LeapMax
Gestural Interaction System

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HELLO!

I am G. Cooper Jones

Undergraduate Digital Culture

w/ Media Processing

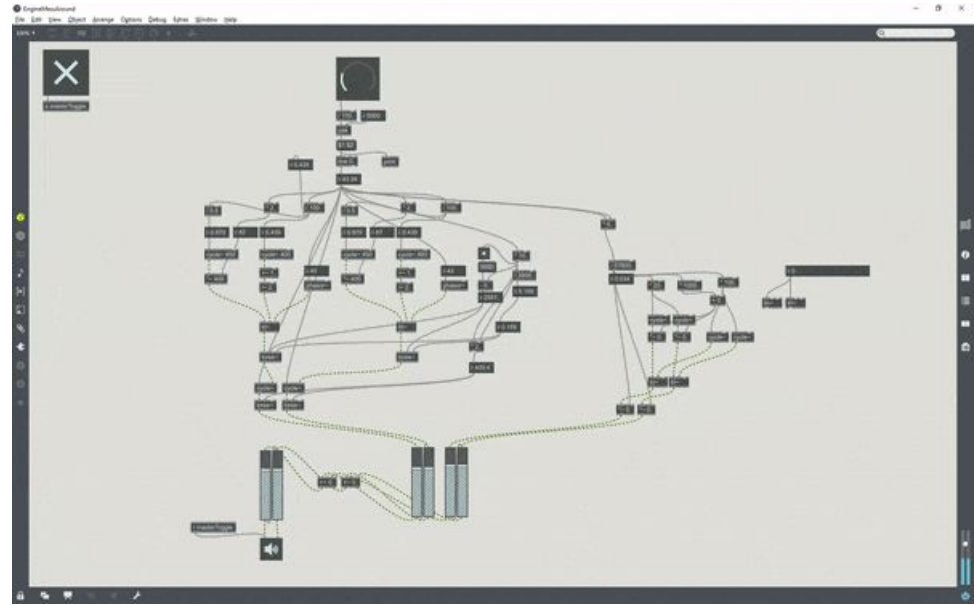Arizona State University

gcjones1@asu.edu

ACKNOWLEDGEMENTS

Background
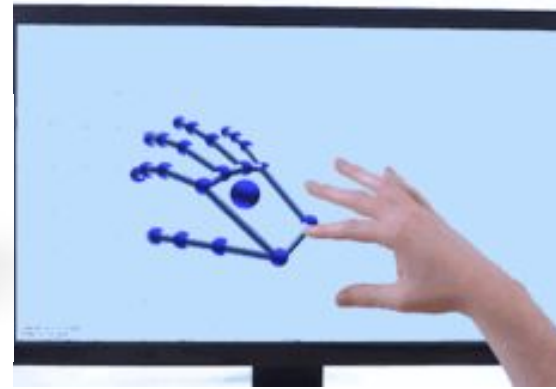
Max, Leap Motion, and Data Gloves

[5]

Max/MSP

Visual Programming Language for Music and Multimedia

MAX/MSP

Visual programming language first developed by Miller Puckette in 1985

Max is especially suited for this project for several reasons:
- very accessible
- low latency live data and audio
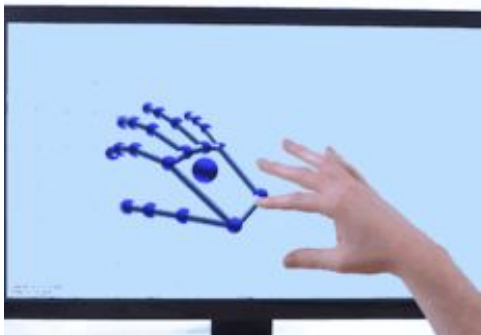- highly modular

[2]

[5]

Leap Motion

Low latency, high accuracy IR hand tracking device

LEAP MOTION

- ○ Two infrared cameras
- ○ Three IR LEDs

The Leap transmits video data to the Leap Motion software where it is analyzed
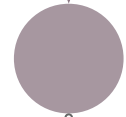
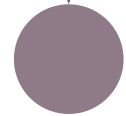Skeletal representation of hand is by the software

[5]

[18]

Leap Motion released in 2013

- Desktop Device
- Minimal finger tracking

Leap Orion released in 2016

- High fidelity finger tracking
- VR/Head Mounted mode
- Windows only

Leap C 4.0 released in 2018

- Increased fidelity
- Streamlined C API
- Language wrappers deprecated

Past Leap Projects

[7]

