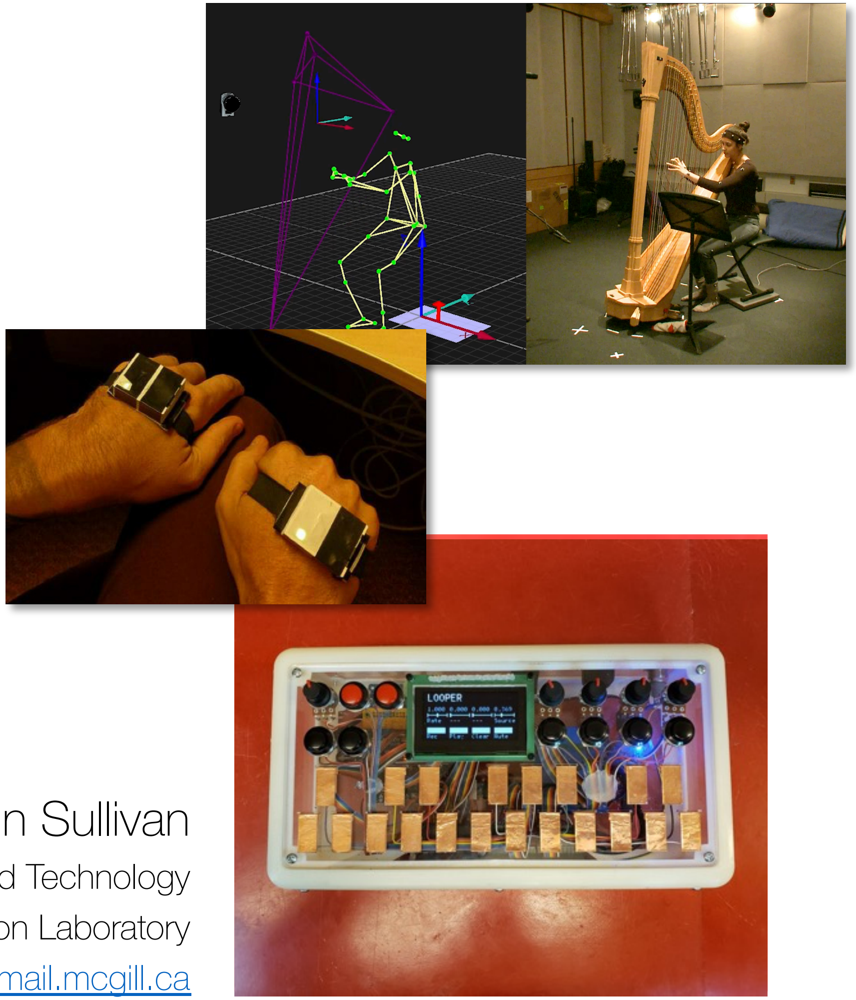
Modulo V:
Diseño de interfaces

Teorias y métodos de interaccion y performance

Principios de interfaces humano-maquina



John Sullivan
Centre for Interdisciplinary Research in Music Media and Technology
Input Devices and Music Interaction Laboratory
john.sullivan2@mail.mcgill.ca

About me:

- Ph.D. researcher: "Designing Digital Musical Instruments for Active Performers"
- Course lecturer, Schulich School of Music, McGill University, Canada
  - Audio programming with Max
  - New media design
- Performance background (bass guitar, keyboards)

Research overview:

- The design and evaluation of new digital musical instruments (DMIs) and interfaces that utilize:
  - digital technology,
  - computers,
  - embedded systems,
  - sensors and gestural control paradigms
  - sound synthesis
- Analysis of musically expressive gesture in instrumental performance
- Expanded use of, and applications for, new instruments, interfaces, and gestural interaction

