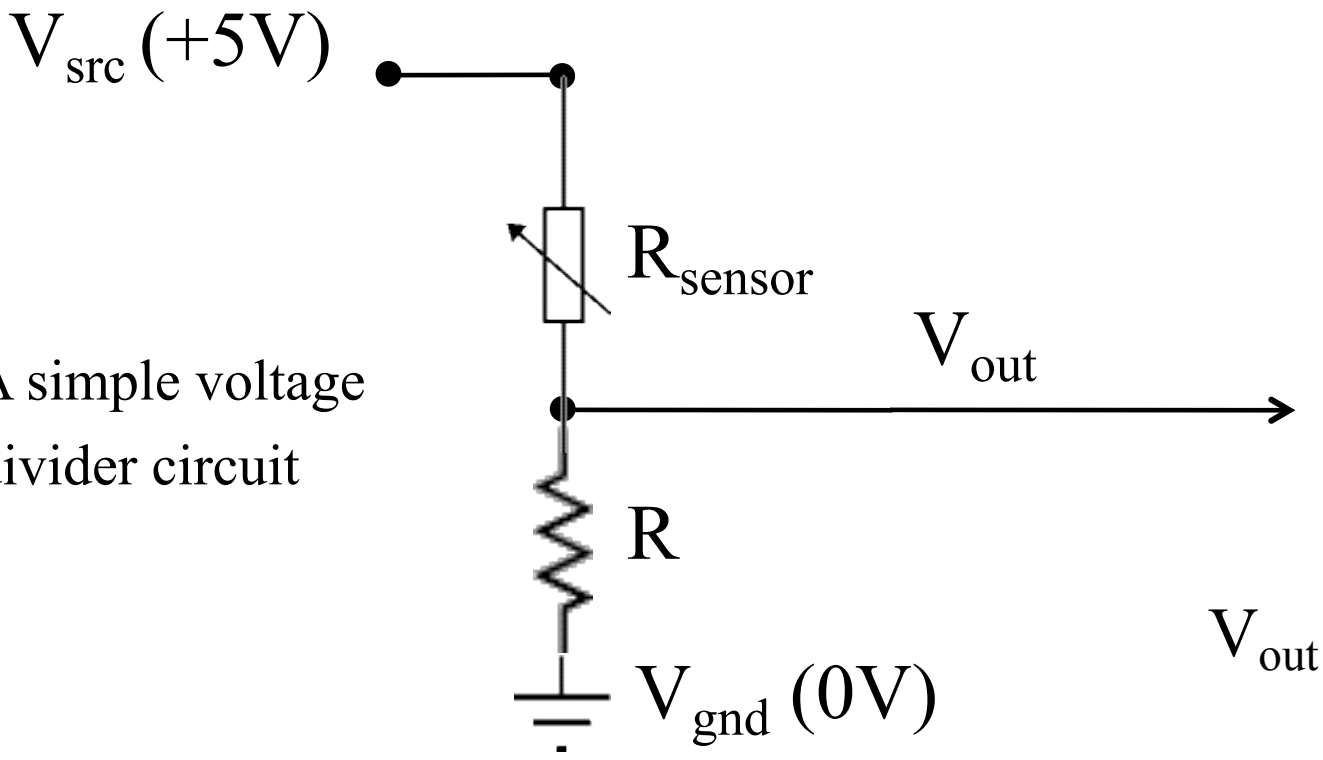
Connecting sensors

- Sensor response requires transduction and digitizing:
  - electrical
    - voltage
    - resistance
    - impedance
  - optical
    - colour
    - intensity
  - magnetic
    - induced current
    - field direction
  - mechanical force



Digitizing

- converting change in resistance into voltage
  - typical sensor has variable resistance (R_{sensor})



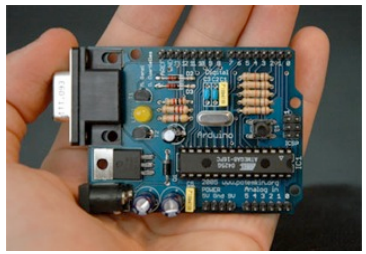
A simple voltage divider circuit

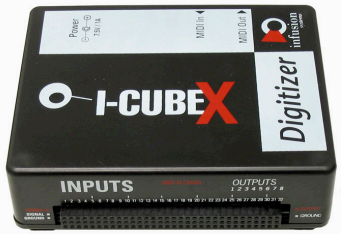
$$V = RI$$

$$V_{out} = \frac{V_{src} * R}{(R_{sensor} + R)}$$

Digitizers for Connecting to Computer

- Some MIDI synthesizers, i.e., Yamaha mu100
- Arduino board
  - Bluetooth module for wireless A/D
- ICubeX
  - A/D to MIDI
- Phidgets
  - A/D to USB
- DAQ boards
  - A/D to computer bus





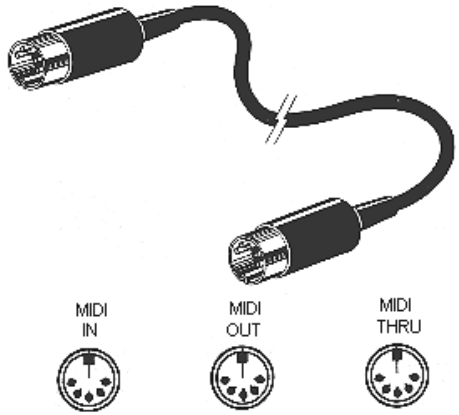
Mapping Sensor to Music

- The relationship between the change in the sensor value to the sound output is called a *mapping*
- The mapping defines how much effort to learn and play your NIME
- Last step is to control your sound output:
  - communication protocol
  - sound synthesizer

This is the heart of the course and what NIME community is specialized in.

Sound output control: communications

- Musical Instrument Digital Interface (MIDI)
  - electronic instrument standard defined in 1982
  - specifies;
    - connectors, data rates, electrical properties, etc.
  - 1 message/msec (approx)
    - note on/off, velocity is typical packet
    - control messages to change instrument synthesis



- Open Sound Control (OSC) *(Wright and Freed, 1997)*
  - TCP/IP, internet protocol, typically UDP based
  - faster, low latency, variable packet types
  - computer to computer, computer to hardware
- Internal protocols, i.e. DAQ driver

Sound Synthesis Techniques

- Methods
  - sampled
  - FM synthesis
  - additive/subtractive
  - granular
  - waveguide/physical modeling
  - scan

- see: *Computer Music Tutorial*, Roads, C., MIT Press, 1996

Sound Synthesizers

- Hardware MIDI synthesizers
  - Yamaha, Roland, Korg, Casio, Moog, Kowai, Symbolic Sound Corporation, Nord modular, and others
- Software
  - STK (Cook)
  - PureData (Pd, Puckette)
  - JASS (van den Doel)
  - Max/MSP (cycling74.com)
  - Chuck (Wang and Cook, 2003)
  - Supercollider (McCartney, 1996)
  - and others

A few practical notes

- Portable:
  - Batteries can be used to make portable
  - Wireless protocols available for portable
- Write pieces for the instrument
- Aesthetics are important
- Plan your checklist for performance
  - too many things can go wrong with technology
- Plan your staging
  - can severely impact performance of sensors
- Plan for producing stable versions
  - hard to learn to play if NIME keeps changing

Module 3 has more details.

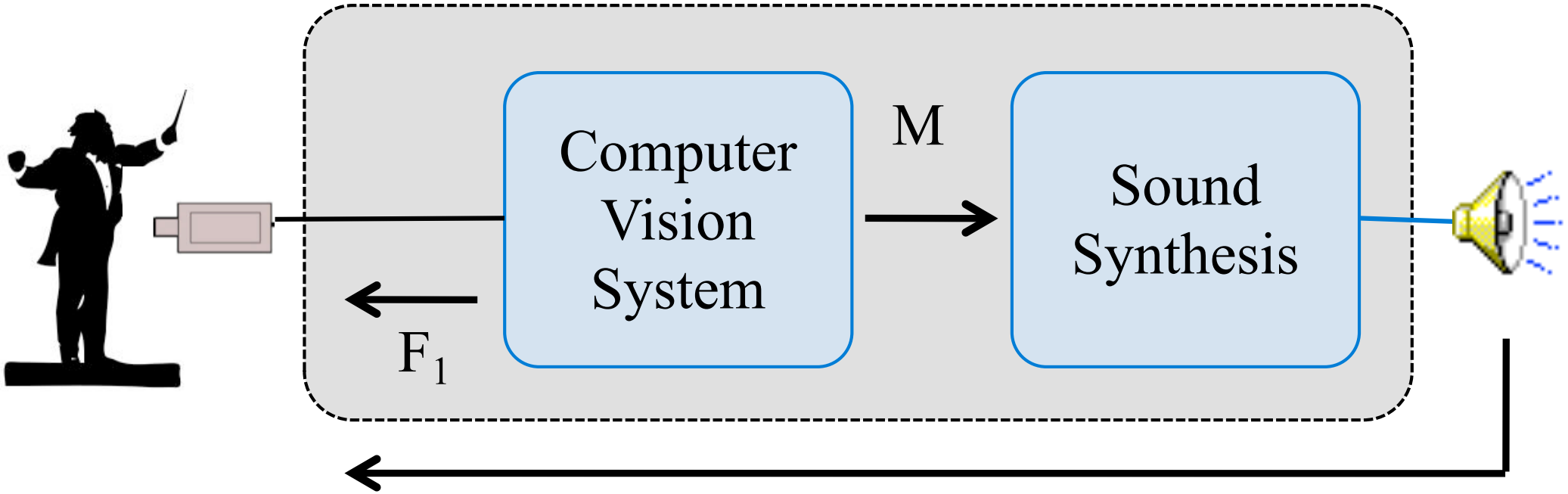
Summary

- Making a NIME is usually easier than playing it (well)
- Choose your:
  - movement type
  - sound space
  - sensing
- Put together your input, mapping and output
- Now you are ready to:
  - practice, practice, practice and perform…
  - aesthetic principles covered in module 3

Module 2: Audio-Visual Interfaces

- Imaginary Piano: visual input only
- Iamascope: visual input and output
- Facial gesture musical interfaces: when vision may be your best option
- Reactable: vision + (passive) touch, through alignment)

Camera-based Interfaces



F_1 : visual feedback in the form of aligned graphics

Imaginary Piano: No visual feedback

Leonello Tarabella, NIME-02

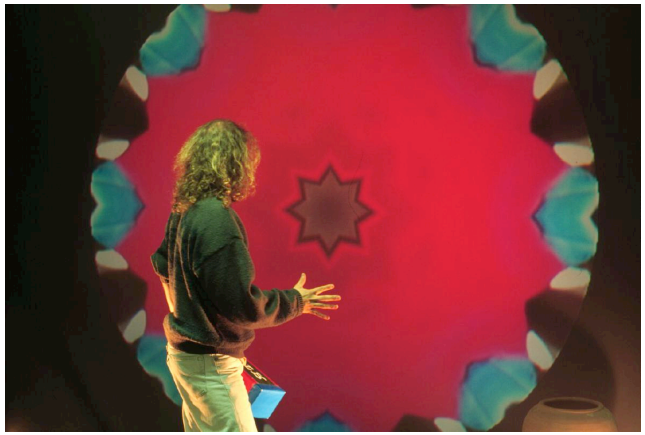
- Video camera with motion-sensitive zone
- No primary feedback

Visual Input Only: Imaginary Piano

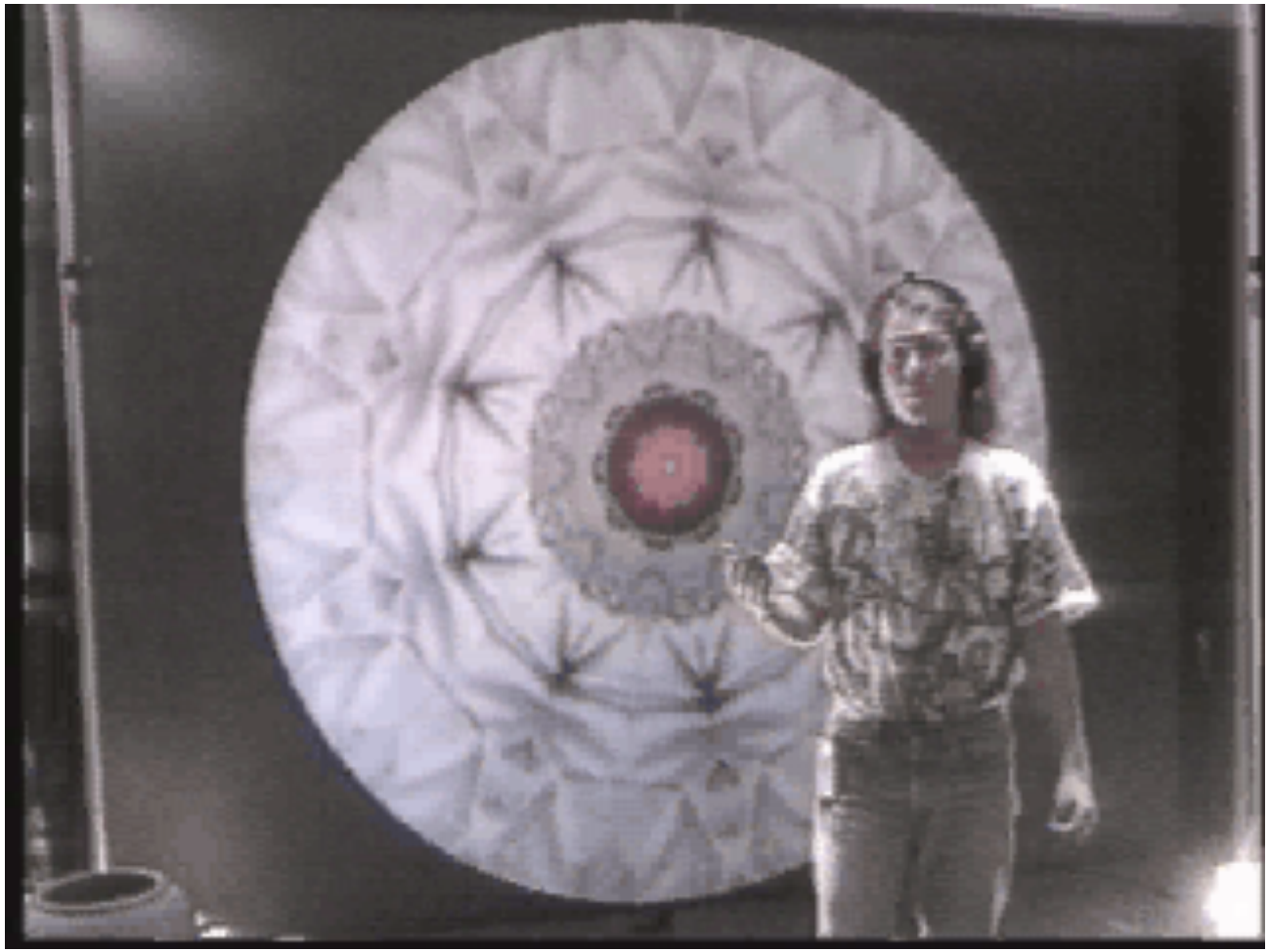
Leonello Tarabella, NIME-02

Visual Input & Output

- Iamascope
- This gives a colourful kaleidoscopic feedback of part of the player. Gestures are used to trigger harmonious chord progressions and arpeggios.
- Quite good coordination between sound and graphics



Iamascope - video



Facial Gesture Musical Interface

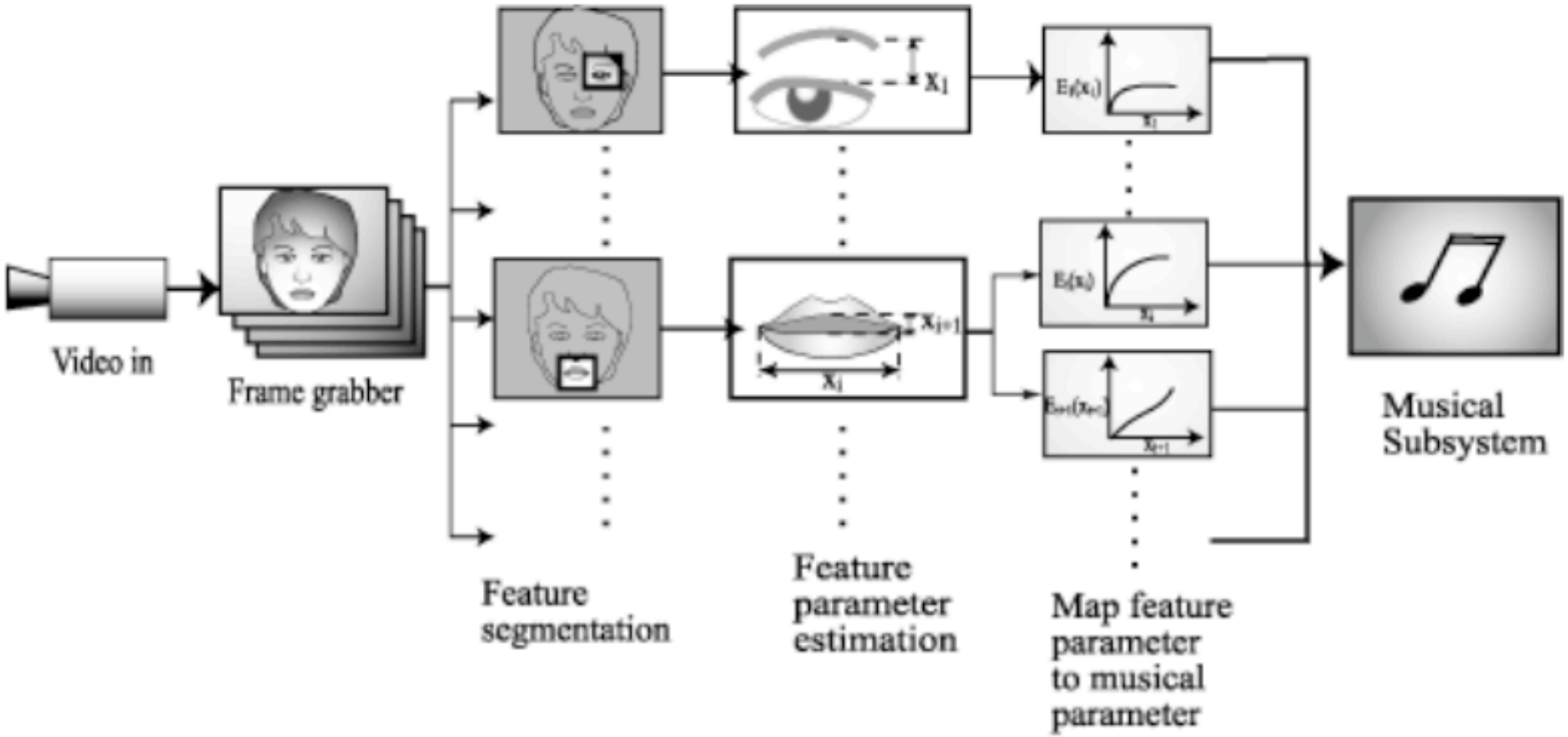


Figure 2 Schematic of the facial action driven musical controller.