[6]
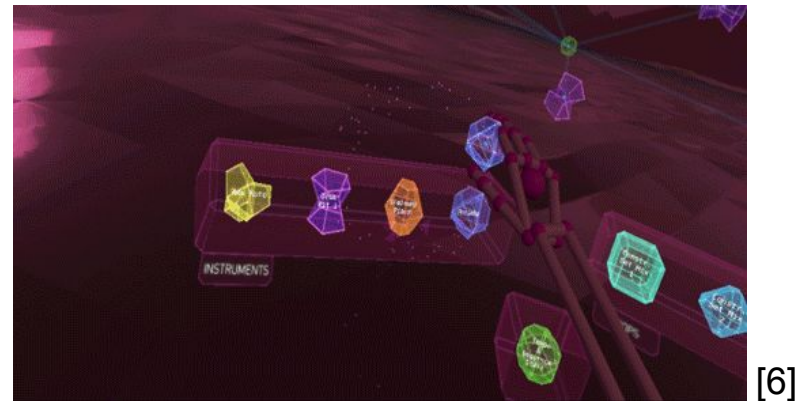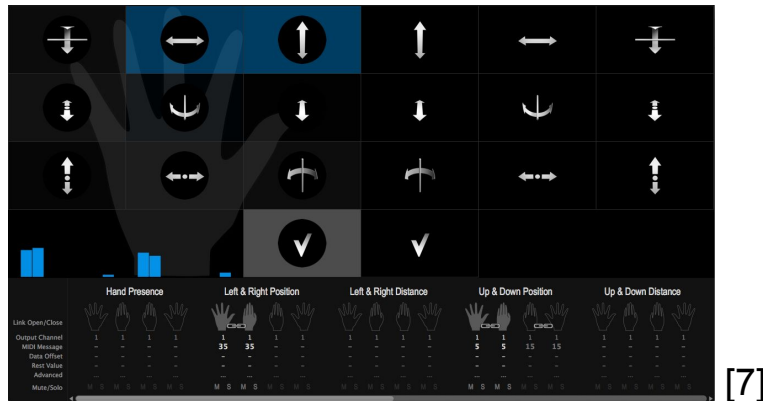
GECO MIDI

This app converts basic hand gestures into MIDI data.

- ○ Desktop mode
- ○ Controller

[8]

Lyra VR

Lyra is a VR experience in which different interactable objects can be used and manipulated to create music and sound.

- ○ Head mounted mode
- ○ Interaction system

[8]

[9]

Data Gloves

Peripherals for tracking hand posture and movement

[10]

Nintendo Powerglove

○ 1989
○ Primitive flex sensors, ultrasonic sensors
○ Measures fingerbend, roll of hand
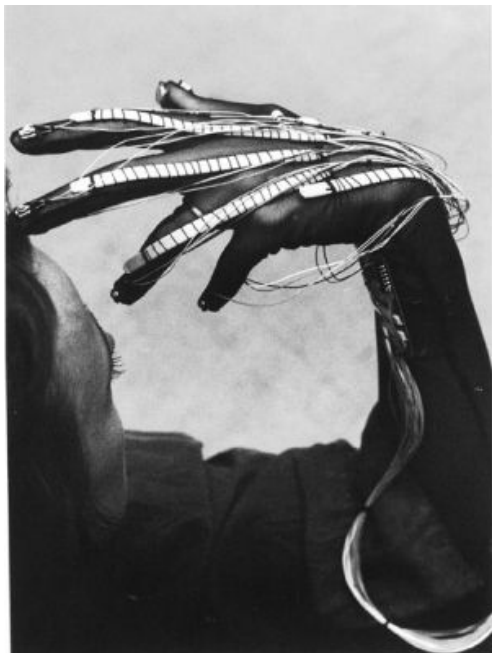
[15]

Lady's Glove

○ 1991 - Laetitia Sonami
○ Flex sensors, Hall sensors, accelerometers, pressure pads
○ Measures a range of gesture based variables
○ Relates gesture to sound

DATA GLOVE SYSTEMS

[9]

Mi.Mu Gloves

- ○ 2010 - Imogen Heap
- ○ Flex sensors, Absolute Orientation Sensor
- ○ Consumer production interface

Musical Interaction with Hand Posture and Orientation: A Toolbox of Gestural Control Mechanisms

[11]