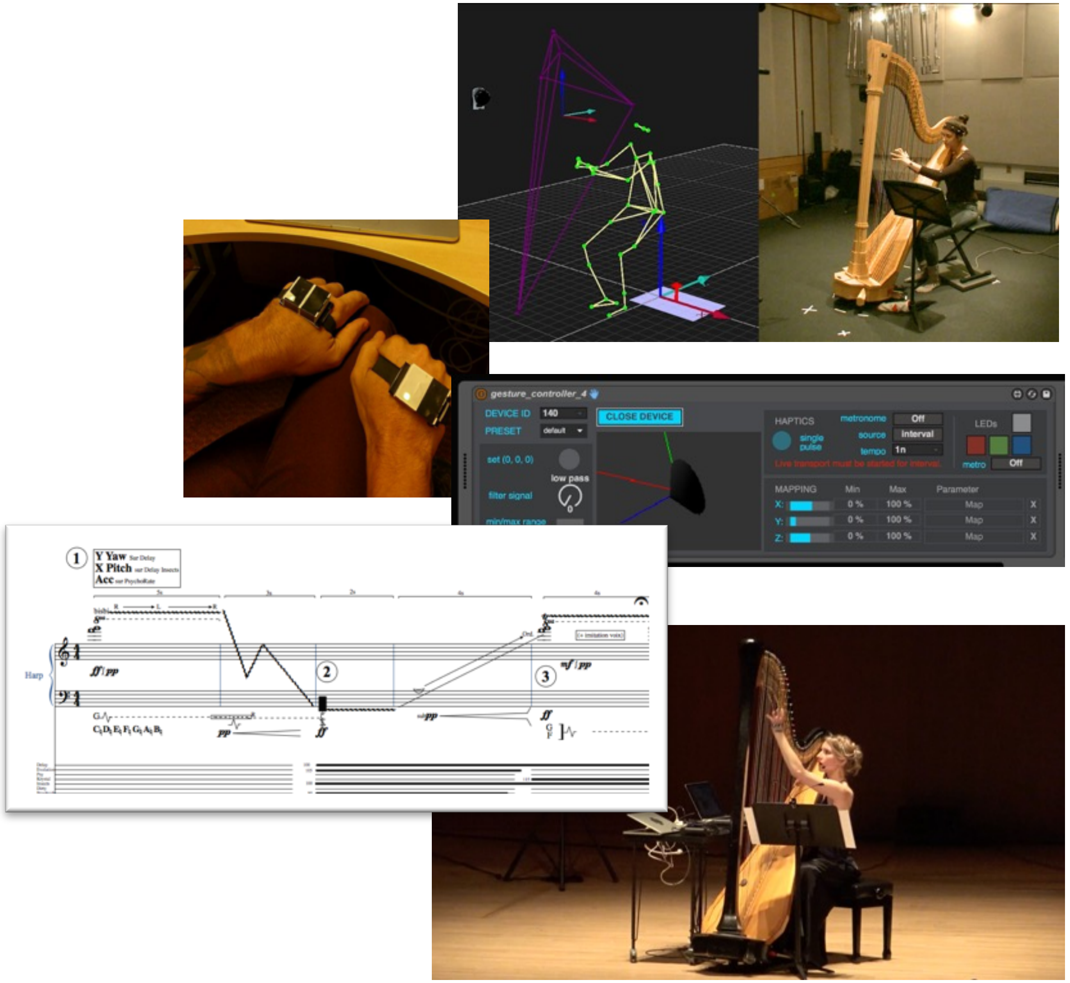
Previous Work: Gestural Control of Augmented Instrumental Performance

Concert Harp: A case study

- **Objective:** Design a gesture control system to augment instrumental performance, based on natural playing technique.