Lyons, NIME-01

Sonification of Facial Actions (SoFA)

- Optical Flow triggers samples
- Samples mapped to facial zones
- Frame is recalibrated with face detection “Saccades”

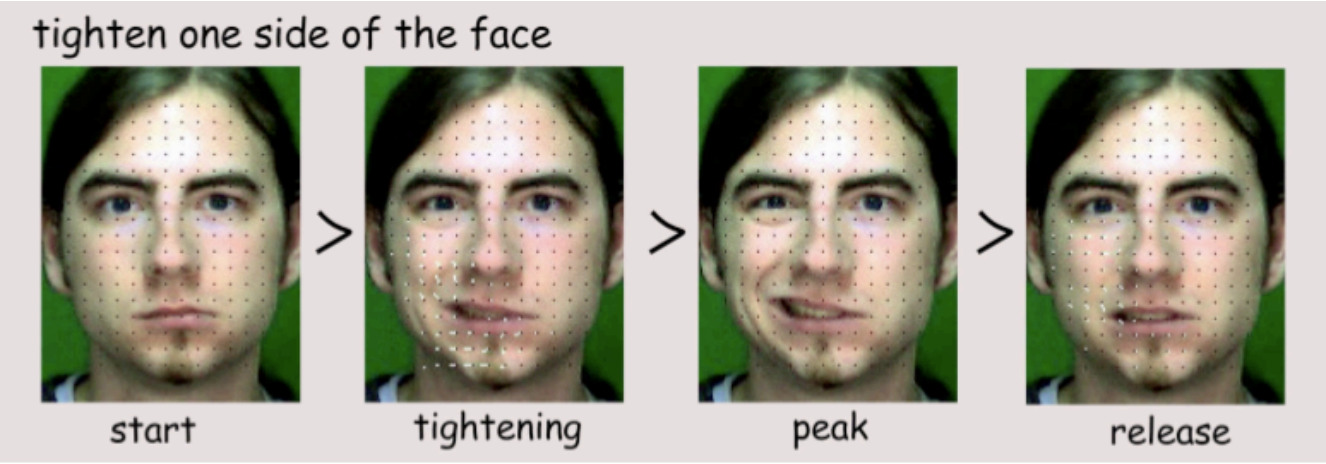


Figure 2 Sample facial action with associated optic flow vector fields illustrated as white line segments.

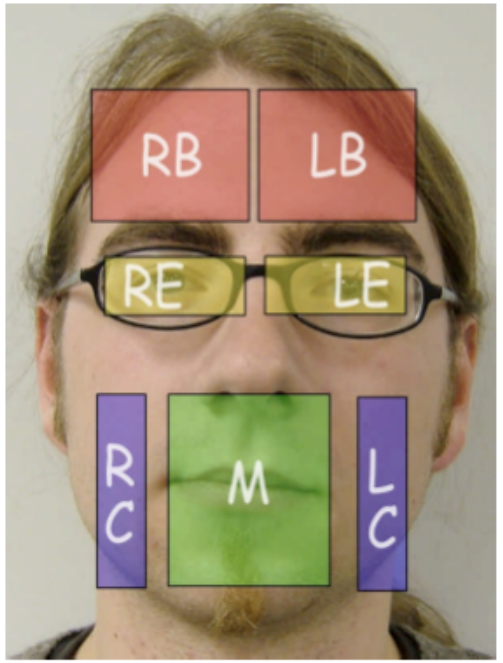
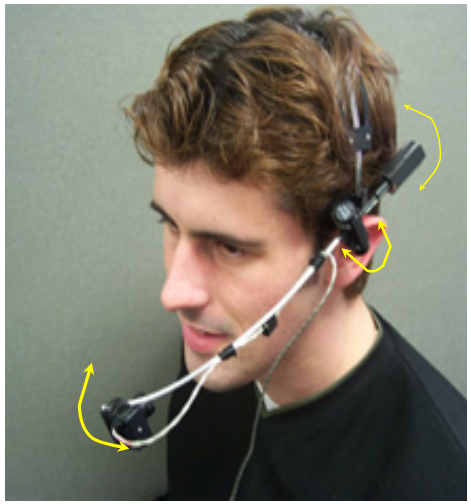


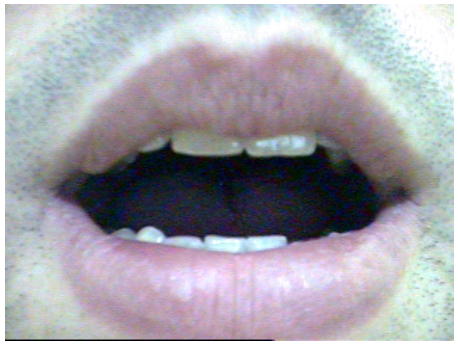
Figure 3. Facial Zones used to trigger MIDI events.

Funk et al., NIME-05

Sonification of Facial Actions (SoFA)

Mouthesizer





- Colour & intensity thresholding
- Morphological transform & filtering
- Connected components + shape analysis

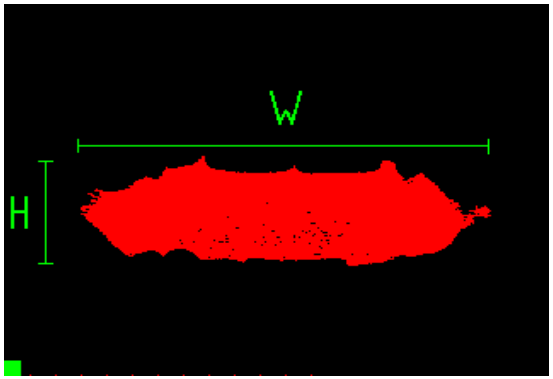
Image processing operations

Lyons et al., NIME-03

Mouthesizer - Video-based Guitar Effects Controller

Mapping:

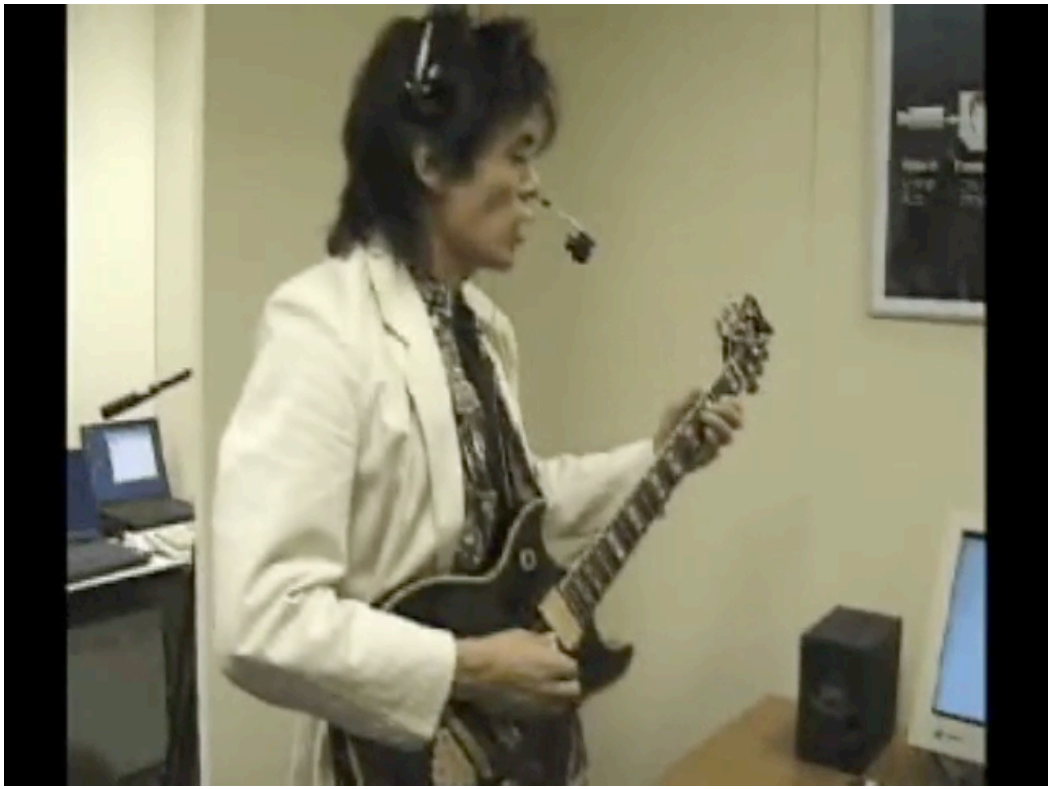
- acoustic
- expressive

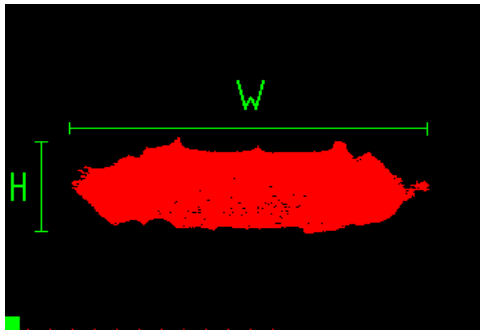


H ⨉ Cutoff Frequency of Resonant Low Pass Filter

W ⨉ Distortion

Mouthesizer - Video-based Guitar Effects Controller





Mouth open/close - “wah-wah” effect (physio-acoustic)

Mouth grimace - Distortion (Facial Expression)

Leveraging Human Expression

- Our expertise in controlling sound with our mouth shape is leveraged by mapping opening/closing of mouth to audio filter effect
- Human expertise in facial expression is leveraged by mapping a grimace to the distortion effect

>Natural mappings are easier to learn and to use

Reactable

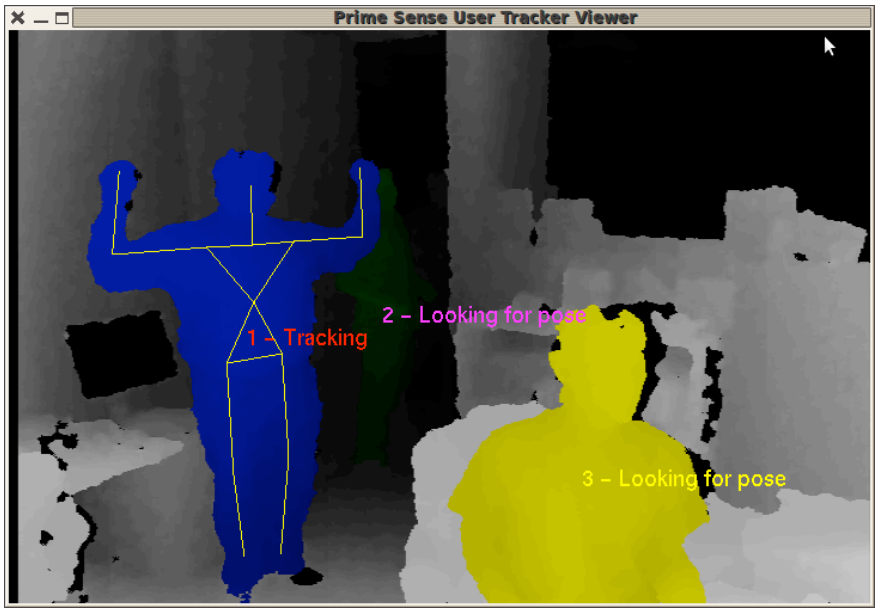
- Video tracking of marked pucks on a table
- Projection of visual feedback

- Sergi Jordà et al., Universitat Pompeu Fabra
- first presented at NIME-03

Reactable

3D Vision Interfaces

- OpenKinect



Summary

- Large number of works have used visual input and output as a way to enhance new musical interfaces
- General principle is that vision offers a powerful way to capture gestural input
- Visual output using camera input can provide transparency

Module 3: Design & Aesthetics

- Technological Expressionism
- NIME & the Music Process
- Challenge of Performance
- Mapping & the Audience: Transparency
- Visual Feedback
- Interaction Metaphor
- Perry's principles

Kanta Horio - "Particle"

Technological Expressionism

- Futurism
- Human-machine relationship
- Joy of New Technology
- Experimentalism

Mari Kimura w/ Lemur Guitarbot

NIME Favors a Return to Process-oriented Music

- "…we are in a period of restoring fluidity to the musical transformative process – of making music more process-oriented again and less artifact-oriented."

  Gideon D'Arcangelo, NIME-04

20th century

21st

New Folk?

hrdrockgrrl's Channel Subscribe

hrdrockgrrl
Joined: **09 September 2006**
Last Sign In: **1 week ago**
Videos Watched: **3,586**
Subscribers: **171**
Channel Views: **6,451**

I'm an amateur musician. My main instruments are jazz piano and bluegrass mandolin, though I also play guitar and cornet.

City: **Los Angeles**
Country: **United States**

Report profile image violation

Oh Shenandoah played on iPhone ocarina
From: hrdrockgrrl
Views: 25,959
Comments: 59

Challenge of Performance

- Audience may not understand your NIME
- Expectations may be varied
- No musical tradition to fall back on
- A demo is not a performance

Hisashi Okamoto, NIME-04
The First Sailing with Limber-Row

Hisashi Okamoto - Limber Row

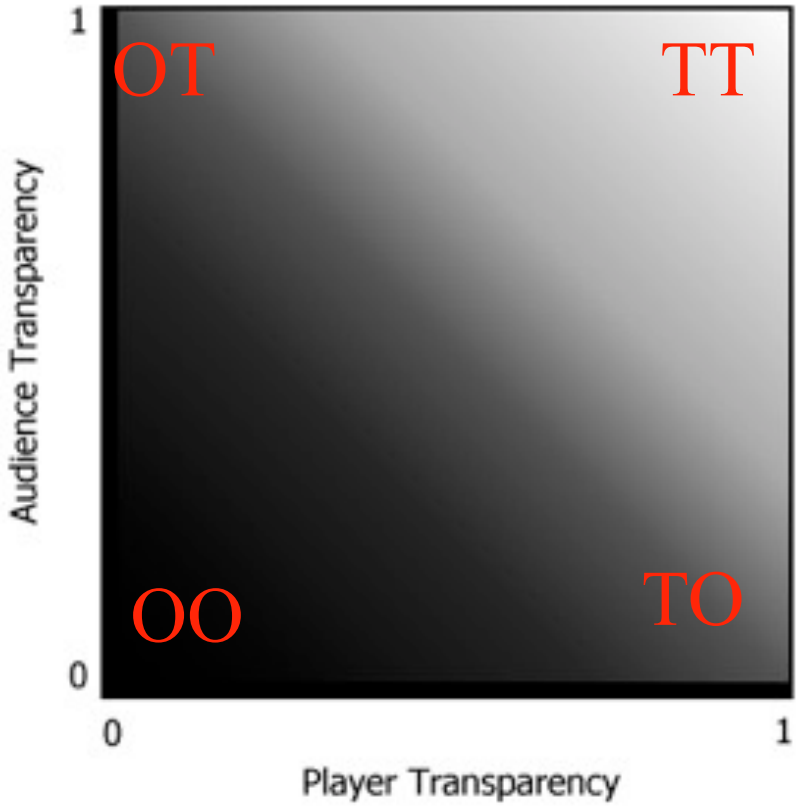
Transparency for Performer & Audience

- Complicated mapping ⟶ OO
- Simplify ⟶ OT
- Complex mapping ⟶ TO

T = transparent

O = opaque

How to achieve ⟶ TT?