Alto Glove

- ○ Seth Thorn
- ○ Flex sensors, FSRs, Absolute Orientation sensor
- ○ Measures gesture in the context of violin performance
- ○ Instrumental vs Free Hand
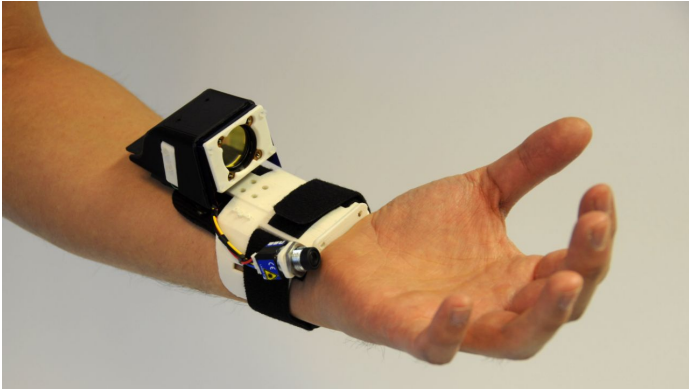
[12]

Digits

- ○ 2012 - Microsoft
- ○ Two IR cameras
- ○ Developed for gesture control of smart phones, games, etc.
- ○ Posture measurement
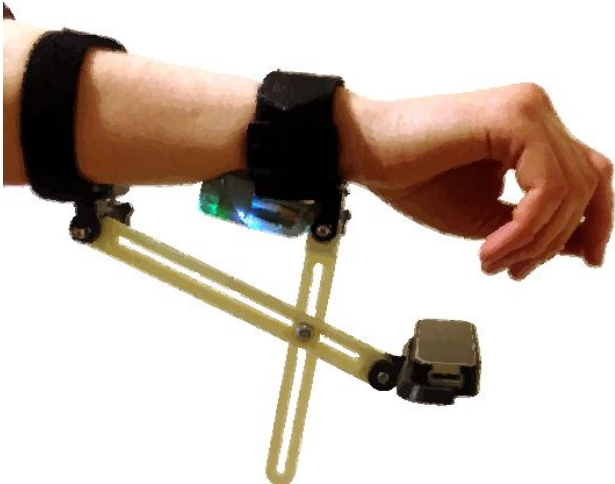
[16]

Leimu

- ○ 2016 - Brown, D., Renney, N., Stark, A., Nash, C. and Mitchell, T.
- ○ Wrist mounted Leap Motion controller, Inertial Measurement Unit
- ○ Proof of concept for Leap Motion as a data glove-like device

WHAT IS THE LEAPMAX PROJECT?

A gestural interaction system developed for Max and Leap Motion which focuses on measuring, calculating, and mapping hand gesture and posture.

1

LeapMax API

Protocol for linking the Leap Motion service to Max.

2

LeapMax Library

A library of Max abstractions which extract more complex gesture and posture data from Leap data.

3

LeapMax Gestural Interaction System

A DMI which is a use case for the LeapMax API and Library.