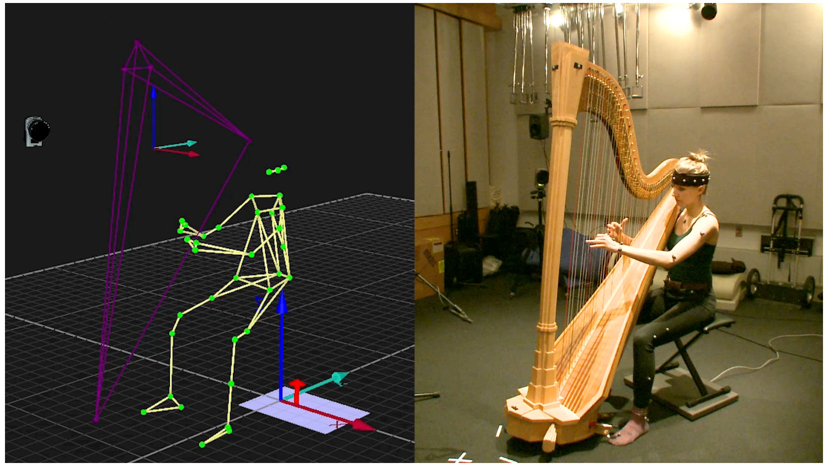
- **Criteria:**

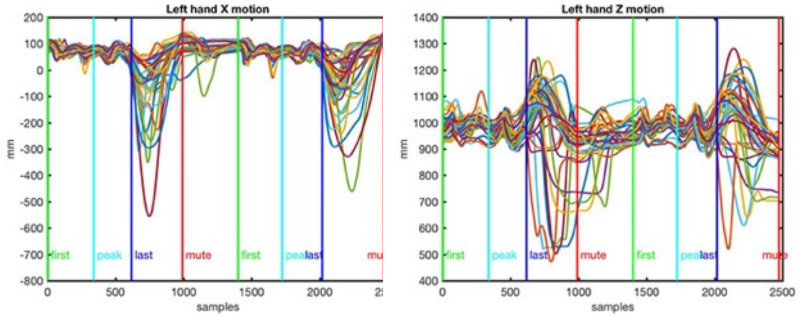
    1. Develop **simple** and **reliable tools** for <u>musicians</u> (who are not necessarily technologists) to use.
    2. Integrate easily into common live performance workflows.
    3. Leverage natural instrumental performance gestures



- *Sullivan, J., Tibbitts, A., Gatinet, B., & Wanderley, M. M. (2018). Gestural Control of Augmented Instrumental Performance: A Case Study of the Concert Harp. In Proceedings of the 5th International Conference on Movement and Computing - MOCO '18. Genoa, Italy.*