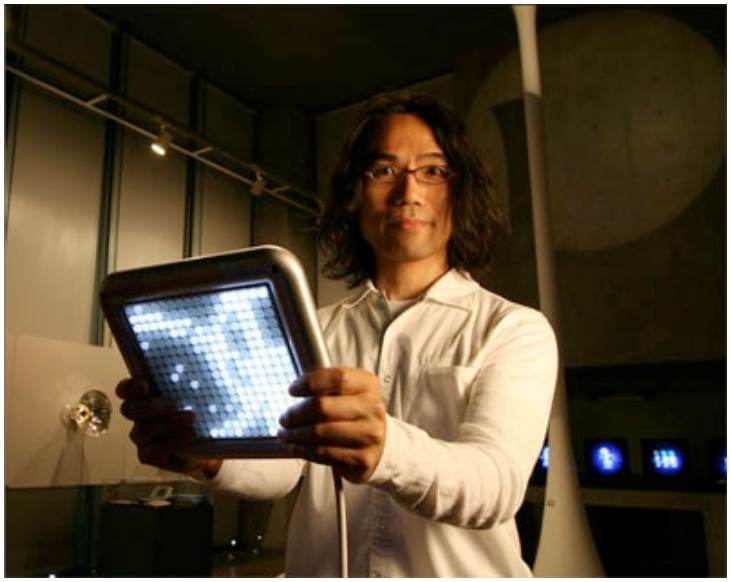


(Gadd et al, 2003)

Visual Cues & Transparency

- Visual Appearance of Instrument
- Visualization of Interaction
- Visualization of Sound Output

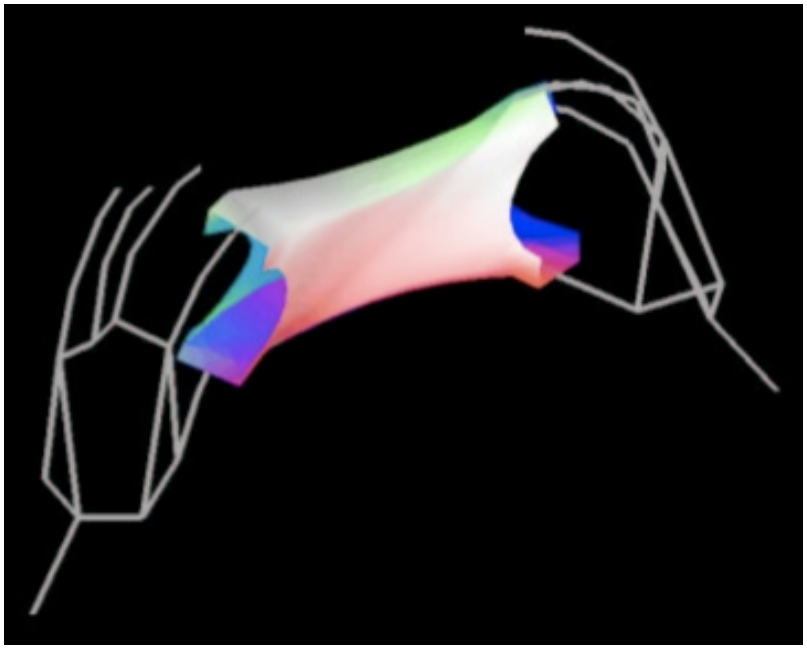
Reactable



Tenori-on

Transparency & Interaction Metaphor

- SoundSculpting *(Mulder and Fels, 1998)*
  - two Cybergloves and Trackers
  - map metaphor of rubber sheet onto sound space
  - transparent for audience and performer



Transparency
Simple & Direct Interface

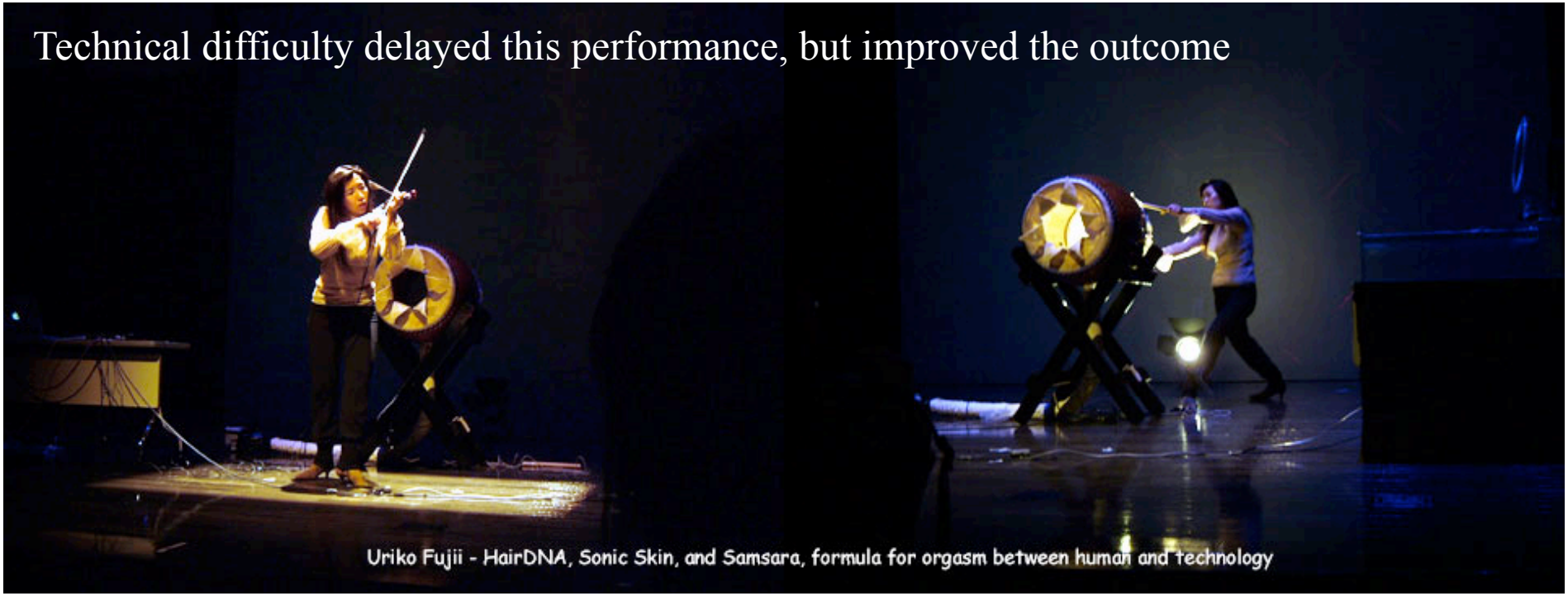
Particle

Kanta Horio, NIME-04

- Contact Mics
- Magnets
- Paper clips

Aesthetics of Failure

- Suspense can highlight the technological challenge
- If there are never difficulties, glitches etc… then the limits are not being pushed



Some Design Guidelines: Perry's Principles

- Rules of thumb for the design of digital musical instruments
- Several of the principles are heavily subscribed

"Principles for Designing Computer Music Controllers"
P. Cook, NIME-01

Revised:

"Principles for Controlling Computer Music Designers"
P. Cook, Keynote talk, NIME-07

Perry's Principles

Human/Artistic Principles

P1: Programmability is a curse

P2: Smart instruments are often not smart

P3: Copying an instrument is dumb, leveraging expert technique is smart

P4: Some players have spare bandwidth, some do not

P5: Make a piece, not an instrument or controller

P6: Instant music, subtlety later

Perry's Principles

Human/Artistic Principles

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P2: Smart instruments are often not smart

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P4: Some players have spare bandwidth, some do not

P5: Make a piece, not an instrument or controller

P6: Instant music, subtlety later

P1: Programmability is a curse
P2: “Smart” Instruments are Often Not

- “Easy to add complexity, features, bandwidth”
- But instruments can quickly become complex, unstable, and difficult to learn
- It is tempting to A.I. to instruments but this can often be bad design if the player feels the instrument too obviously has a ‘mind of its own’

Perry's Principles

Human/Artistic Principles

P1: Programmability is a curse

P2: Smart instruments are often not smart

P3: Copying an instrument is dumb, leveraging expert technique is smart

P4: Some players have spare bandwidth, some do not

P5: Make a piece, not an instrument or controller

P6: Instant music, subtlety later

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P5: Make a piece not a controller
P6:Instant Music, Subtlety later

- Making music is the goal
- The ideal new musical interfaces has:

  'Low entry fee with no ceiling on virtuosity'

  Wessel & Wright, NIME-01

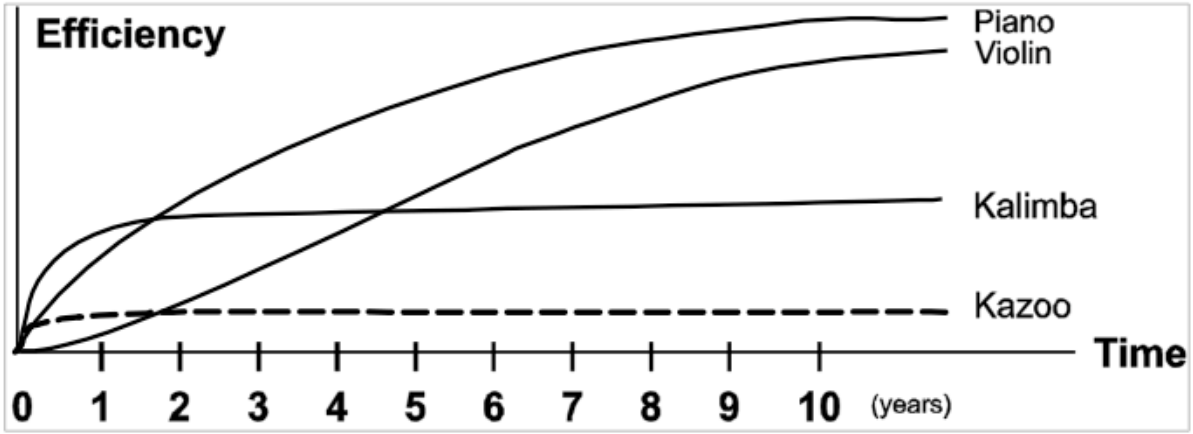

Figure 1. Approximate learning curve for the (a) kazoo, (b) kalimba, (c) piano and (d) violin, within a period of 10 years.

Jorda, NIME-04

Perry's Principles

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Perry's Principles*

Technological:

P7: Miracle, Industry Designed, Inadequate

P8: Batteries, Die (a command not an observation)

P9: Wires are not that bad (compared to wireless)

Misc.:

P10: New algorithms suggest new controllers

P11: New controllers suggest new algorithms

P12: Existing Instruments suggest new controllers

P13: Everyday objects suggest amusing controllers

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P13: Everyday objects suggest amusing controllers

P13: Everyday objects suggest controllers that are both amusing & good

- Sonic Banana *(E. Singer, NIME-03)*
- Java mug & Fillup Glass *(P. Cook, NIME-01)*

Perry's Principles*

Technological:

P7: Miracle, Industry Designed, Inadequate

P8: Batteries, Die (a command not an observation)

P9: Wires are not that bad (compared to wireless)

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Perry's Principles*

New (as of 2007)

P14: More can be better (but hard)

P15: Music + Engineering is a great Teaching tool

P17: Younger students are more fearless

Perry's Principles*

New (as of 2007)

P14: More can be better (but hard)

P15: Music + Engineering is a great teaching tool

P17: Younger students are more fearless

P15: Music + Engineering = Good Zone for Education

- High student interest
- Motivation for learning a range of core topics including:
  - Sensors
  - HCI
  - DSP
  - Math skills
  - Programming
  - Networking

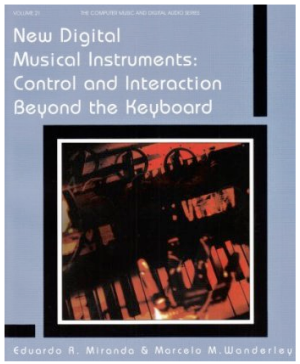
Joe Paradiso & student (NIME-02)

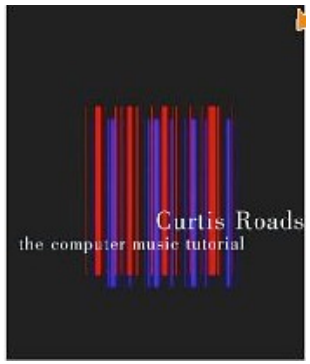
Where to study this field?

- KAIST
- IRCAM, Paris
- CCRMA, Stanford
- CIRMMT, McGill
- Princeton, CS & Music
- NYU Interactive Telecommunications Program
- SARC, Queen's, Belfast
- University of London
- University of Michigan
- others (growing field)

Specific Learning Resources

- Miranda & Wanderley (2006)
- Igoe (2007)
- Roads (1996)
- NIME Proceedings
- ICMC Proceedings
- Computer Music Journal
- Organized Sound
- J. New Music Research





Summary

- Technology is increasing the fluidity of musical culture
- NIME presents special challenges for performers
- Well-designed visual feedback can greatly improve mapping transparency for audience and player
- Interaction metaphors another strategy
- Initial failure can enhance eventual success
- Perry's principles provide practical policies

Questions/Discussion

Break

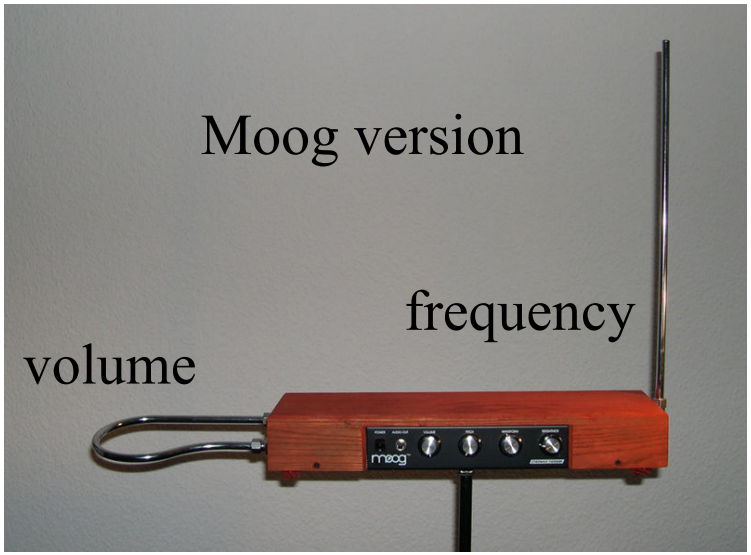
Start again in 15 minutes

Module 4: Case Studies

photo: Lydia Kavina

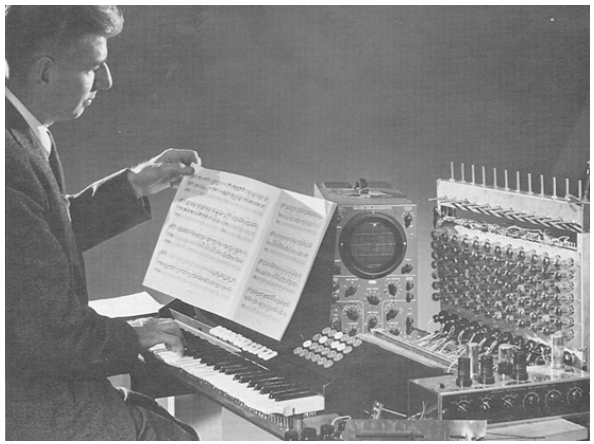
Early NIMEs

- Leon Theremin, 1928
  - senses hand position relative to antennae
    - controls frequency and amplitude
  - Clara Rockmore playing



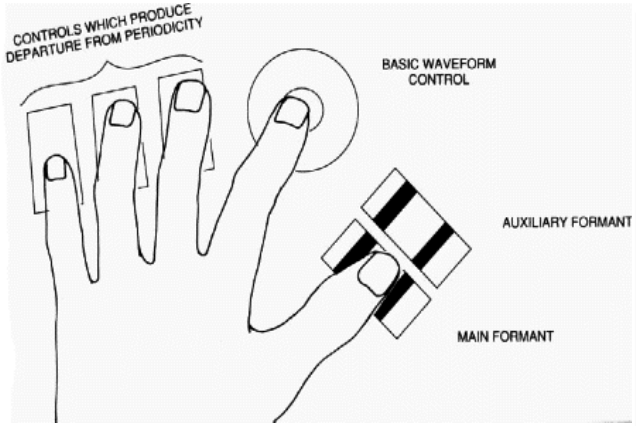
Early NIMEs

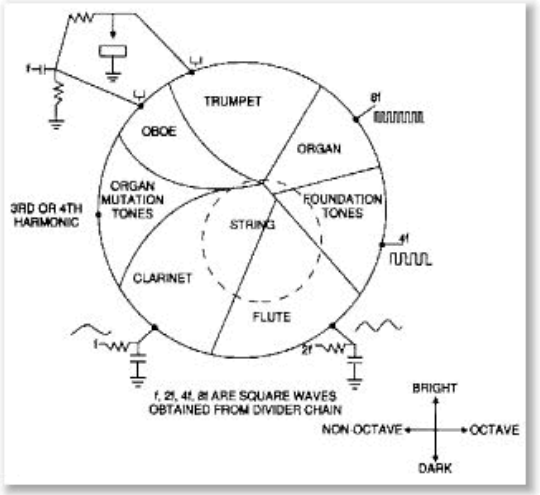
- Hugh Le Caine (1940s)
  - electronic sackbut
  - sensor keyboard
    - downward and side-to-side
    - potentiometers
  - right hand can modulate loudness and pitch
  - left hand modulates waveform
    - precursor to the mod-wheel



Science Dimension volume 9 issue 6 1977

Canada Science and Technology Museum



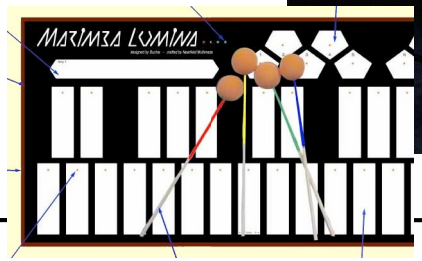


Buchla's Midi Controllers

- Thunder (1990)
  - 36 touch sensors

- Lightning 2 (1996)
  - LED based position sensing

- Marimba Lumina (1999)
  - pads and ribbon controllers (strips)
  - bars are sensitive to proximity, hit location and movement
  - 4 different mallets for different effects



Buchla 200e Series music controllers

- Modules can be combined:
  - Control and Signal Router
  - Multi Dimensional Kinesthetic Input Port
  - Midi Decoder/Preset Manager
  - System Interface Arbitrary Function Generator (2 panel units)
  - Complex Waveform Generator
  - Source of Uncertainty
  - Quad Function Generator
  - Frequency Shifter / Balanced Modulator
  - Triple Morphing Filter
  - Quad Dynamics Manager

There's a lot of NIMEs out there

	2001	2002	2003	2004	2005	2006	2007	2008	Total
Instrument-like	1	2	2	2	2	4	4	1	18
Instrument-inspired	2	4	1	1	-	3	2	1	14
Extended instrument	2	4	5	3	5	7	6	5	37
Alternate controllers	21	31	24	23	35	22	19	22	197
Total	26	41	32	29	42	36	31	29	266

Table 3.2: Classes of instruments presented at the NIME conferences, by year

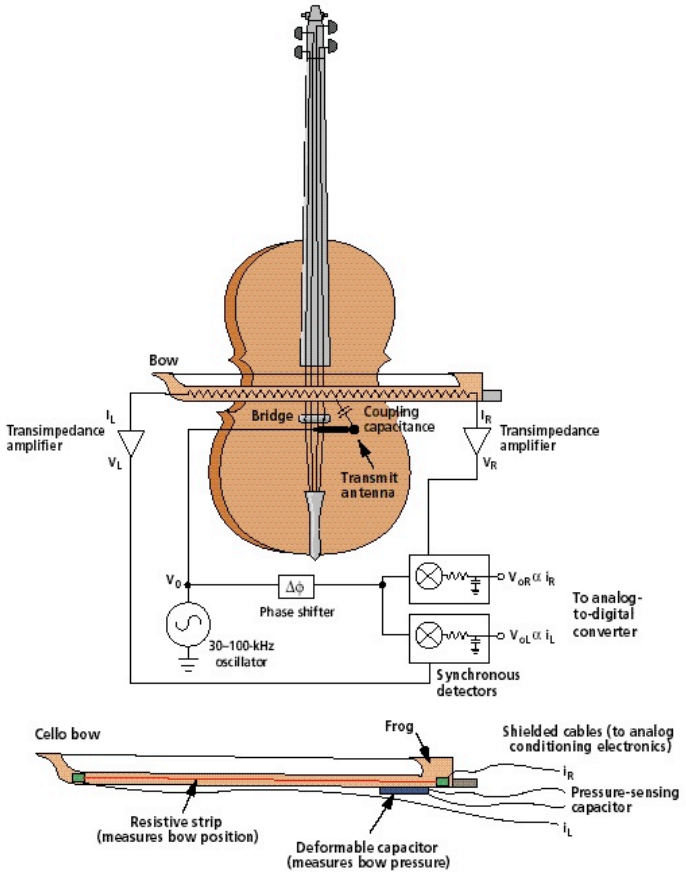
(Marshall, 2009)