LeapMax API

Communicating between Max and Leap
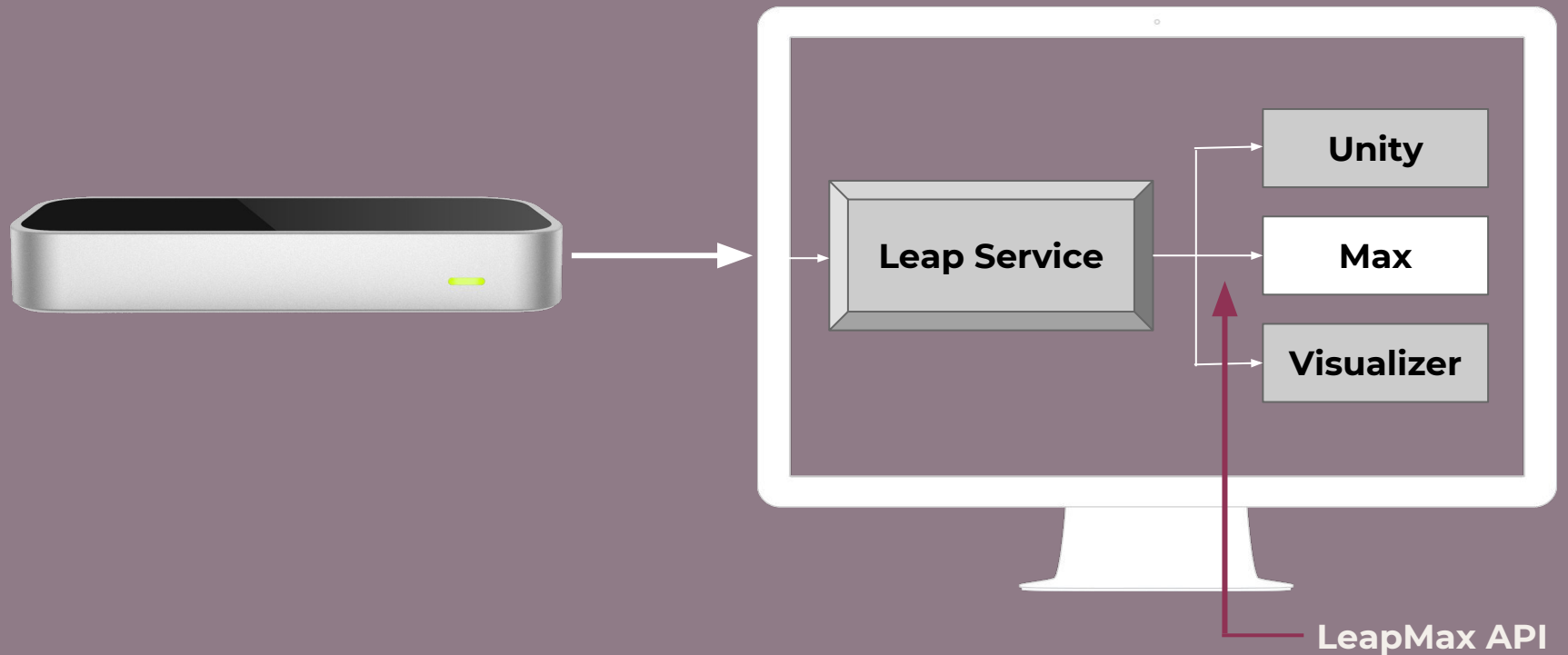
Leap Data Management

1. Image data is passed from the Leap device to the Leap service

2. Hand tracking data is calculated by the Leap service

3. Data is passed to programs connected to the Leap service through an API

Previous Max APIs

[3]
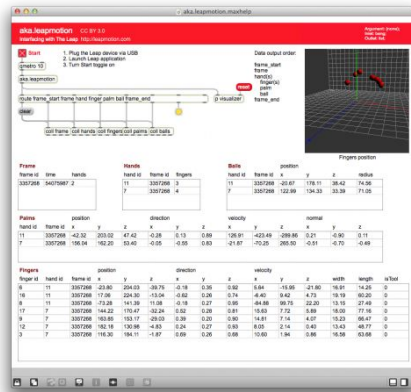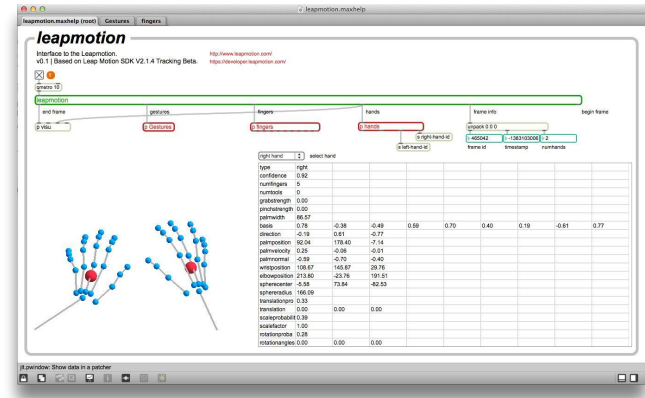
aka.leapmotion
by Masayuki Akamatsu

- ○ Released in 2013
- ○ Uses the Leap C++ API for v. 0.7.0
- ○ No finger typing
- ○ Communicates data through labeled Max messages

[4]

leapmotion-for-max
by Jules Francoise

- ○ Released in 2014, updated for Orion
- ○ Uses the Leap C++ API for v. 3.*
- ○ Hand and finger identification
- ○ Communicates data through labeled Max messages

- ○ Both APIs are now deprecated
- ○ Develop an updated and more efficient Max API for Leap

CONSIDERATIONS AND IMPROVEMENTS

Problem:

The leapmotion-for-max object outputs 38 messages per frame per value being tracked.

This means if there are five values being tracked, Max must handle 190 messages.

Problem:

The current naming conventions and hierarchical message structure make writing an abstraction object to access a single value difficult.
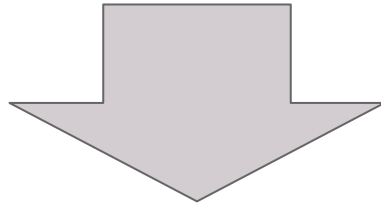
Solution:

Use Max Dictionaries to store data.