Phase 1
Motion Capture Study





Left hand X and Z position

Phase 2
Hardware/Software design

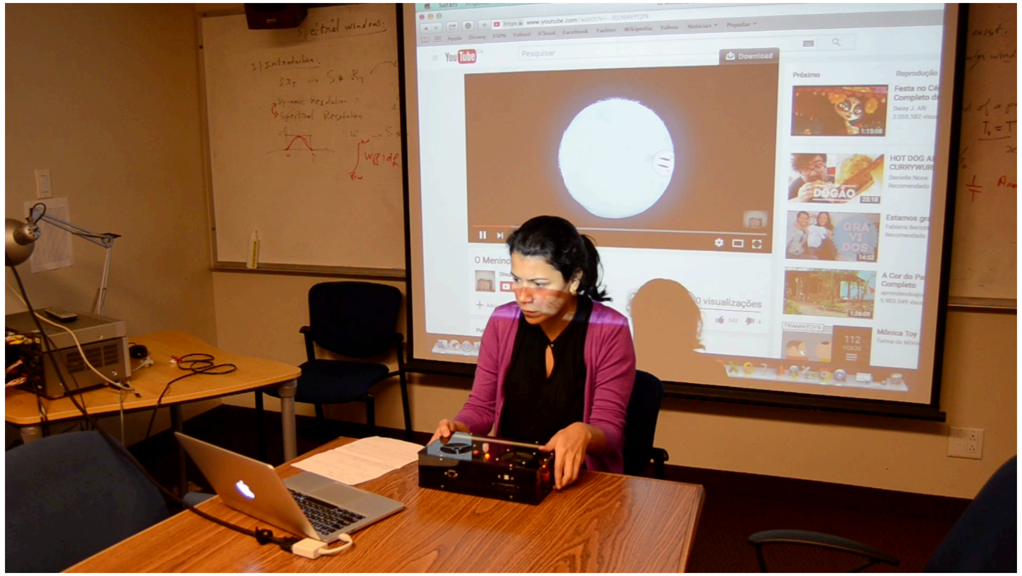
https://www.genkiinstruments.com/

Phase 3
Rehearsal & Implementation

Performance: ICLI ‘18 Porto

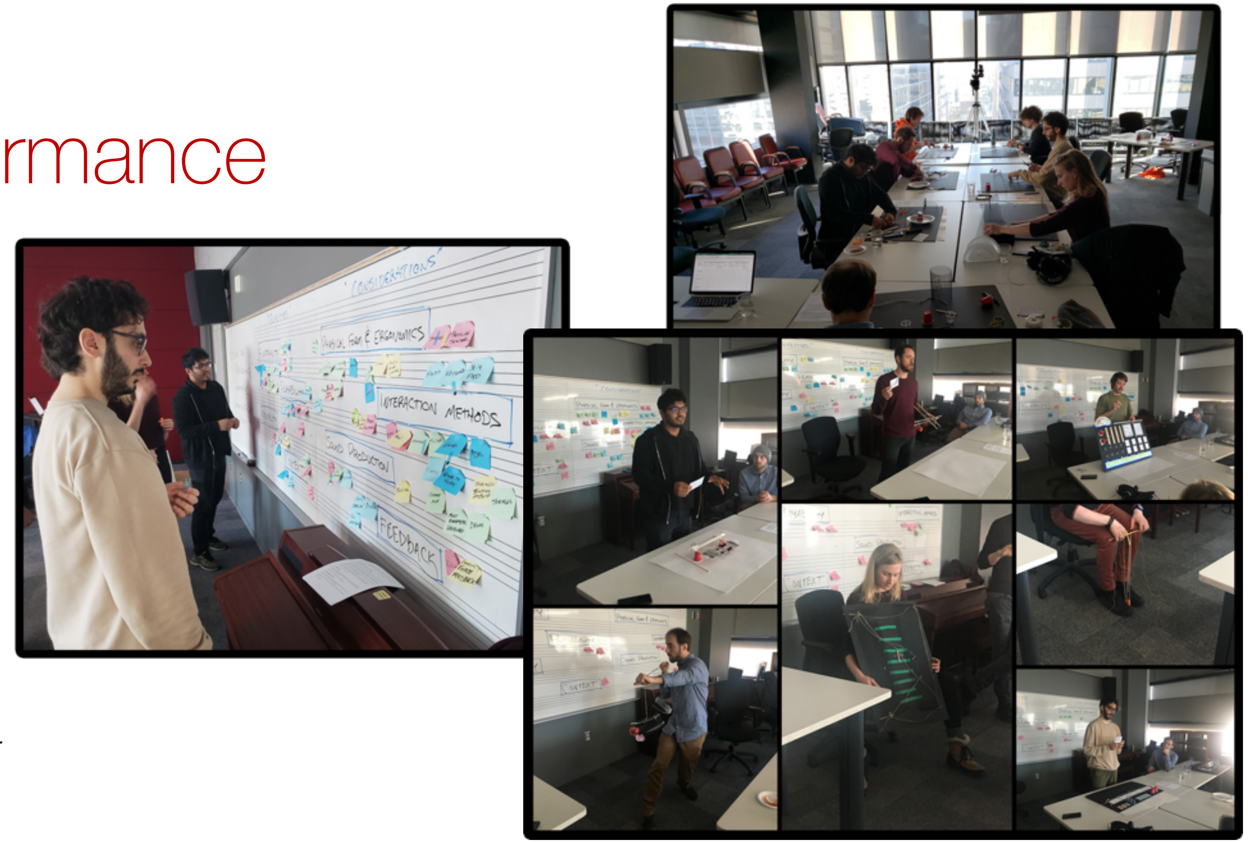
The Noiseboxes

- Stand-alone DMI.
    - Prynth framework RasPi/SuperCollider
    - https://prynth.github.io/
- Transfer and extend some of the characteristics of acoustic instruments:
    - Coupled user control and sound production
    - Make music instantly (low entry fee)
    - Augment with gestural control of sound synthesis parameters
- Pilot study to examine how users develop new performance techniques and emergence of individual style.
- Video analysis of performance gesture.
- Longitudinal study to learn about long term engagement with novel interfaces and DMIs.



- *Sullivan, J. (2015). Noisebox : Design and Prototype of a New Digital Musical Instrument. In International Computer Music Conference (ICMC). Denton, US. (pp. 266–269).*

Current Work: Design for Performance

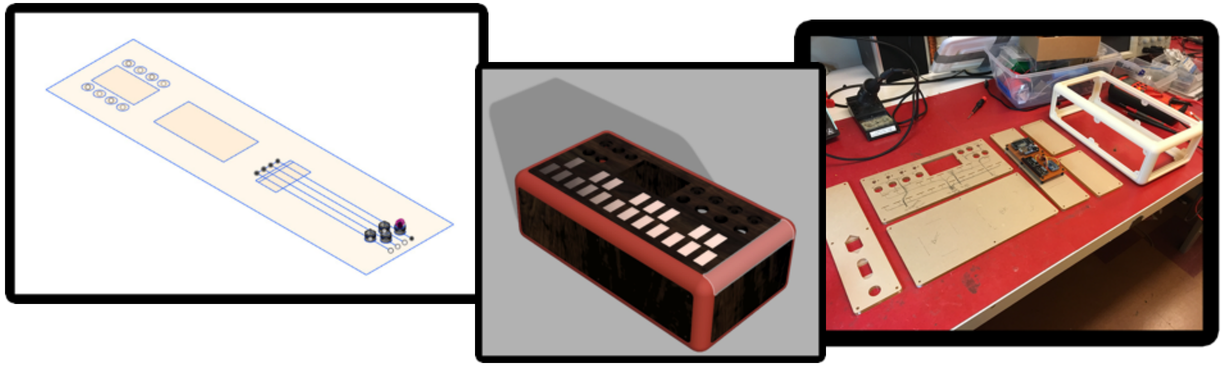


A participatory approach to digital musical instrument design

- Co-design workshops with musicians
  - #1: Creation of non-functional prototypes

    >>> develop multiple new DMIs
  - #2: Evaluation of prototypes, selection of final criteria