- Most are classed in the "Alternate" category
- Growing about 35/year from NIME
- Mobile-based is a growing category

Augmented Instruments

- Hypercello *(Gershenfeld & Chung, 1991)*

  - related Hyperbow *(Young, 2001)*



Yo-Yo Ma, Tanglewood on August 14, 1991

Augmented Instuments

- Yamaha Disklavier
  - MIDI controlled acoustic piano
  - solenoid actuators to play keys
  - records key press
- Radio Baton + Disklavier performance
  - Jaffe & Schloss, *The Seven Wonders of the Ancient World*, 1991

Augmented Instruments

- Hyper-Flute *(Palacio-Quintin, 2003)*
  - standard Boehm flute
  - sensors:
    - magnetic field, G# and C# keys
    - ultrasound tracking
    - mercury tilt switch
    - pressure sensors (left hand and thumbs)
    - light sensor
    - buttons

Alternative Instruments: Using different sensors

Sensor	Occurences	Property Sensed
FSR	68	Force
Accelerometer	56	Acceleration
Video Camera	54	
Button/Switch	51	Position (On/Off)
Rotary Potentiometer	31	Rotary Position
Microphone	29	Sound Pressure
Linear Potentiometer	28	Linear Position
Infrared Distance Sensor	27	Linear Position
Linear Position Sensor	23	Linear Position
Bend Sensor	21	Rotary Position (Bending)

Table 3.3: Most popular sensors from NIME instruments

(Marshall, 2009)

Sensor trends from NIME

Sensors	Occurrence (2009–2013)	Occurrence (2001–2008) [10]
accelerometer	75 (30)	56
FSR™ (Force Sensing Resistors™) [1]	38	68
buttons and potentiometers [2]	29	110
gyroscope	30 (9)	
video/image [3]	23	54
IR (infrared) [4]	22	27
magnetometer	16 (4)	
capacitive	15	
biosensing [5]	13	
piezoelectric disc	12	
non-definable [6]	12	
microphone	11	29
textiles	11 [7]	
photo/light	10	
bend	9	21
Hall effect	7	
ultrasound	4	
pressure/flow	4 [8]	
fiber optic	2	

(Medeiros & Wanderley, 2014; [10] *Marshall, 2009)*

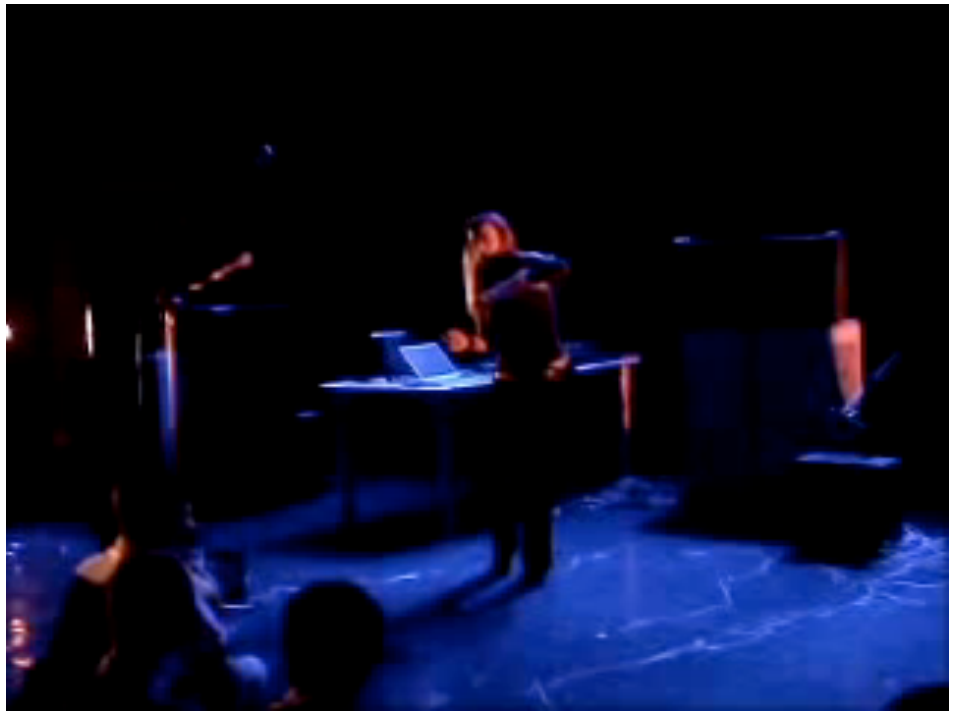
Medeiros CB, Wanderley MM. A Comprehensive Review of Sensors and Instrumentation Methods in Devices for Musical Expression. *Sensors*. 2014; 14(8):13556-13591.

Alternative Instruments

- approaches to taxonomy:
  - sensed property (i.e. wind)
  - player action (i.e. percussion)
  - instrument shape
  - relationship to body

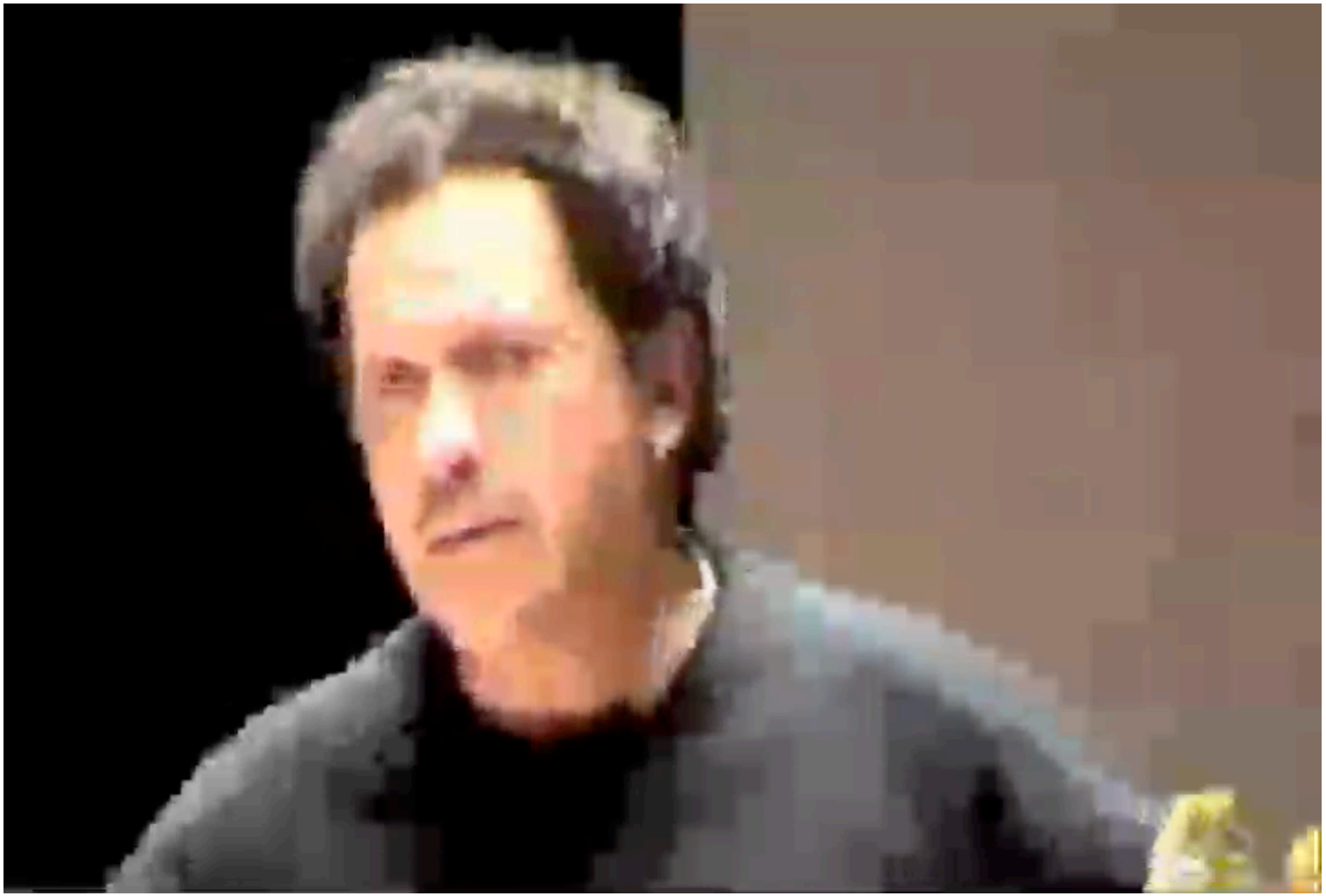
Hands Only - free gesture + physical

- Lady's Glove *(Sonami, 1991+)*
  - hall effect sensors, microswitches, resistive strips, pressure pad, accelerometer
  - controlled musical effects



free gesture + contact gesture + voice

- The Hands *(Waisvisz, 1984)*



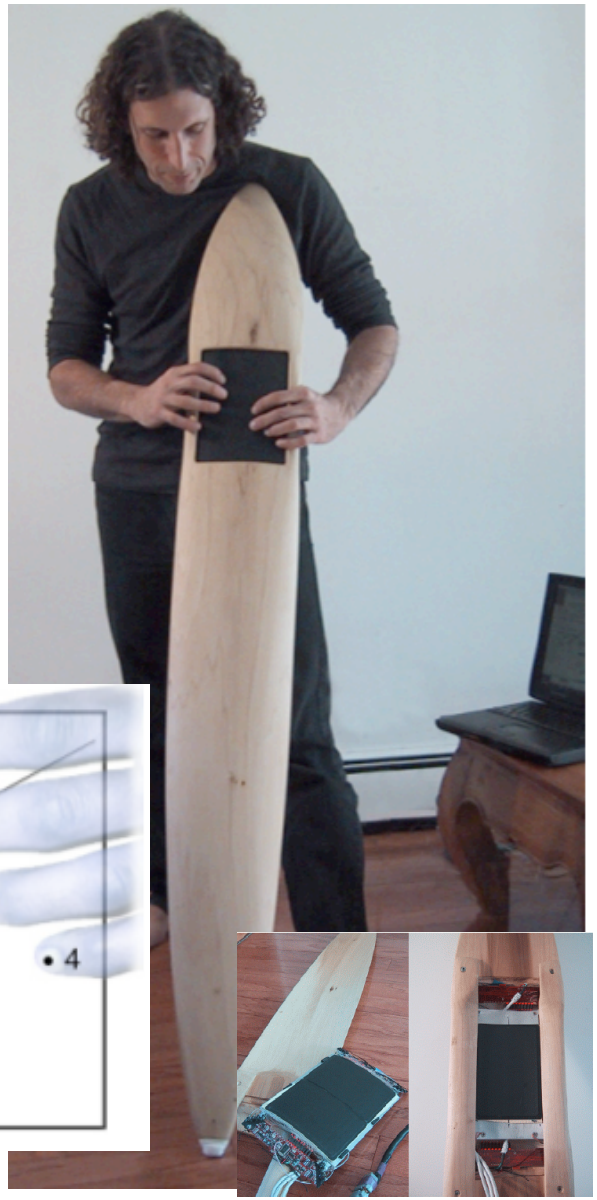
Hands Only - free gesture

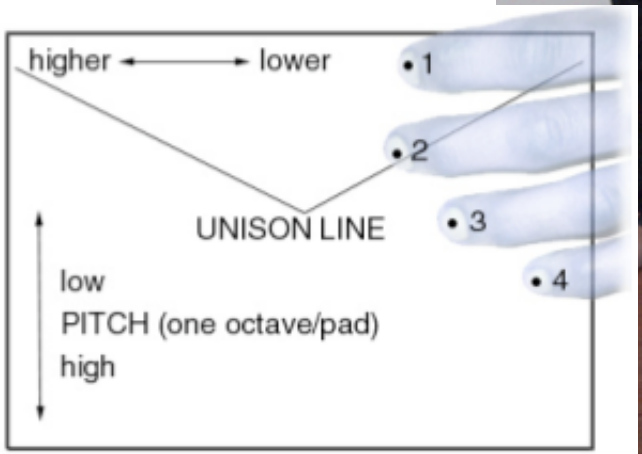
- Manual Input Sessions
  (Levin and Leibermann, 2004)
  – camera and OHP

- SoundSculpting *(Mulder and Fels, 1998)*
- GloveTalkII/GRASSP/DIVA, *(Fels et al., 1994+)*
  – cybergloves, tracker, switches
  – controlled formant synthesizer
- and more…

Hands - Contact gesture

- Most typical type of NIME
- Ski *(Huott, 2002)*
  - fibre optic multitouch pad
    - Tactex Inc.
  - mappings:
    - playback: linear, polar and angular control modes
    - percussive
    - pitch tuning:
  - MIDI controller
  - upright form factor



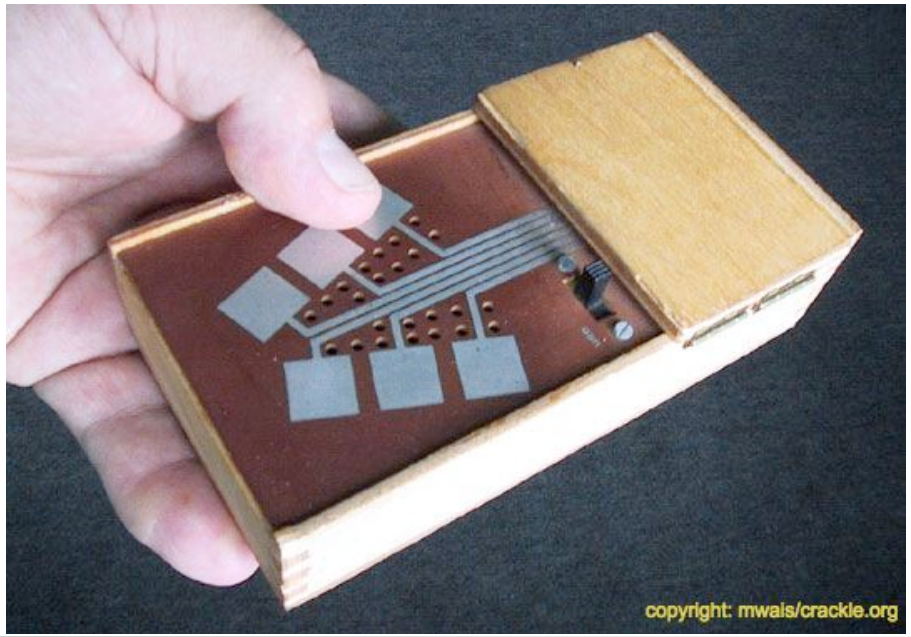


Hand - Contact gesture

- Pebblebox *(O'Modhrain & Essl, 2004)*
  - microphone + stones
  - granular synthesis
- play with stones
  - mixes granules

Hand - Contact gesture

- Crackle box *(Waisvisz, 1975)*
  - analog circuit
  - op-amp with body resistance connected to pins
  - in the tradition of circuit bending



Hand - Contact gesture

- Lippold Haken's Continuum
  - touch sensitive - neoprene covered
    - x, y along board
    - z - pressure
  - MIDI controller
    - sound effects
    - continuous frequency
    - pitch bends

Jordan Rudess (Dream Theater), 2005

Breath and Hands

- iPhone Ocarina *(Wang, 2009)*
  - touch screen plus microphone
  - mapped to tones for ocarina sounds

Face/Head Control

- eSitar *(Kapur et al, 2004)*
  - accelerometer for head tilt
    - experimented with volume, duration, and more
- Mouthesizer (Lyons et al., 2003)
- SoFA, (Funk et al., 2005)
- Tongue'n Groove (Vogt et al., 2002)
  - ultrasound probe to measure tongue movement

Body

- Miburi from Yamaha, 1994
  - bend sensors at arm joints
  - two buttons/finger and thumb
  - two pressure sensors/foot
  - MIDI controller