Develop a modular naming system for easy data access.

What are Dictionaries?

○ Use key-value pairs to store structured data.

○ Max dictionaries are global.

Why Dictionaries?

○ Dictionaries pass by reference rather than by value.

○ Data is stored and retrieved from a single place in memory.

○ Data storage and retrieval can be separated and abstracted

n = number of values

Pass by Value

Leap Object

$3*n$
Linear Complexity

All Values   *All Values*

All Values

Data   Data   Data

Pass by Reference

Leap Object

$n+3$
Constant Complexity

All Values

Max Dictionary

One Value   *One Value*   *One Value*

Data   Data   Data
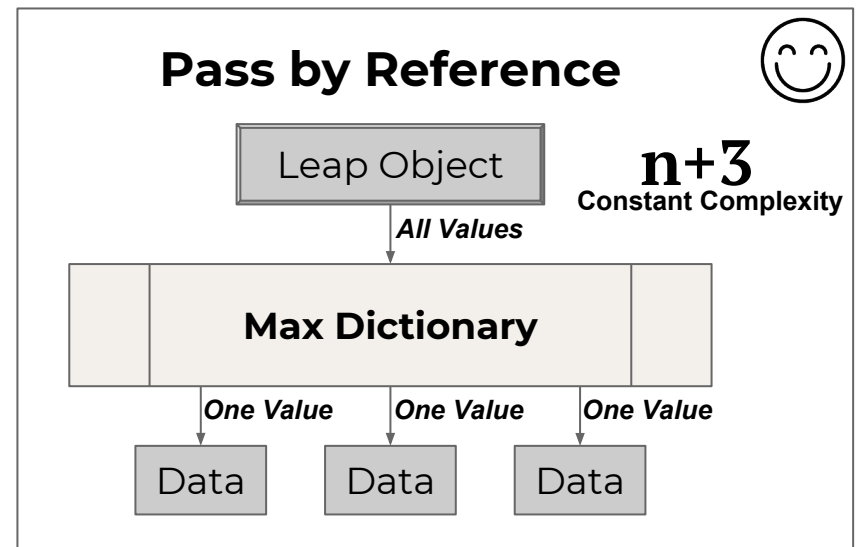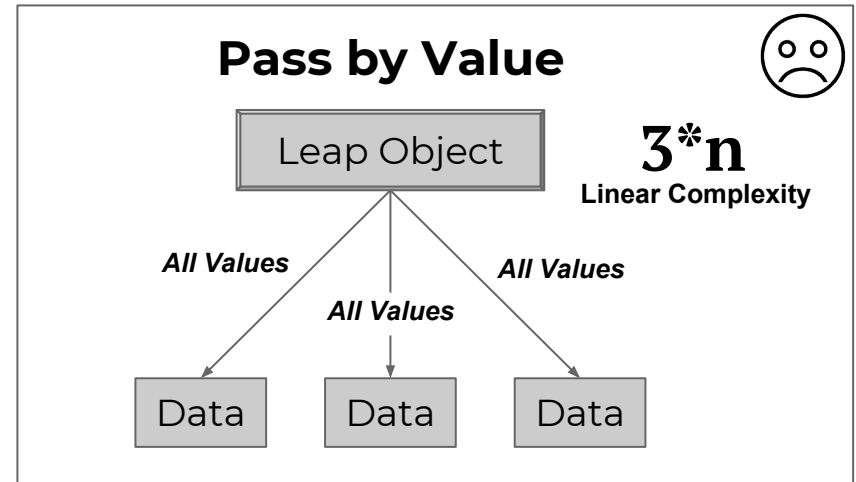
DICTIONARIES:
NAMING CONVENTION