    >>> finalize design
  - #3: Evaluation and approval of finished instrument
- Longitudinal Study
  - Tracking performers as they work with the instrument



New Work: The Bionic Harp

Objective: Co-design a new control interface for concert harp

- In collaboration with harpist Alexandra Tibbitts
- Direct instrument augmentation vs. freehanded gesture
- Integrated, wireless control surface to easily connect with audio software via MIDI and OSC.
- Iterative design utilizes rapid prototyping techniques to quickly develop and test ideas
- Evaluation and feedback via focus groups of harpists

Expected outcomes

- Development of a well-tested interface fit for active use in performance
- live@CIRMMT concert performance in February 2020
- Contributions to the field:
  - Active research on augmented instruments and expanded harp practice
  - Towards design recommendations for development of DMIs intended for active use*
  - Towards a refined methodology for participatory design of new musical interfaces

* *Sullivan, J., & Wanderley, M. M. (2019). Surveying Digital Musical Instrument Use Across Diverse Communities of Practice. International Conference on Computer Music Multidisciplinary Research (CMMR). Marseilles, France.*

Musical Interface Design

I. Interfaces, Controllers, DMIs and more
   a. A model of a Digital Musical Instrument (DMI)
   b. Taxonomy of musical interfaces

II. Designing gestural controllers
   a. What is Musical Gesture
   b. Gesture Acquisition
   c. Mapping
   d. Feedback
   e. Hardware and fabrication
   f. Designing the interface

III. Workshop: Design for Performance

“Electronic String Spyre”,
Laeticia Sonami

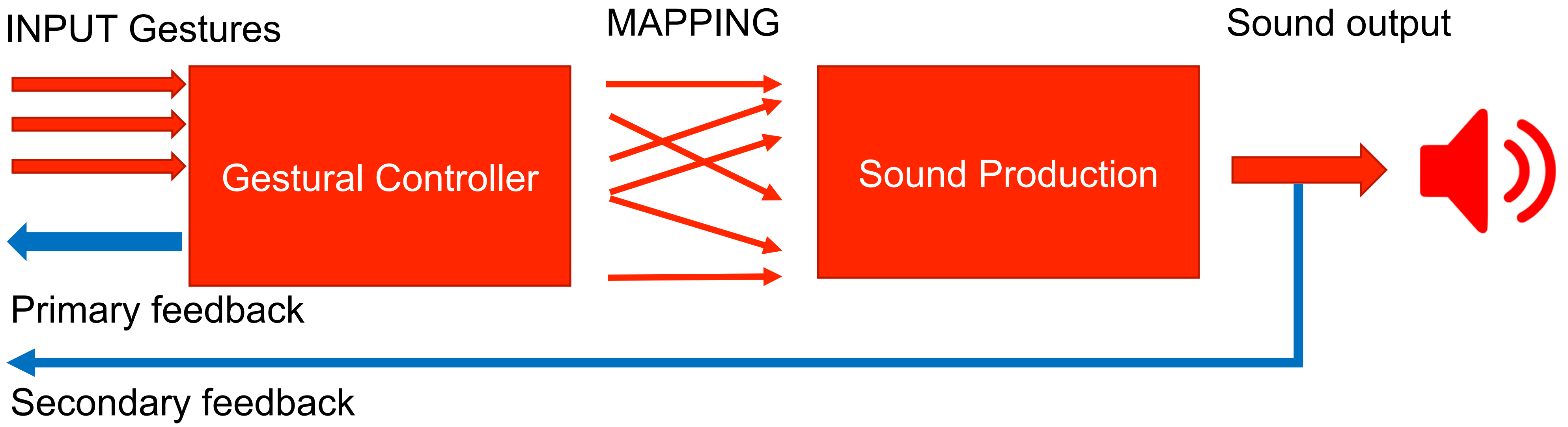
Interfaces, controllers DMIs and more

- In the last 100 years (+/-), new technologies have made it possible to synthesize and process sound (music) in ways not directly linked to mechanical processes and acoustic properties of materials.

- Importantly, the controller and sound generator are no longer acoustically coupled.

- Using standardized digital protocols like MIDI and OSC, many different types of user interfaces can be connected to control the sound generation.