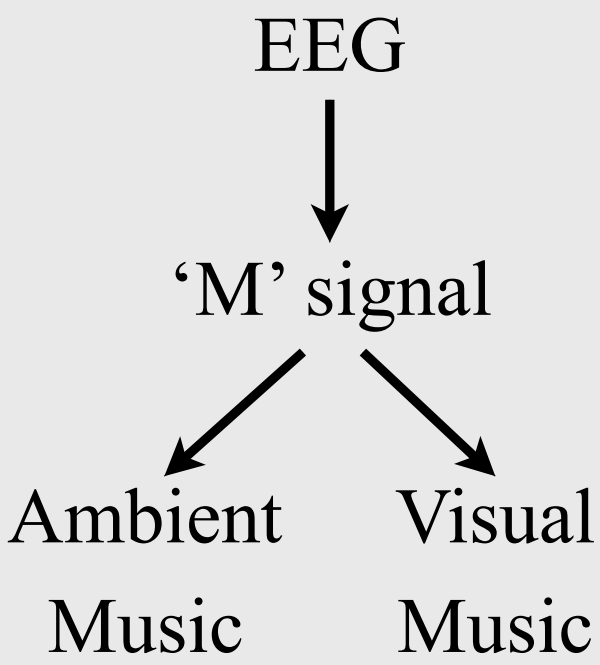
Inside Body

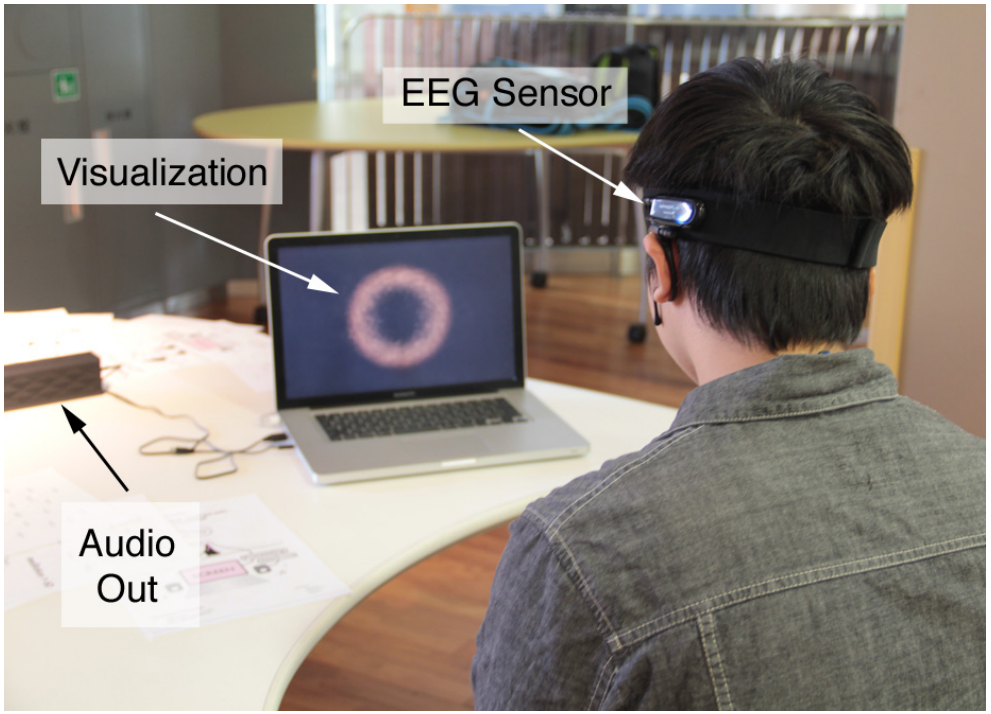
- Biomuse *(Knapp and Lusted, 1990)*
  - 8 channel signal amp
    - EMG, EKG, EOG, EEG
- miniBioMuseIII *(Nagashima, 2003)*
  - 8 EMG channels
    - mapped to bandpass filters, sinewave generators and FM synthesizers
  - used in BioCosmicStorm-II
- Enactive Mandala *(Tokunaga and Lyons, 2013)*
  - EEG + ambient audio & visual music

- Tibetan singing bowls *(Tanaka and Knapp, 2002)*
  - EMG and position sensing

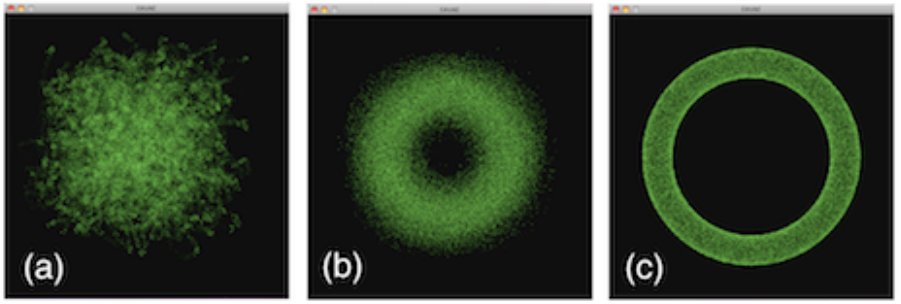
Enactive Mandala
EEG Audio-Visualization

Mapping





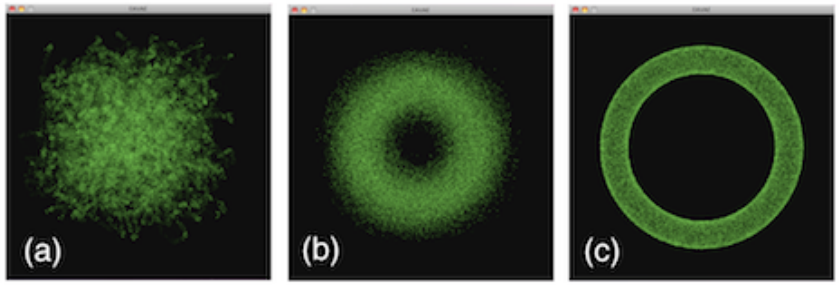
Meditative state 'focuses' cloud of moving particles



Enactive Mandala - Real-time EEG Audio-visualization

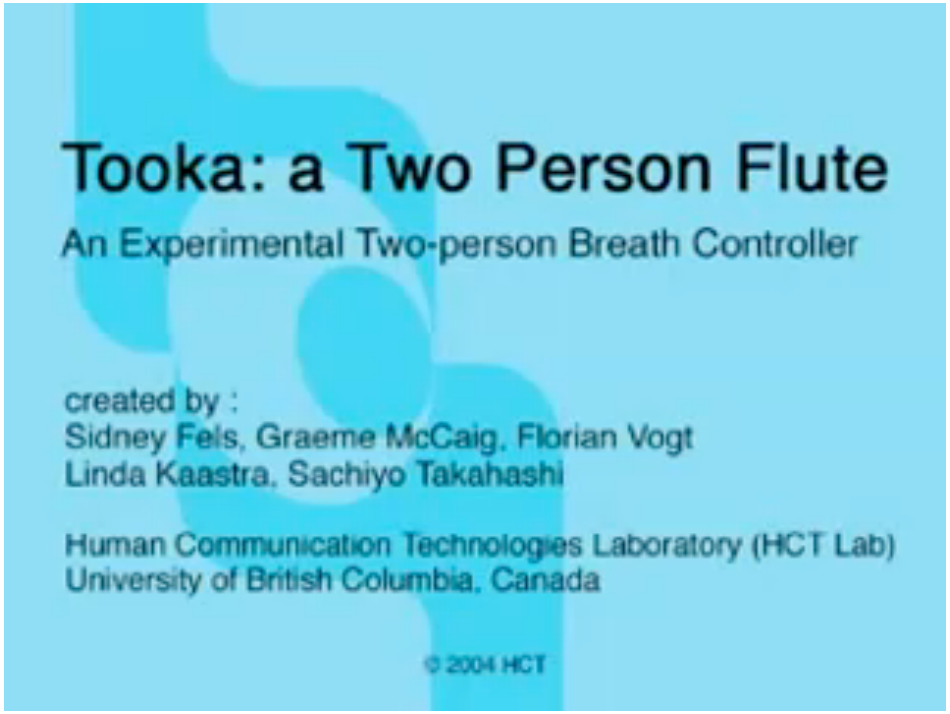
Enactive Mandala
Brain state Audio-Visualization

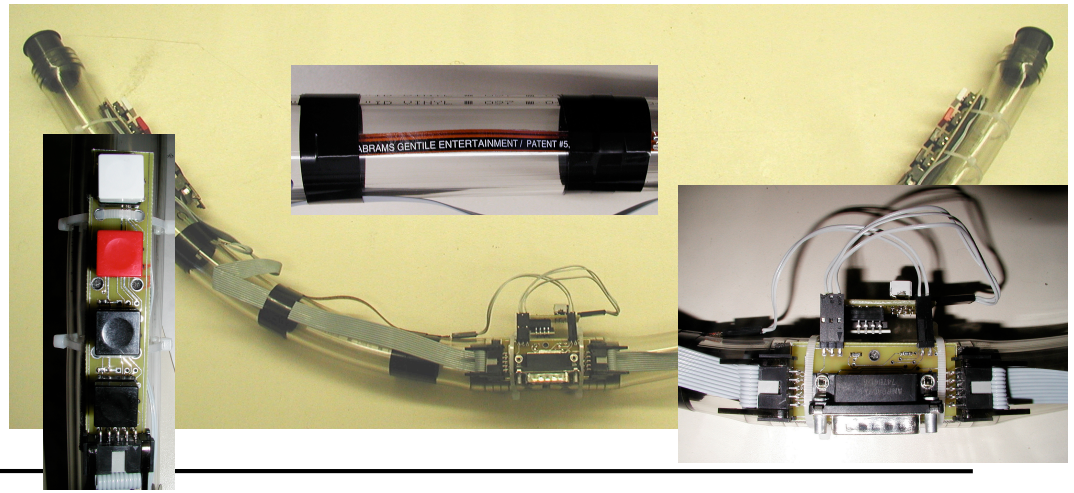
- Meditative state is learned **enactively** through effort, and feedback from the NIME **in context**
- Effective mapping is needed so that audio and visual feedback are transparently meaning
- This becomes a **new expression**, augmenting existing human physiology with technology and design
- Example of an **Augmented Expression**



Collaborative Instruments

- Tooka *(Fels and Vogt, 2002)*
  - pressure for breath
  - buttons for fingers
  - bend sensor
  - touch sensor
- two players share breath
- coordinate movements
- MIDI mapping





NIMEs for Novices:
Jam-o-drum *(Blaine and Perkis, 2000)*

- 4 player audio/visual interface
  - drum pads sensors with rotation sensor around rim
- Drum circle concept
- Various musical games
  - turn taking
  - collaboration

NIMEs for Novices

- *Interactive instruments embody all of the nuance, power, and potential of deterministic instruments, but the way they function allows for anyone, from the most skilled and musically talented performers to the most unskilled members of the large public, to participate in a musical process* ***(Chadabe, 2002)***

- "Walk up and play"

NIMEs for Novices

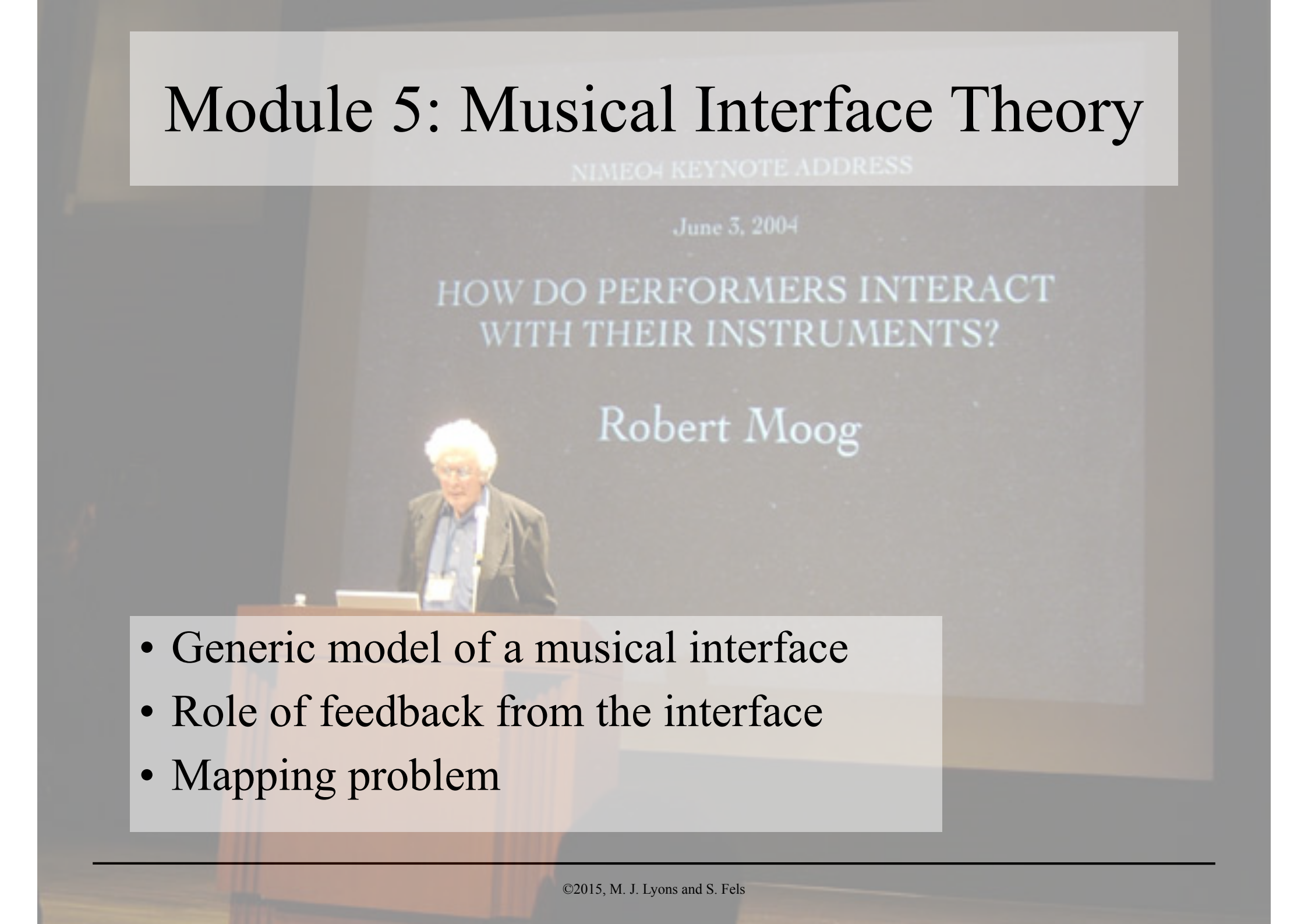
(Blaine & Fels, 2003)

			Aptitude	
			Novice	Virtuoso
Capacity	Single player	Single interface	Electronic Bullroarer Iamascope	Duet on piano
		Multiple interfaces	Musical Trinkets	Jazz Ensembles
	Multiple players	Single interface	Beatbugs Squeezables Audio Grove Sound Mapping Speaking Orbs Jamodrum	Mikrophonie I, Tooka
		Multiple interfaces	Augmented Groove Brain Opera Drum Circle	Mikrophonie II

Summary

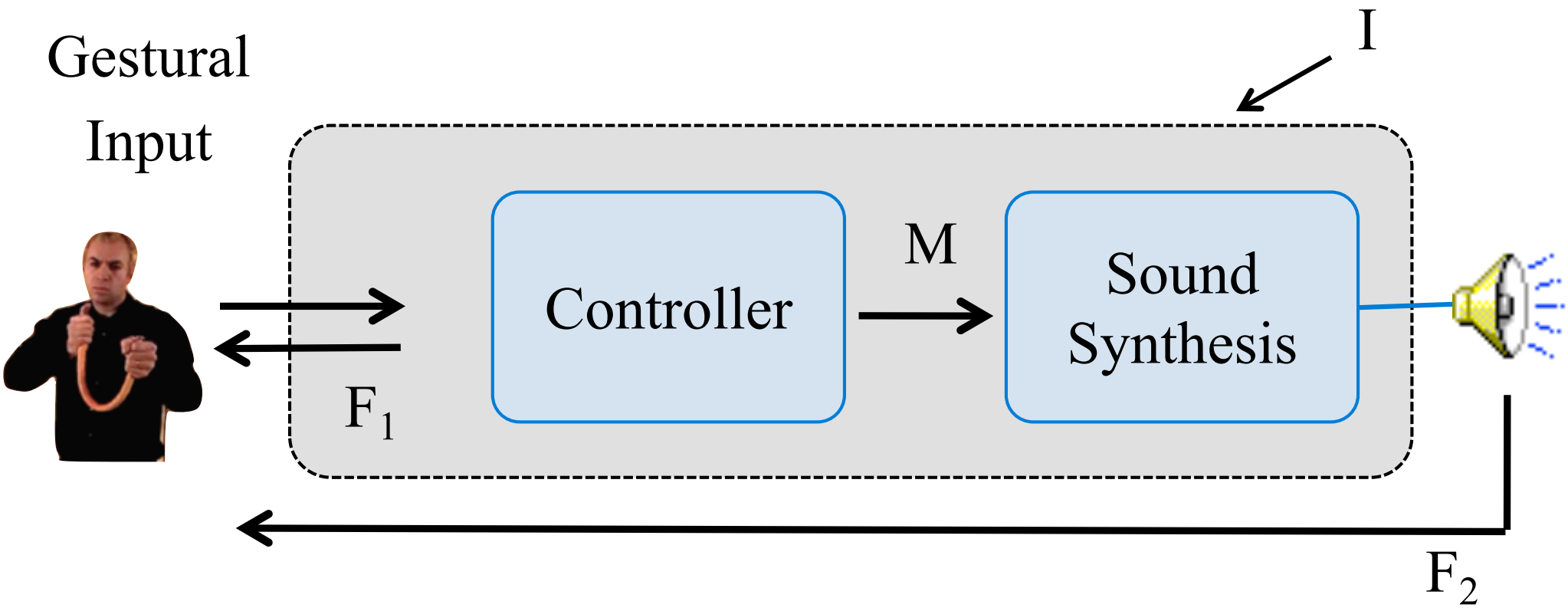
- Creating a NIME may be easy to do
- Creating a good mapping is hard
- Playing it well takes practice to be a virtuoso
  - some NIMEs created to be easy to play but not so expressive
- Without a piece, difficult to gain acceptance
- Often audience doesn't know what is going on
- Many explorations trying different ways to make music

Module 5: Musical Interface Theory



- Generic model of a musical interface
- Role of feedback from the interface
- Mapping problem

NIME – Generic Model



M : Mapping,

F_1, F_2 : Primary & Secondary Feedback

I : Interface

Based on: Miranda & Wanderley (2006)