Goals: Consistency and Modularity

Leap Data Hierarchy

Global	Hand Type (right or left)	Finger Type (index, middle, ring, pinky, or thumb)	Bone Type (metacarpal, proximal, intermediate, or distal)
frameid	id	fingerid	prevjoint
timestamp	pinchdistance	isextended	nextjoint
hands	grabangle	tipposition	width
	pinchstrength		rotation
	grabstrength		
	arm		
	palmposition		
	palmvelocity		
	palmnormal		
	palmwidth		
	palmdirection		
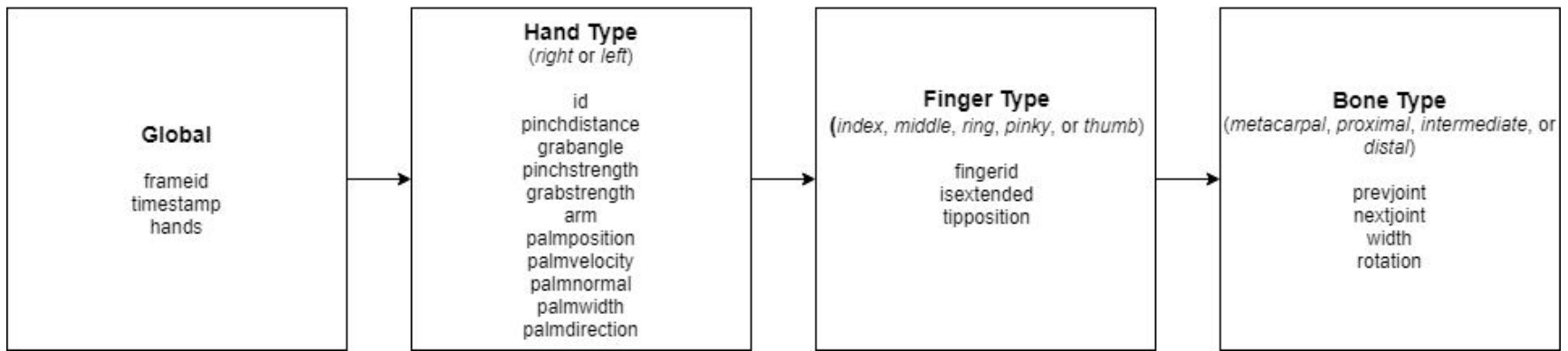
Follows the Leap Motion C API data structure: **Global, Hand, Finger, Bone**

Example Variable Names:
- frameid
- rightpalmposition
- rightindextipposition
- leftpinkydistalrotation

ORIENTATION MANAGEMENT

In order to be used in Head Mounted mode, the orientation of the Leap device needs to be tracked.

[8]

[17]

| Rotation Transformation | Global Frame |
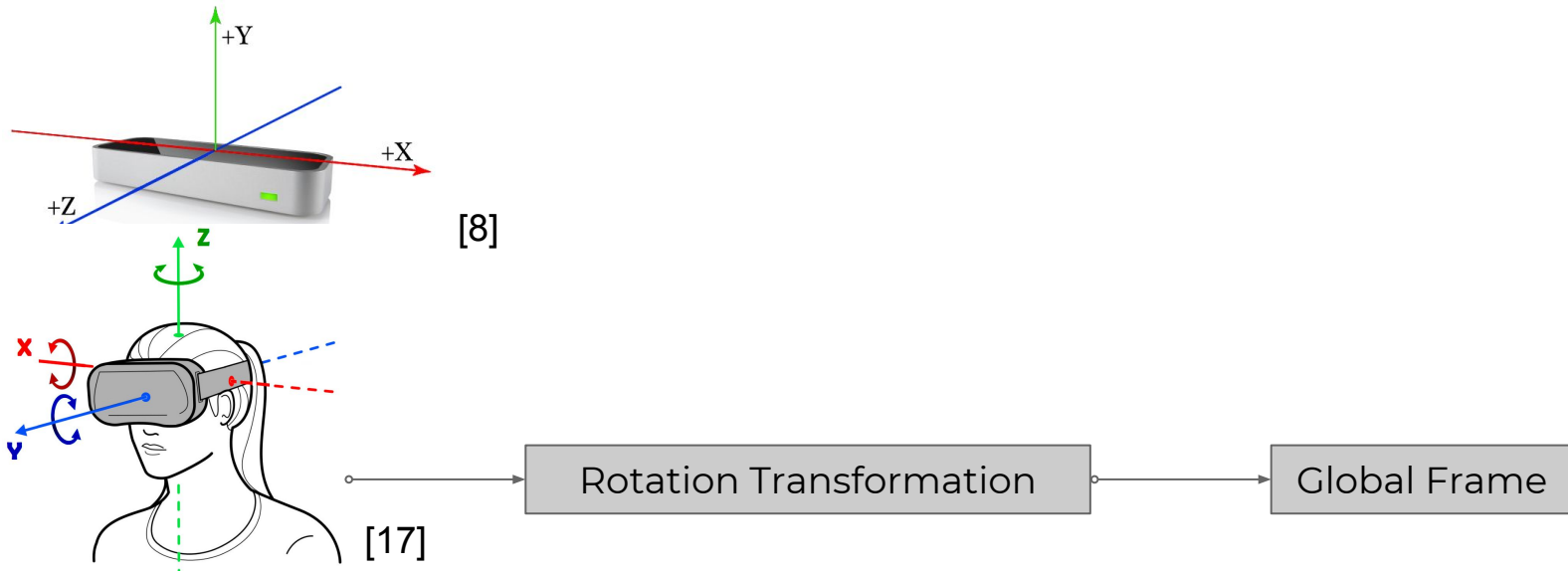
The LeapMax object accepts a rotation quaternion, then transforms the data returned by the Leap Motion into Global space.