A Digital Musical Instrument (DMI)



- a DMI denotes an instrument that contains the following parts:
  - a gestural **controller** (or input device, user interface, control surface)
  - **sound generation** unit
  - **mapping** strategies relate the two parts
  - **feedback** provides the performer information about their performance

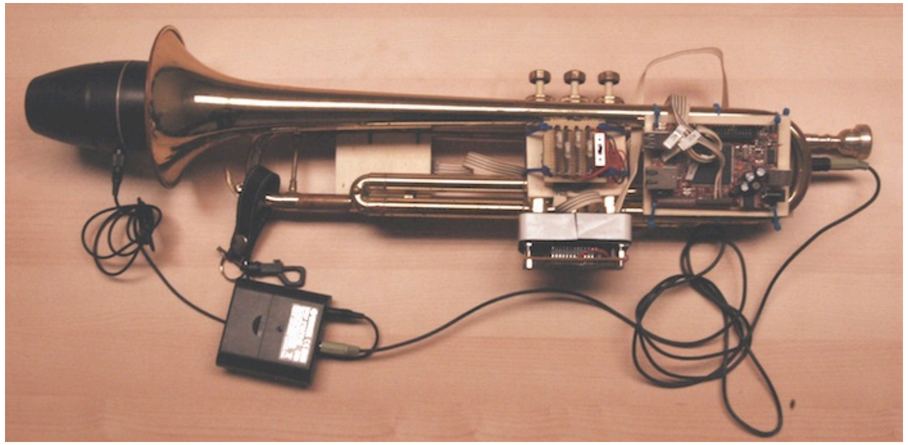
Musical Interfaces

- We can classify gestural controllers into categories based on their similarity to existing instruments.

1. Augmented musical instruments
2. Instrument-like gestural controllers
3. Instrument-inspired gestural controllers
4. Alternate gestural controllers

1. Augmented Musical Instruments

- also referred to as extended or hybrid instruments, or hyper-instruments
- existing acoustic or electric instruments equipped with additional sensors to provide more gestural parameters to map to synthesis or sound processing.
- instrument retains its default features/sounds/playability
- Common sensors used: pressure and bend sensors, buttons, switches, accelerometers, air pressure sensors (for wind instruments)
- common examples include augmented flutes, trumpets, guitars, pianos, drums, violins.



Augmented trumpet (Thibodeau, 2015)

2. Instrument-like Controllers

- seek to model an existing acoustic instrument as closely as possible.
- leverages playing techniques of existing instruments (more people will know how to play it)
- can create different sounds with familiar instrument, ie. play electronic sounds with a bowed string instrument.
- control of certain parameters may not be well matched (articulation and timbre modulation is hard on a keyboard, for instance)

- most common example are keyboard MIDI controllers, and wind controllers.

Akai EWI 5000 Wind Controller

3. Instrument-inspired Controllers

- designs are directly derived from or inspired by existing instruments
- but don't seek to directly reproduce existing instruments exactly
- existing playing techniques may partially be applied to these controllers but not completely.
- may be designed to overcome intrinsic limitations of existing instruments

- examples include the Radio Baton (Max Mathews), VideoHarp, expanded keyboard controllers

Haken Continuum

“Radio Baton”, Max Mathews, early 80s

“Eigenharp”, 2009

“Axis-49”, C-Thru Music, 2009.

4. Alternate Controllers

- not directly modeled on or necessarily inspired by existing acoustic instruments.
- Can take many different forms and offers a great variety of design possibilities.
- Classification according to some of their features (Mulder, 2000):
    - Touch controllers
    - Expanded range controllers
    - Immersive controllers

- some examples include the PebbleBox, Lemur, GyroTyre

The Hands (Waisvisz)