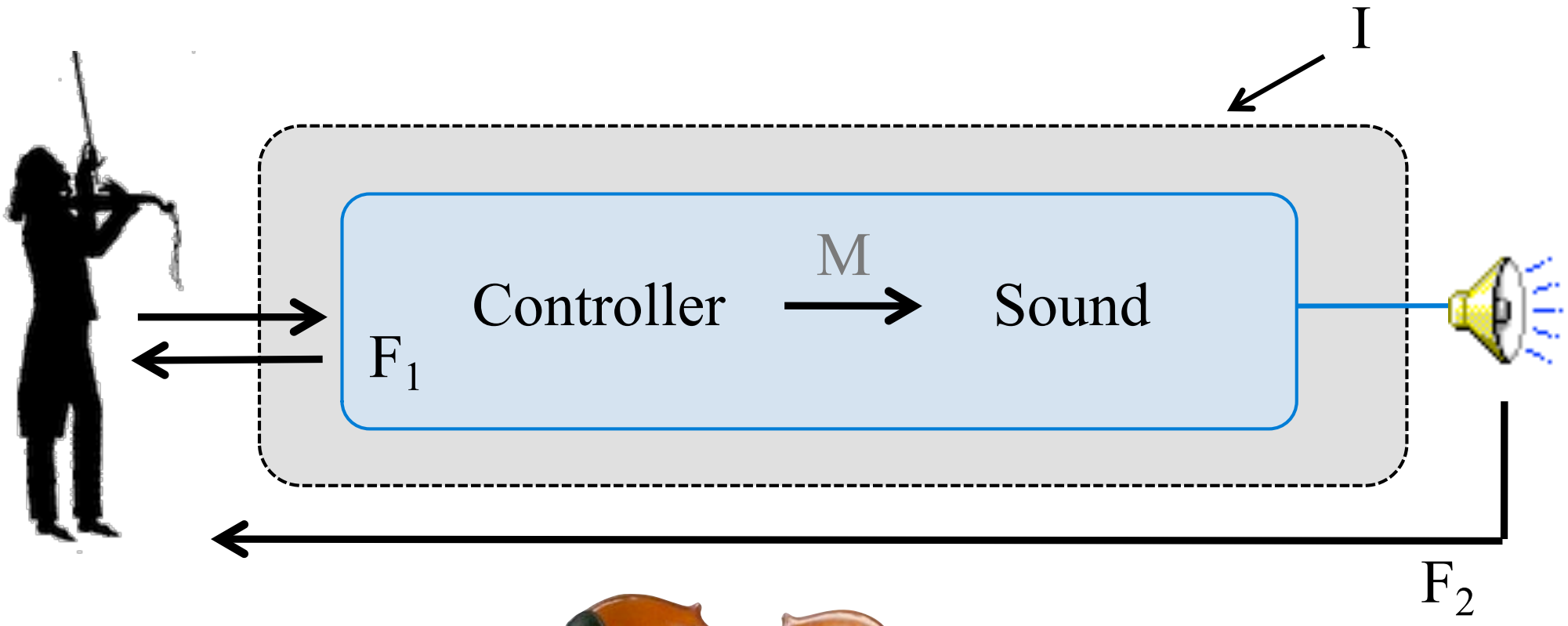
Feedback Design: F1 and F2

- Sound } F_2

- Tactile* } F_1
- Kinesthetic
- Visual**

- *Includes vibro-tactile feedback due to sound waves on the instrument
- ** Re: Module 2 on Visual Interfaces

Model: 'Traditional' Instrument



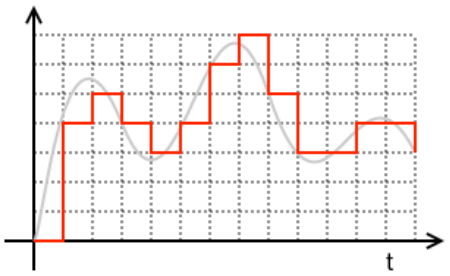
Gestural Input

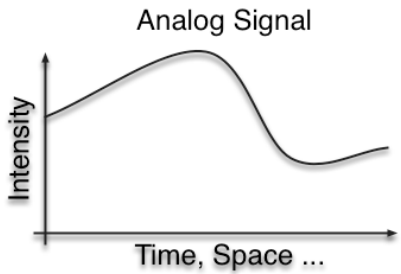
NIMEs decouple

- Control separate from Synthesis
- Mapping (M) is designed
- Feedback (F1 and F2) is designed
- Controller/Interface is designed

NIME representations

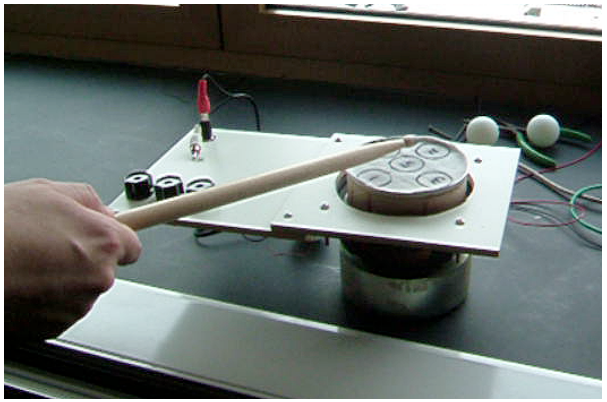
- discrete vs. continuous controllers
  - keys vs knobs
- acoustic vs electronic sound output
  - vibrating string vs. speaker
- digital vs analog representations
  - bits vs. voltage





NIME, DMI, Instrument

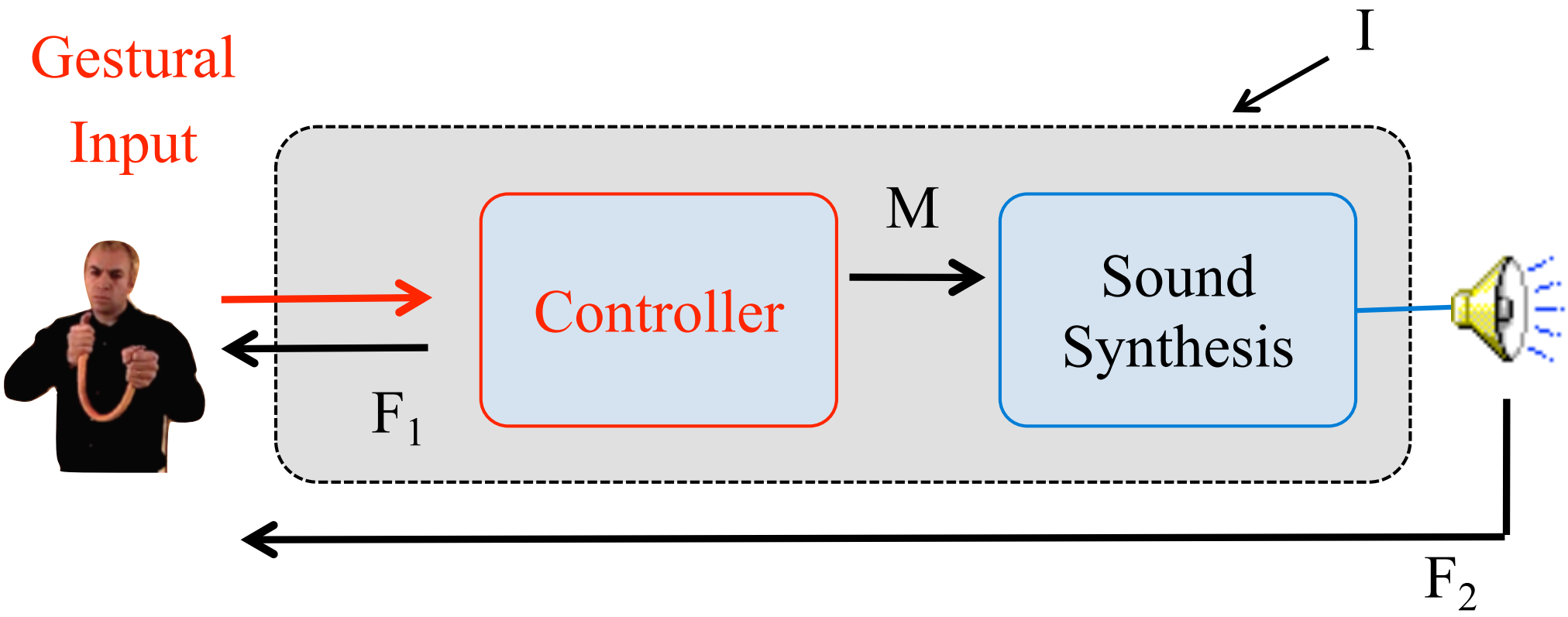
- **musical interface** and **nime** used interchangeably
- DMI – ‘Digital Musical Instrument’
- DMI & MI may be preferable because a NIME will not be new forever



Digital NIME

- Computer enables arbitrary design of interface behaviour:
  - controller
  - feedback (F1 & F2)
  - mapping (M)
  - synthesizer

Musical Interface – Generic Model



M : Mapping,

F_1, F_2 : Primary & Secondary Feedback

I : Interface

Based on: Miranda & Wanderley (2006)

Designing Controllers: Gestural Input

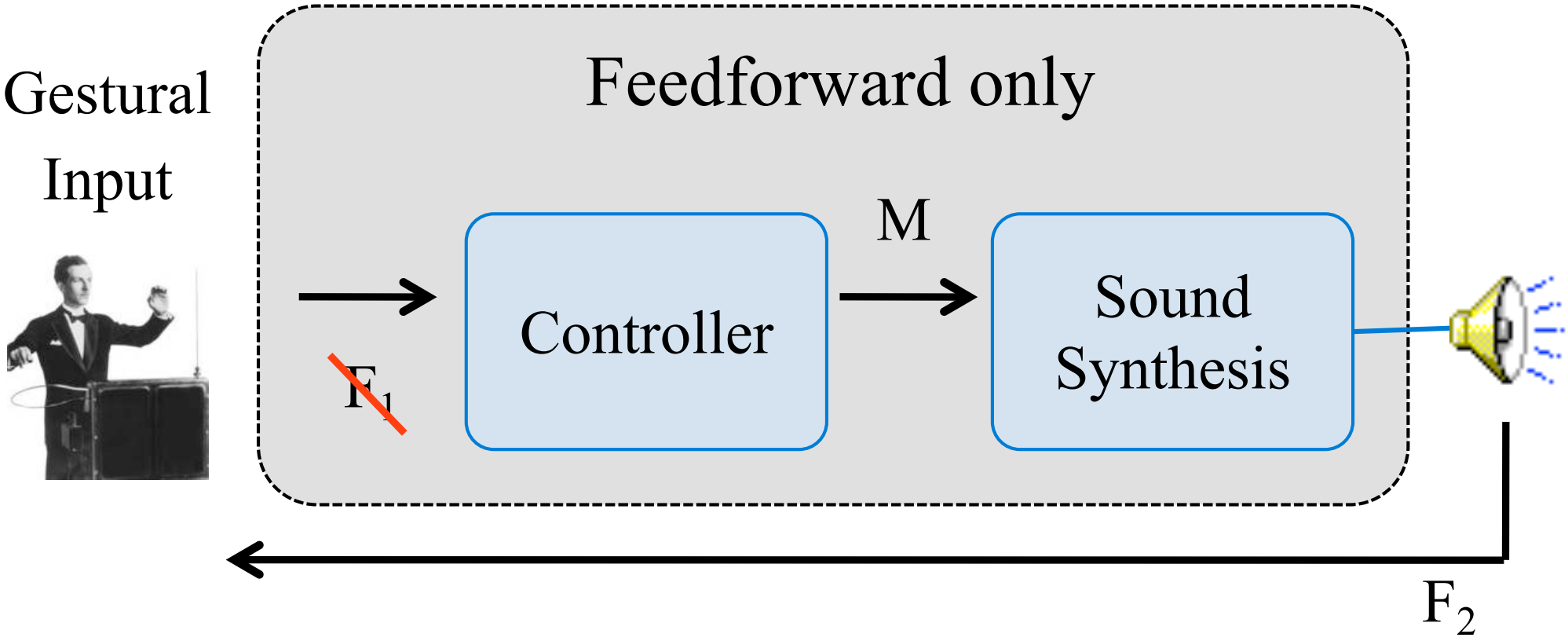
- Free gesture interfaces
  - no physical contact
- Physical contact interfaces
  - all acoustic instruments
- NIMEs can be in either

Free Gesture Interface

- Theremin (1919)
- Sound feedback (F_2) only
- No primary tactile
  or visual feedback (F_1)

- Have been few virtuosos
- Considered difficult to
  master

Léon Theremin



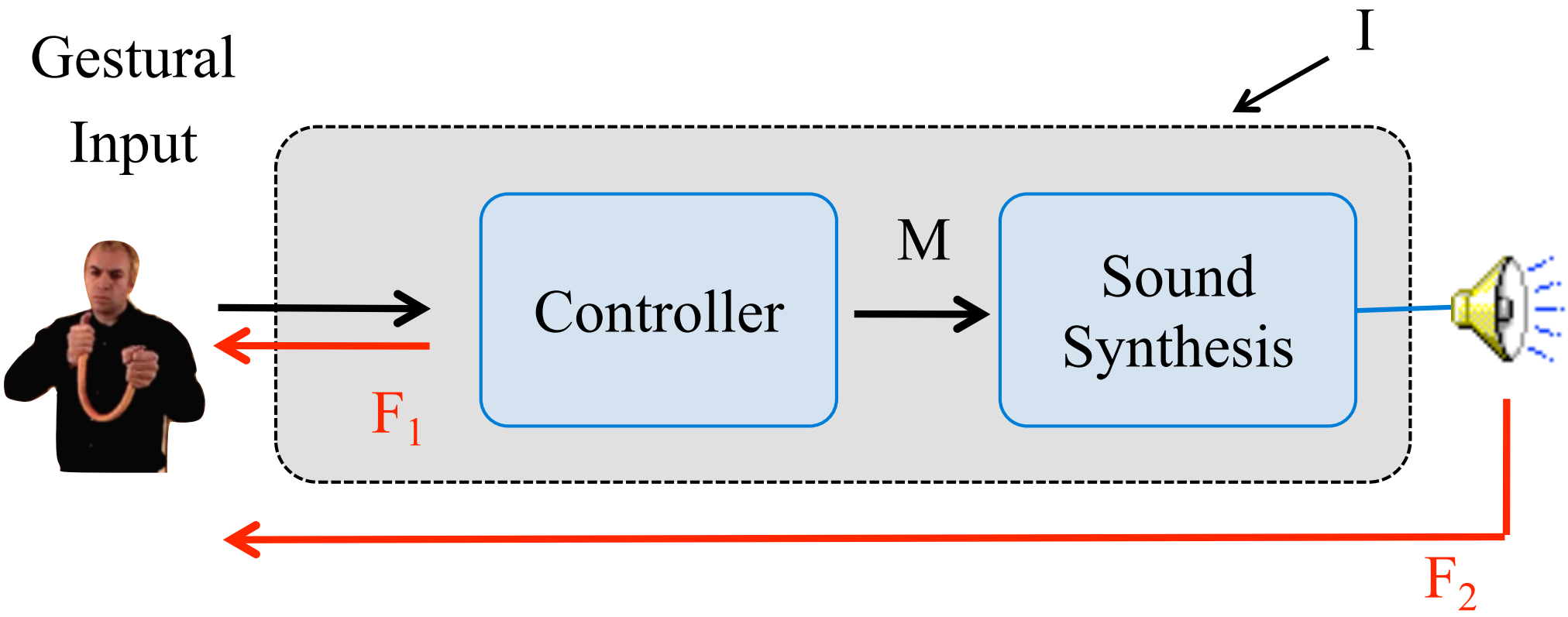
Theremin lacks significant primary feedback

The Hands

- Passive F_1

Michel Waisvisz *et al.*
STEIM, Amsterdam
(Studio for Electro-instrumental Music)

NIME – Generic Model



M : Mapping,

F_1, F_2 : Primary & Secondary Feedback

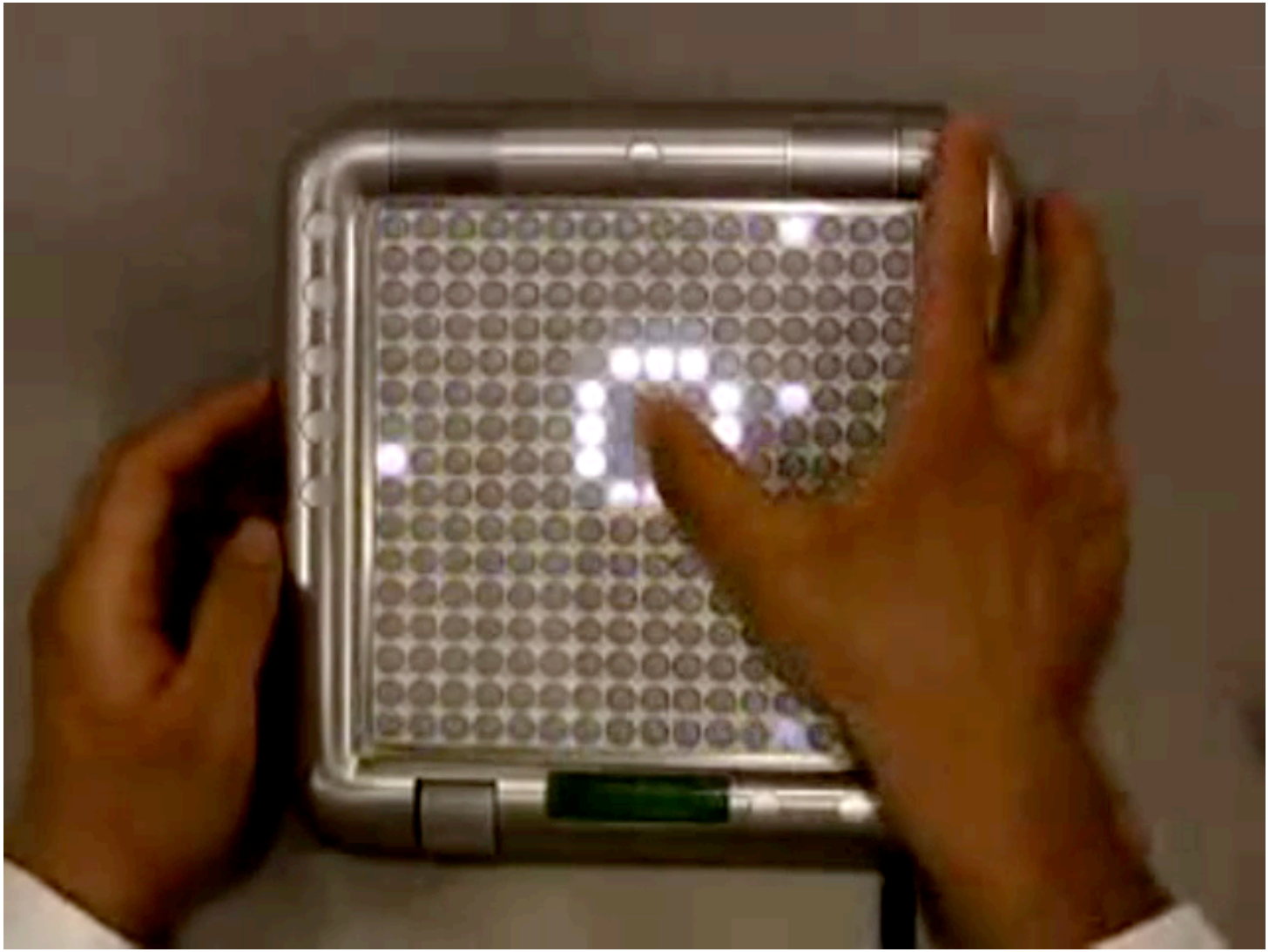
I : Interface

Based on: Miranda & Wanderley (2006)