Start/Stop

Leap Orientation Quaternion

qmetro 10 — 0. — 0. — 0. — 0.

leapmax

dictionary leap

frameid: 6962
timestamp: 803683760138
hands: 0
isRight: 0
isLeft: 0
leftid: 6
leftpinchdistance: 28.646328
leftgrabangle: 2.276631
leftpinchstrength: 0.640221
leftgrabstrength: 1.
leftarmprevjoint: 173.86 2.41 329.63
leftarmnextjoint: 193.90 -83.87 90.78
leftarmwidth: 60.539734
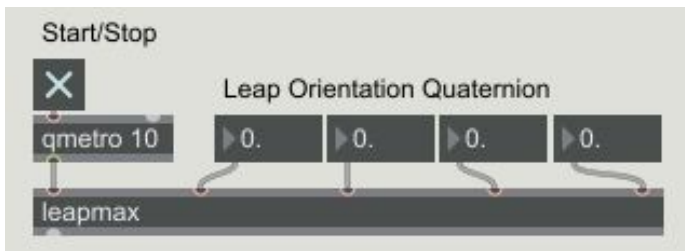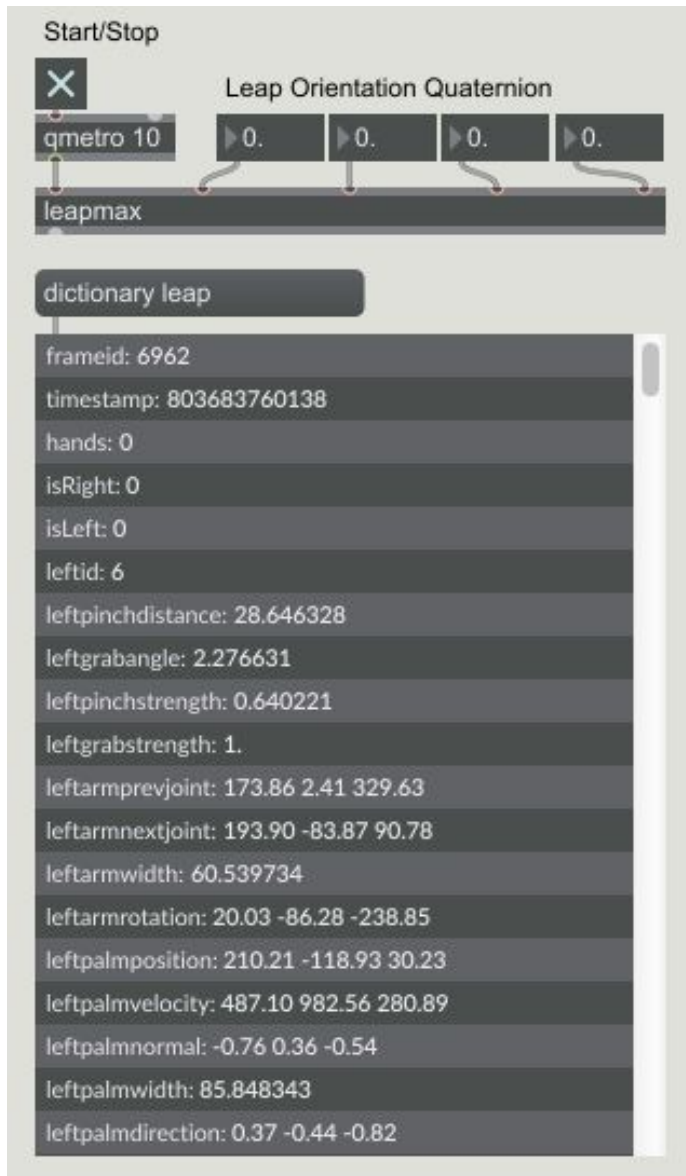leftarmrotation: 20.03 -86.28 -238.85
leftpalmposition: 210.21 -118.93 30.23
leftpalmvelocity: 487.10 982.56 280.89
leftpalmnormal: -0.76 0.36 -0.54
leftpalmwidth: 85.848343
leftpalmdirection: 0.37 -0.44 -0.82