https://youtu.be/SIfumZa2TKY

“Reactable”, MTG, 2010

https://www.youtube.com/watch?v=0h-RhyopUmc

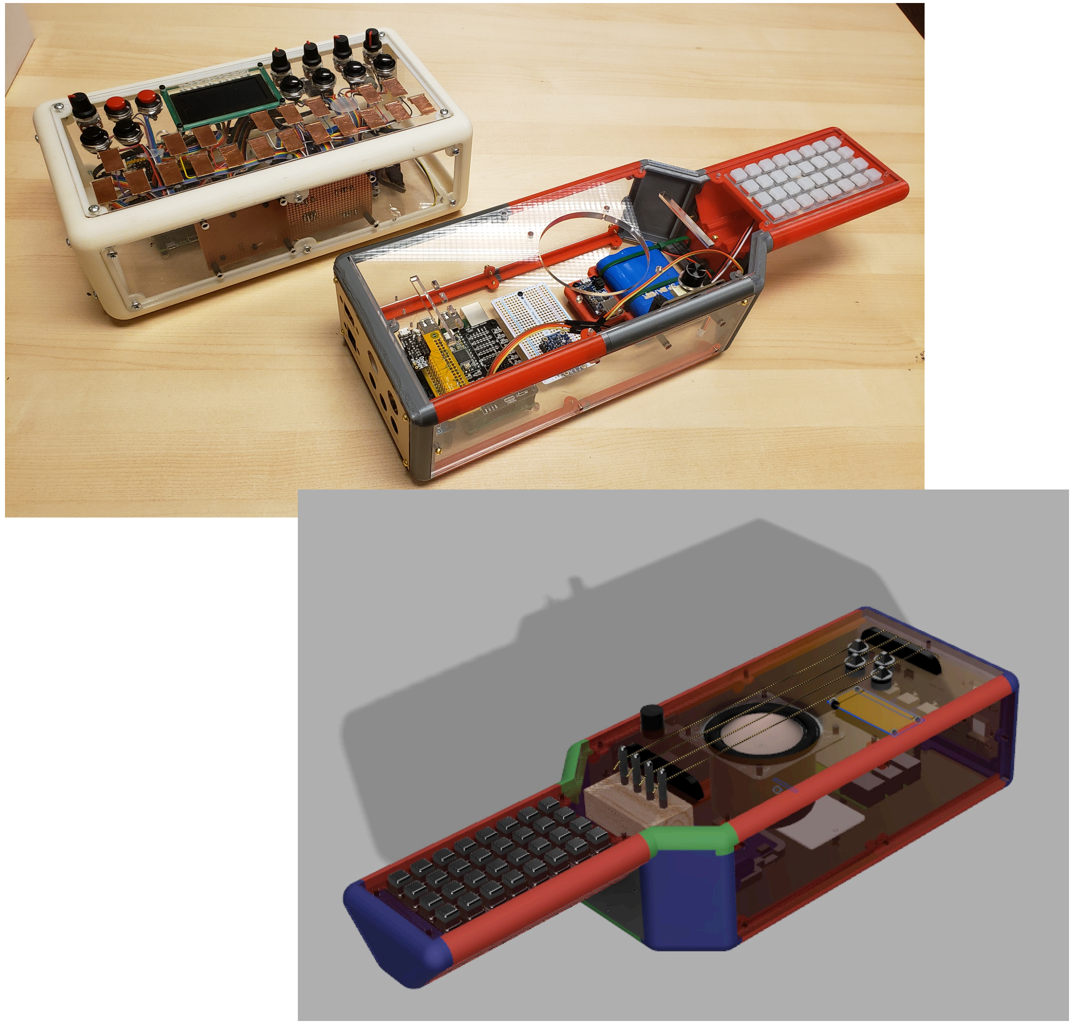
“Monome”,
Crabtree & Cain,
2005.

“AlphaSphere”,
2013

“Buchla Thunder”,
Don Buchla, 1990.

“The Mitt”, Ivan Franco 2016.

“Noisebox v3 & Stringbox”, John Sullivan, 2019.



Musical Gesture

- Gesture is studied across many research communities in a wide variety of contexts (language, semiotics, neuroscience, to name a few), and the term may be used to refer to:
  - empty-handed movements (motioning during speech for example), manipulation of objects or tools, general body movements, facial expressions, dynamic contours in music perception and performance, even sensations of touch, taste and feel.
- Physical gestures can be simply classified into two groups:
  - Empty-handed (free, semiotic, or naked gestures)
  - Manipulation (ergotic, haptic, or instrumental gestures)

Musically speaking, **gesture** is the term we may use to mean any human action used to generate sounds.

Classification of gesture

There are a variety of similar classifications for musical gesture.

- Delalande (1988)
    - Effective (sound producing)
    - Accompanist (non-sound producing body movements)
    - Figurative (perceived by listener)
- Cadoz (1988)
    - Instrumental gesture
        - *ergotic*
        - *epistemic*
        - *semiotic*
- Wanderley, et al. (2000, 2004, 2006)
    - Instrumental (sound producing)
    - Ancillary (non-sound producing)*

A gestural controller can be very well-suited for acquiring ancillary gestures, which are known to convey expressiveness in performance and can thus be translated to additional variables for sound generation and control.

- https://www.youtube.com/watch?v=qB76jxBq_gQ
- https://www.youtube.com/watch?v=aEkXet4WX_c
- https://youtu.be/4izN85WS49I?t=815

Gesture Acquisition

- Gesture can be captured in at least 3 different ways:
  - direct acquisition (using sensors to measure the physical actions of the performer)
    - pressure
    - linear or angular displacement
    - acceleration
  - indirect acquisition (analyze the structural properties of sound being produced by the instrument/performer)
    - short-time energy
    - fundamental frequency
    - spectral envelope
    - amplitudes, frequencies and phases of sound partials
  - physiological acquisition (biosignals – brain (EEG), neuromusciular (EMG), skin conductance (GSR), etc.)