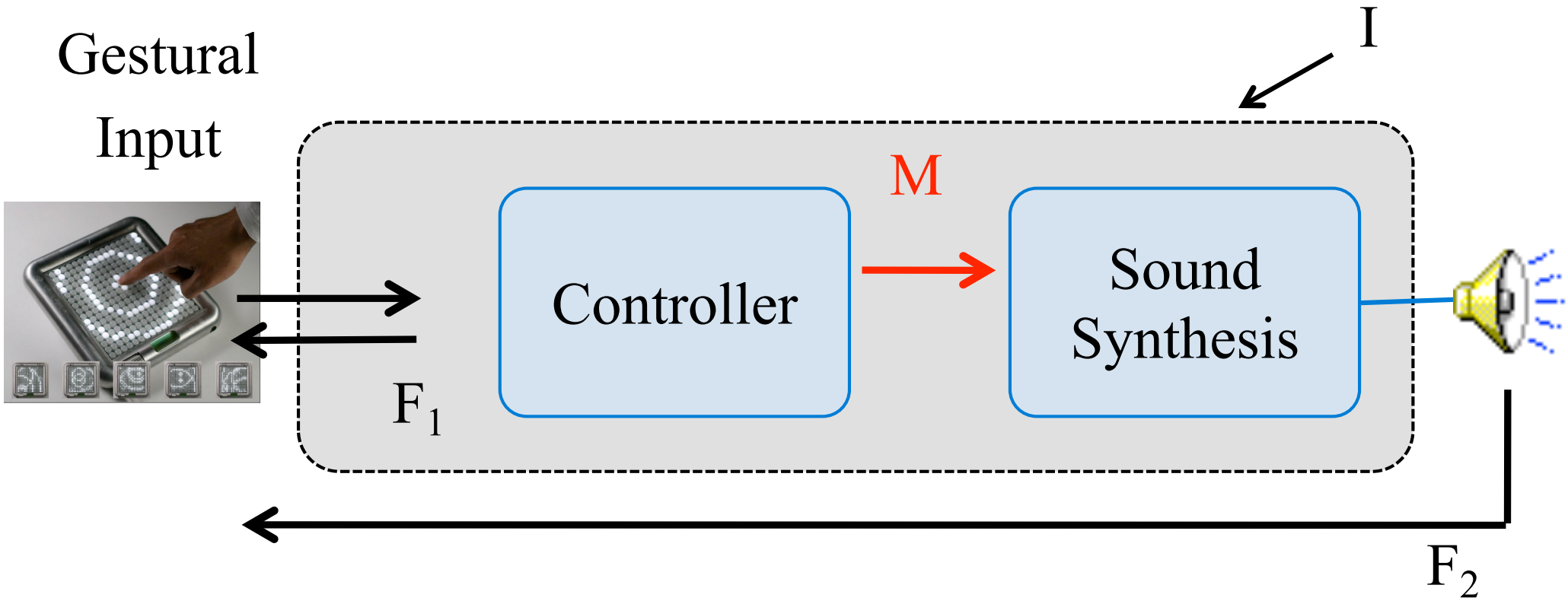
F_1 : Visual & Tactile Feedback

Nishiburi & Iwai NIME-06

Tenori-on



NIME – Generic Model



M : Mapping,

F_1, F_2 : Primary & Secondary Feedback

I : Interface

Based on: Miranda & Wanderley (2006)

Instrument Mapping

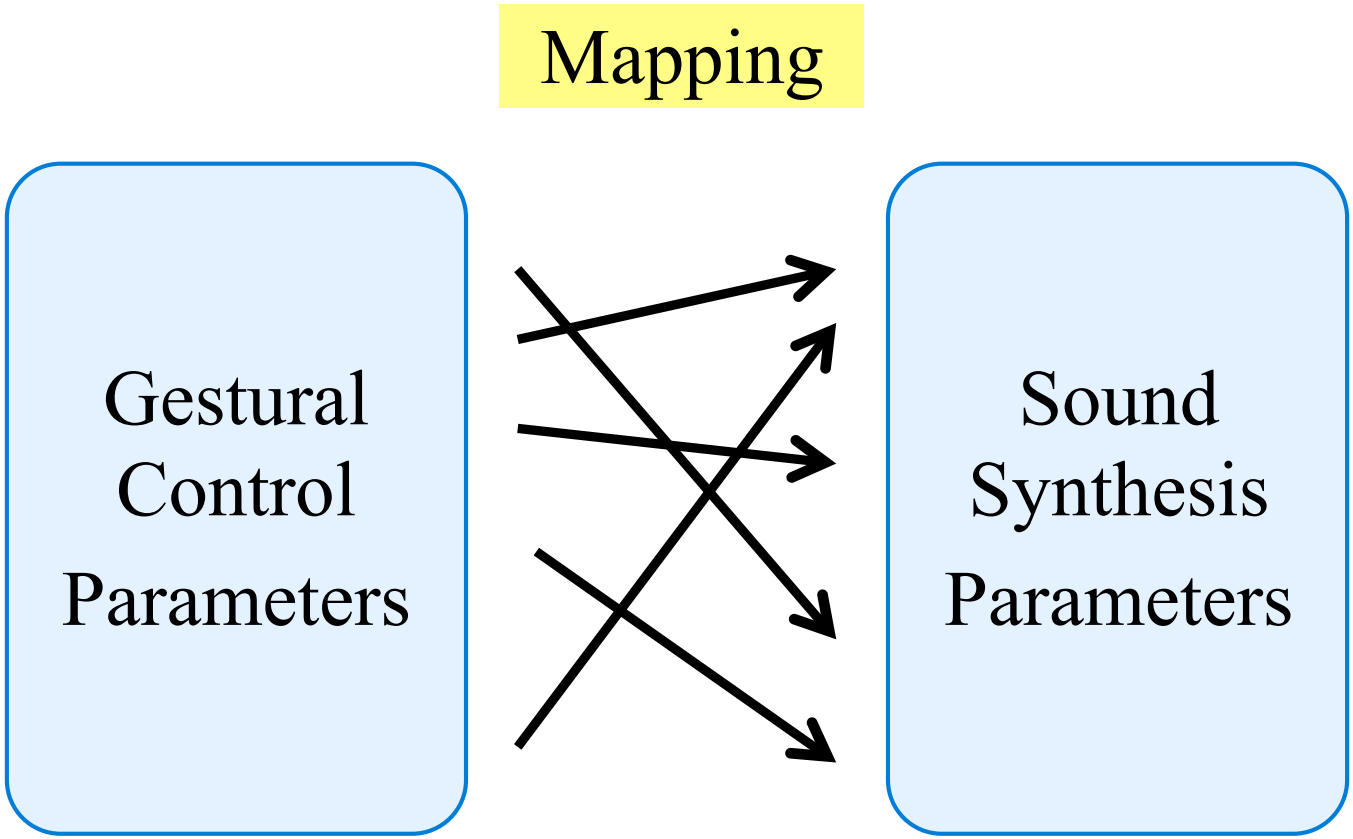
Shakuhachi

Fairlight CMI, 1980s T. Kriese

Polyphonic Digital Sampling Synth

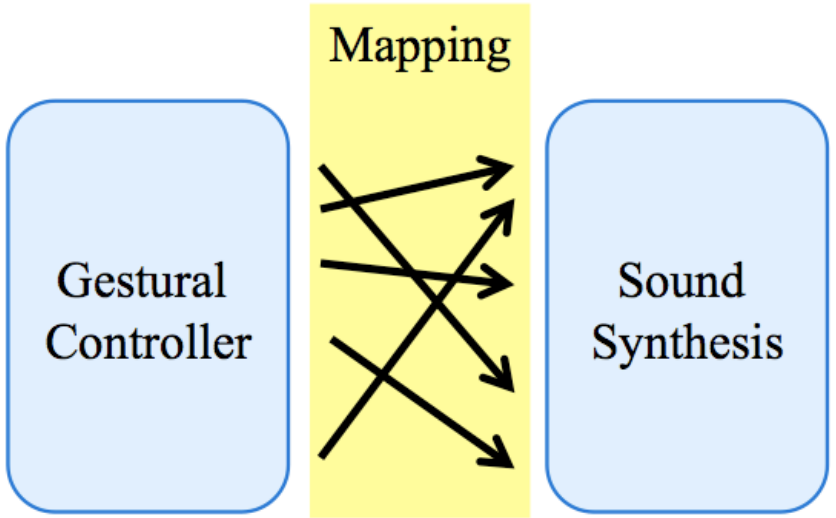
Matrix
(Overholt, 2001)

‘Mapping Problem’:
How to design the gesture to sound mapping?



‘Mapping Problem’:
How to design the gesture to sound mapping?

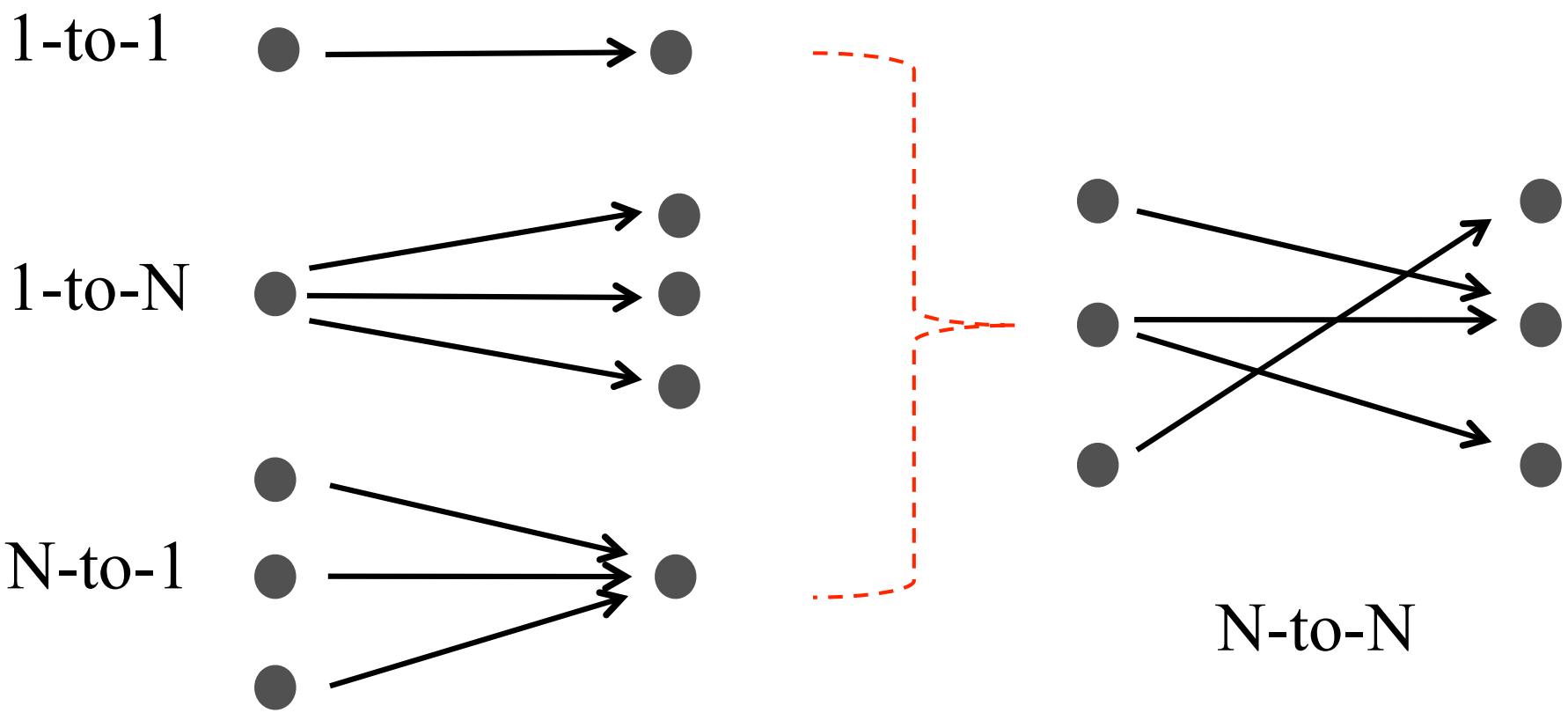
- Dimensionality
- Complexity
- Mapping Strategy
- Other aspects …



The mapping layer can be considered as the essence of a musical interface

Hunt, Wanderley, and Paradis (2003)

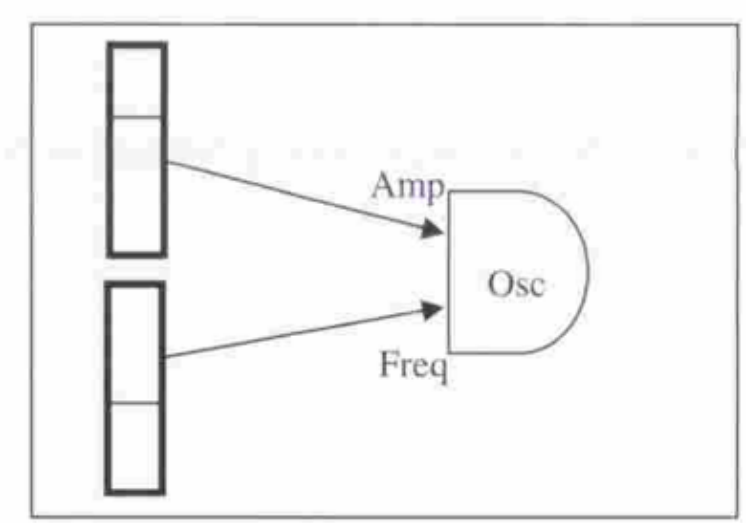
Dimensionality: Types of Mapping



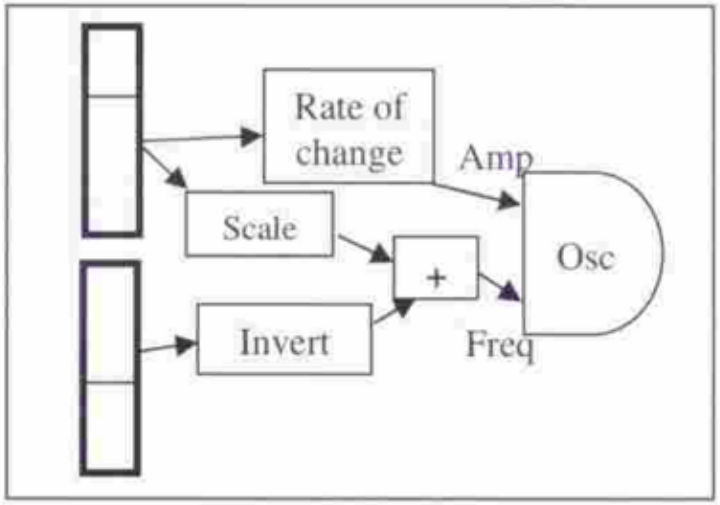
Gestural Parameters

Synthesis Parameters

Complexity:
Simple & Complex Mappings



Simple



Complex

Hunt, Wanderley, and Paradis (2003)

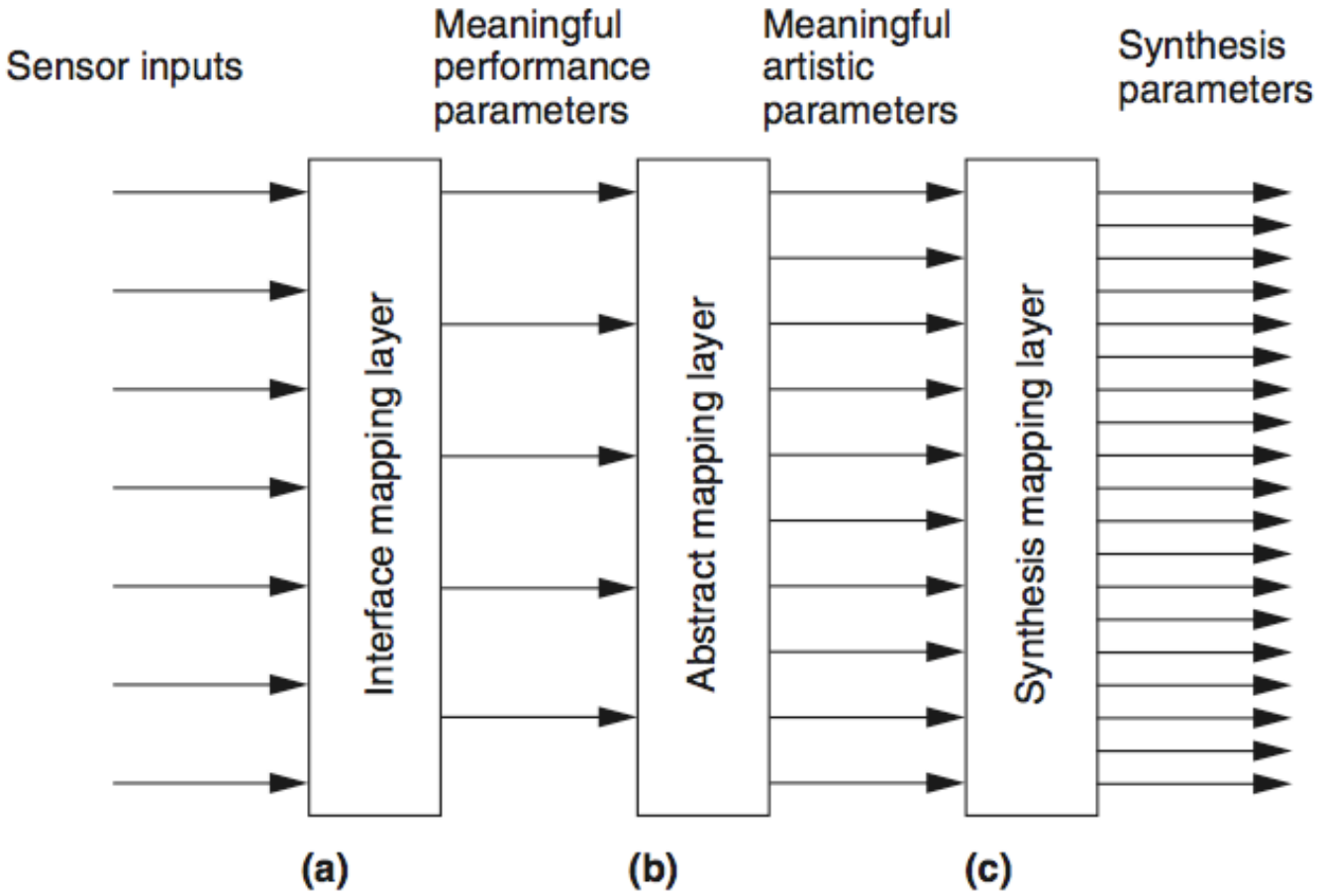
Mapping Complexity

complexity can lead to better expression

- 1 to 1 usually doesn't do the trick
    * not interesting
    * not enjoyable
    * not satisfying

Hunt, Wanderley, & Paradis, NIME-02

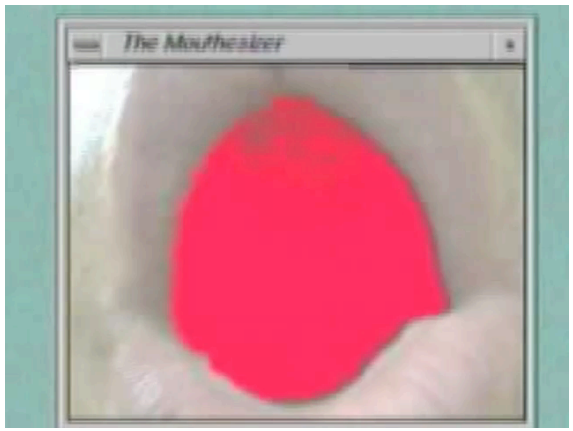
Understanding Complexity: Three Layer Mapping Strategy



Hunt, Kirk, and Neighbour (2004)

Abstract Mapping Layer example

Mouthesizer interface (Module 2: Camera-based Interfaces)
Controlling a Formant Filter using Mouth Shape



Lyons et al., NIME-03

Mapping Design Strategy

- Advantage to have a control interface which is based on the **perceptual qualities** of timbre spaces
- Better mapping leads to more playable interface

- How do we characterize playability?

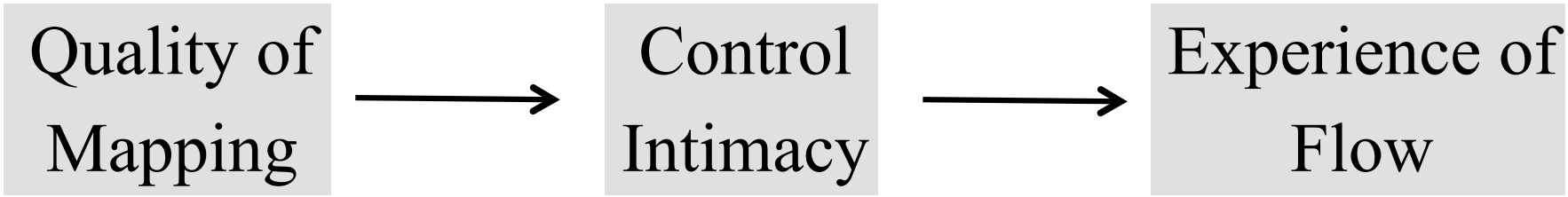
Musical Control Intimacy

"... the match between the variety of musically desirable sounds produced and the psycho-physiological capabilities of a practiced performer."

Moore (1988)

Control Intimacy depends on **gesture to sound mapping**

Flow in musical expression



- Special contact with the instrument
- Development of a subtle feeling for sound
- Feeling of effortlessness
- Playful & Free-spirited feeling handling of the material

A. Burzick (2002)

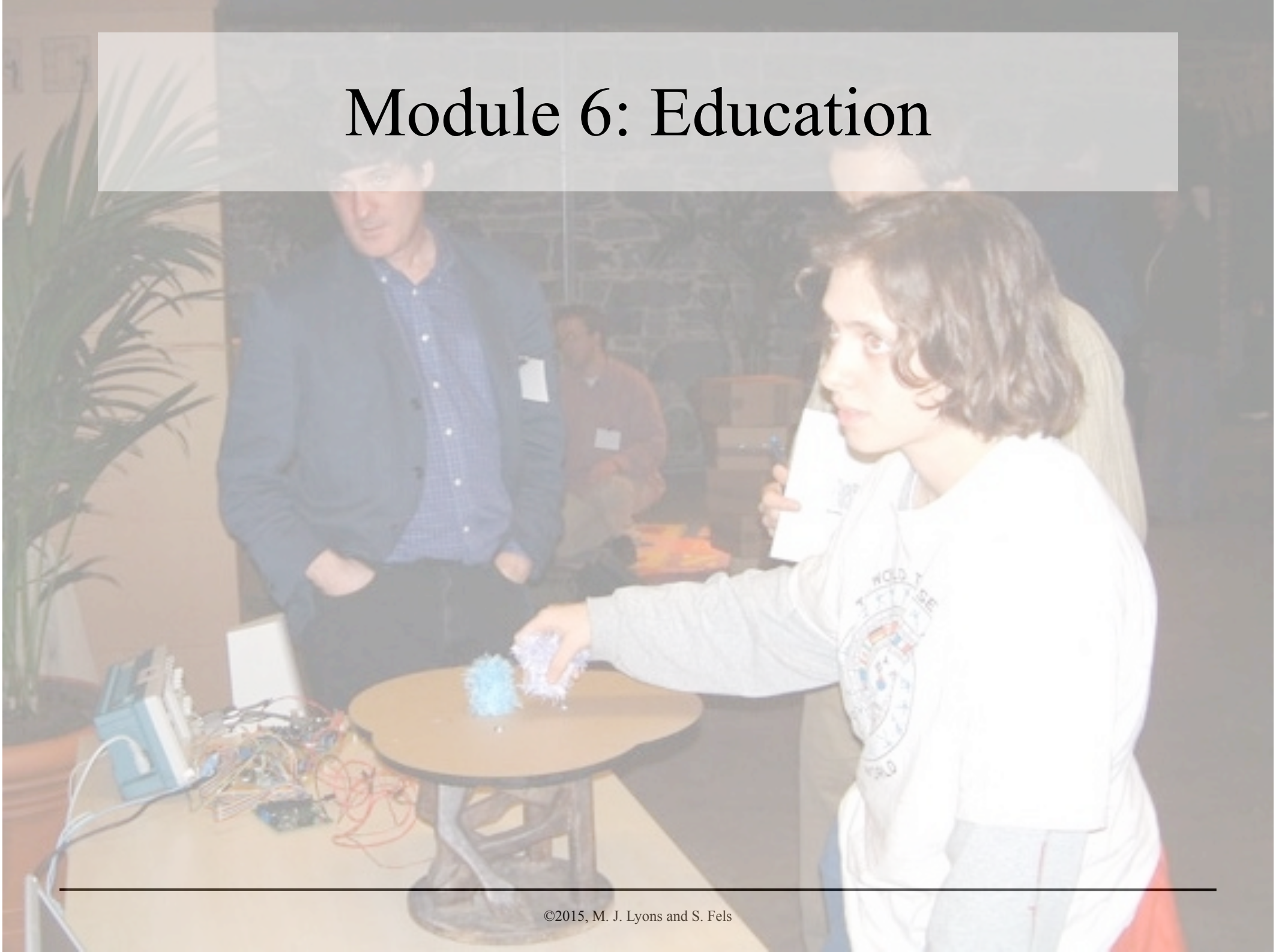
Threats to Intimacy

- Latency between gesture and sound
- Lack of primary feedback
- Poor mapping

Summary

- Generic musical interface model is helpful in understanding what makes & breaks a NIME
- Mapping constitutes the essence of a digital NIME
- Mapping is not straightforward and many design ‘strategies’ have been tried
- Multiplayer mappings can be better than simple one-to-one mappings
- Studies of mapping and feedback are core research topics of NIME

Module 6: Education



NIME is Multidisciplinary

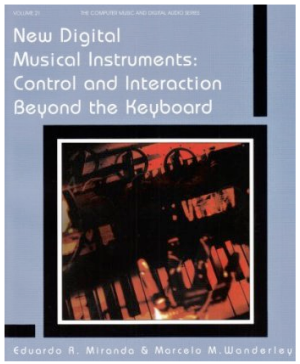
- Sound Synthesis
- Sensors, Effectors, Microcontrollers
- Basic Electronics
- Communication Protocols (MIDI, OSC, TCP etc.)
- Sound Synthesis and Processing
- Acoustics
- Human-Computer Interaction
- Music

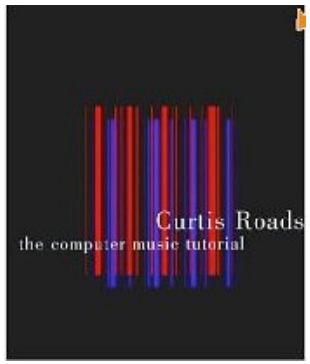
Where can you study this field?

- KAIST
- IRCAM, Paris
- CCRMA, Stanford
- CIRMMT, McGill
- Princeton, CS & Music
- NYU Interactive Telecommunications Program
- SARC, Queen's, Belfast
- Queen Mary, University of London
- Goldsmiths, University of London!

Specific Learning Resources

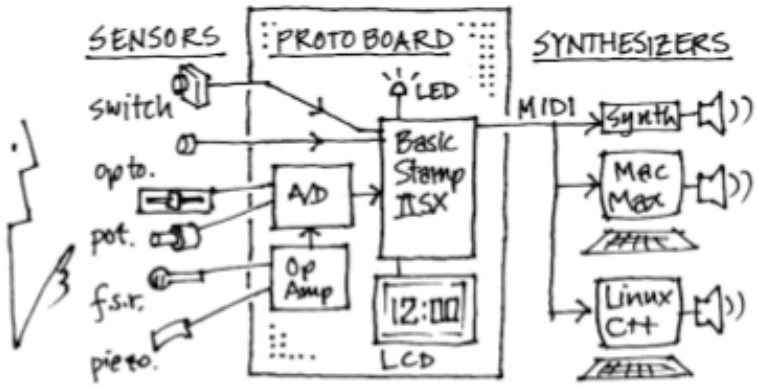
- Miranda & Wanderley (2006)
- Igoe (2007)
- Roads (1996)
- NIME Proceedings
- ICMC Proceedings
- Computer Music Journal
- Organized Sound
- J. New Music Research

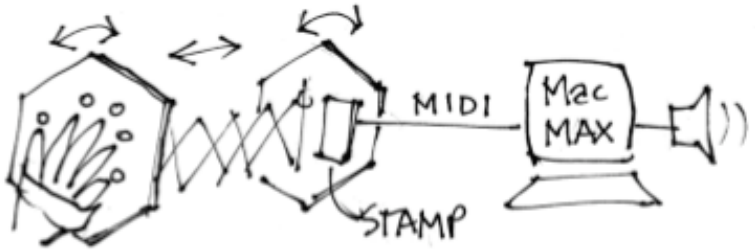




Typical Curricula

- beginning graduate or senior undergraduate level
- Courses tend to be project oriented
- Students learn what they need
- Live performance or Demo is necessary for completion of the course (ITP, CCRMA)





Verplank, Sapp, Matthews (NIME-01)

New Interfaces for Musical Expression

interactive telecommunications program

- NYU ITP NIME Course
- Master's program in design & technology attracting students from a wide range of backgrounds

Gideon D'Arcangelo

Hans C. Steiner

Jamie Allen

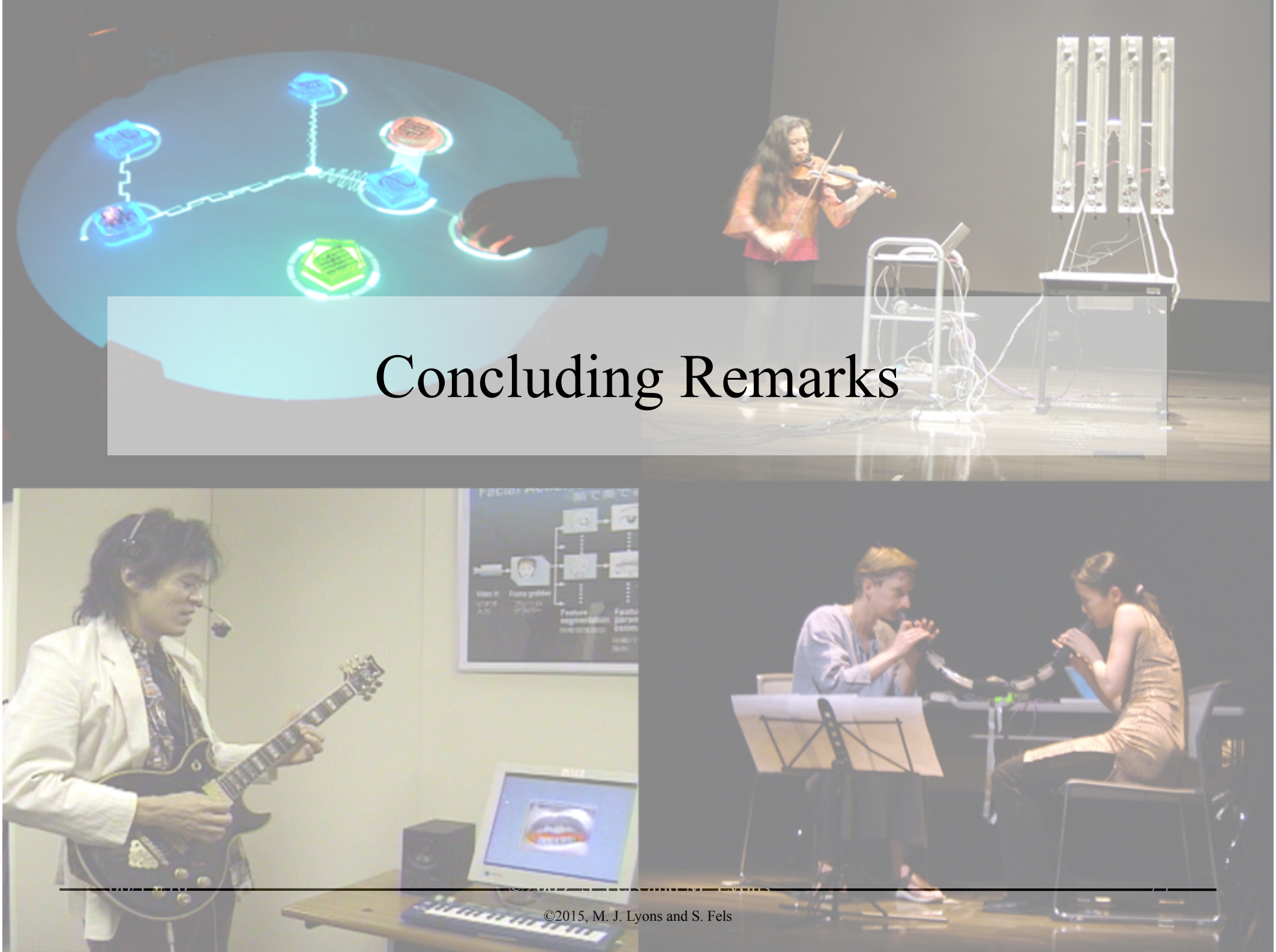
Taku Lippit (NIME-04)

NIME Curriculum - Topics

- Historical Survey of Musical Instrument Types
- Attributes of Musical Expression
- Music Theory and Composition
- Musical Interface Responsiveness
- Discrete vs. Continuous Controllers
- Gestures and Mapping
- Novice and Expert Interfaces
- Spectacle and Visual Feedback in Performance
- Collaborative Interfaces

Summary

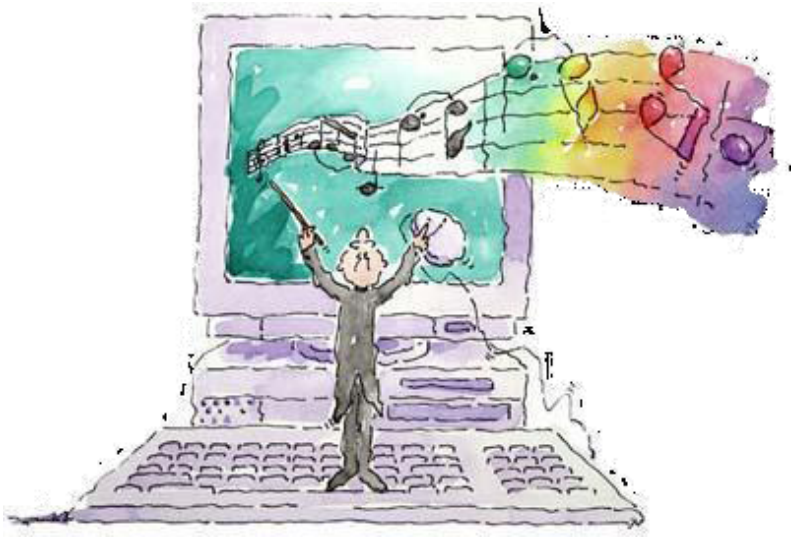
- Substantial resources for learning about NIME
- NIME courses are usually project based
- Number of universities offering programs of study is expanding
- Next frontier: high schools, science fairs



Concluding Remarks

How to Play the Computer?

- Computers offer a wide range of sound and music creation opportunities
- How can we create new interfaces to play computers in a way that is appropriate to human brains & bodies?



Musical Interface Grand Challenge

- Can we create new forms of technologically-mediated human expression that are matched to our physiology and psychology?
- How can these new *augmented expressions* contribute to the progress of human culture and civilization?




Here's how…

- NIME tools
- NIME principles
- NIME examples
- NIME theory
- NIME education

How to get involved

- NIME community
  - community@nime.org
    - subscribe with community-request@nime.org
- NIME website
  - www.nime.org
- ICMC website
  - www.computermusic.org/
- Contact us:
  - Michael Lyons, michael.lyons@gmail.com
  - Sidney Fels, ssfels@ece.ubc.ca
-

Bigger picture

1. introduced the theory and practice of NIME
2. NIME community is very accessible and growing
3. get to know some of the people of NIME
4. easy to start creating NIMEs and a lifetime of enjoyment to master
5. musical expression transcends gender and culture
6. if you are not having fun, it's probably not for you

Questions & Discussions

- Contact us:
  - Michael Lyons, michael.lyons@gmail.com
  - Sidney Fels, ssfels@ece.ubc.ca

www.nime.org

http://www.kasrl.org/chi2015_musical_interfaces.pdf