Mapping

Unlike acoustic instruments, mapping relationships are not predefined, and for a DMI, they can be far from obvious.

Parameter mapping: The designer must relate the input variables to sound and control parameters of the synthesizer or software.

“We consider mapping to be an integral part of a DMI. In fact, it defines the DMI’s essence.”
(Hunt, Wanderley & Paradiso, 2003)

2 primary mapping strategies:

- Explicit mapping strategies (most common)
- Use of machine learning, feature extraction, or pattern recognition as tools to perform mapping

Explicit mapping strategies

- Generally described as a *few-to-many* relationship (few sensor control signals, many synth/sound processing parameters).
- There are three basic strategies to follow:
    - one-to-one: one synth parameter is driven by on gestural parameter (simple)
    - one-to-many: one gestural parameter influences various synth parameters at the same time (complex)
    - many-to-one: one synth parameter is driven by two or more gestural parameters. (complex)
    - (also many-to-many, but less common) (complex)
- Complex mappings, while less suitable for a beginner, may outperform simple mappings and provide a more expressive interface.
    - Consider acoustic instruments, which usually possess complex mappings

Feedback

- For performers using DMIs or controllers, feedback from an instrument is important, as with traditional instruments.
- The primary feedback modalities are:
    - visual
    - auditory
    - tactile-kinesthetic
- Feedback for an instrument can be classified in two ways:
- *Primary* vs *secondary*
    - primary: visual, auditory (e.g., sound of a key being pressed), and tactile-kinesthetic
    - secondary: the sound produced by the instrument
- *Passive* vs *active*
    - passive: feedback resulting from the physical characteristics of the system (e.g., the noise of a switch)
    - active: explicitly produced by the system in response to a user action

Feedback (cont.)

- Incorporating feedback into interface design:
  - Auditory feedback is assumedly present (sound of the instrument being played, both *primary* and *secondary*), though in certain circumstances additional consideration may be necessary (networked performance, certain temporary instrument states like tuning or setup)
  - Visual and tactile-kinesthetic may be incorporated as *passive* feedback.
    - (e.g., visual: hand/finger location indicating pitch, or knob position)
    - (e.g., tactile: different materials indicate position of fingers/hands on the instrument, that are mapped to different controls/parameters)
  - However, additional visual or tactile-kinesthetic feedback may be desired:
    - Adding in LED or OLED displays
    - Incorporating haptic motors (as found in mobile phones)

Hardware and fabrication

- A bunch of wired up sensors alone don't make a controller or a DMI.
  - Other sessions in this course will specifically address the technologies: sensors, microcontrollers, digital communication and network protocols, software and programming.
- But an instrument or interface will have to take physical form which requires some basic fabrication work:
  - 3D printing and laser cutting are useful tools for fabricating quick and easy custom enclosures for an interface. In addition to looking and playing better, they will also protect the delicate circuits that you have designed and make them durable for real world use.
  - Recommended design tools:
    - 2D design (laser-cutting): Inkscape (free), Adobe Illustrator ($), AutoDesk Fusion 360 (free for students)
    - 3D design (3D printing): Blender, SketchUp Free, TinkerCad (all free); AutoDesk Fusion 360 (free for students)
- Maker spaces and fablabs offer inexpensive access to fabrication tools like laser cutters and 3D printers. Also the university may provide access.

Hardware and fabrication (cont.)

Also, many early instrument prototypes have begun their life built out of repurposed containers: carboard box, cigar box, Tupperware, etc. Whatever works!

Designing the interface

- Steps towards the design of a DMI or controller:
    a. Decide on the gestures that will be used to control the system
    b. Define gesture capture strategies that will best translate the gestures into digital signals (choice of sensors and algorithms to convert the raw input signals)
    c. Determine the sound synthesis or music software and processes that will be used in the performance
    d. Map sensor outputs to synthesis and music control inputs. This process can be arbitrary, as the control surface and sound generation are not acoustically coupled
    e. Decide on feedback modalities: visual, tactile, and/or kinesthetic

☕

pause

Workshop: Design for performance

Objective: to design a non-functional prototype (NFP) of a DMI or controller based on the music and performance you want to make, using the concepts from the lecture.

Activities:

1. "Draw the music"
2. NFP design activity – work in groups of 2 (pair engineers with musicians)
3. Instrument presentations
4. Discussion: designs, key elements, qualities