The result is the leapmax object:

- Max C external that interfaces with the Leap service

- Accepts a metro bang in the first inlet to cue frame collection

- Transforms the Leap data corresponding to an orientation quaternion

- Outputs the transformed data to a named Max dictionary

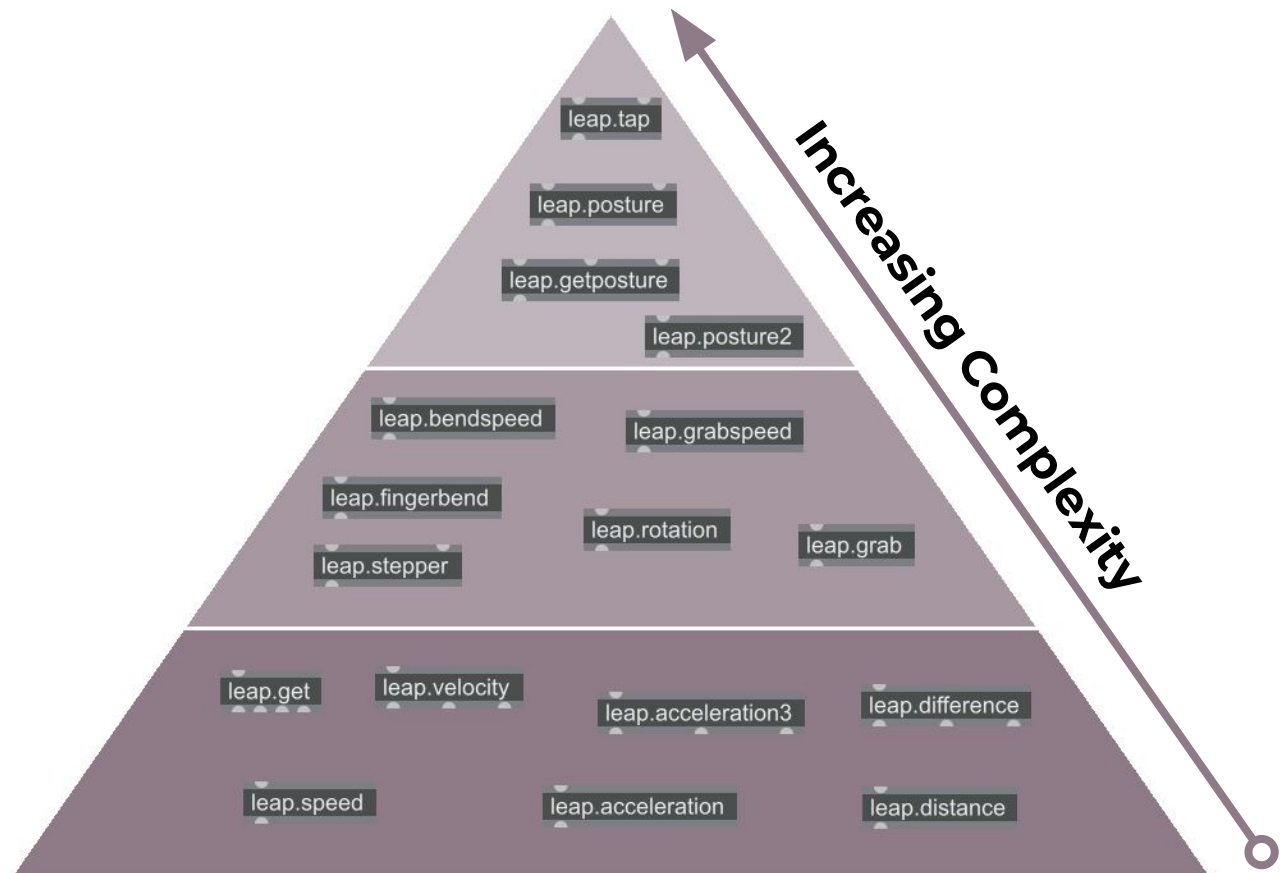# LeapMax Library

Interpreting Leap Data

LEAPMAX LIBARY

A series of abstractions for extracting more complex gesture data from data provided by the Leap Motion

Design goals for the LeapMax library include:

- Modularity
- Reusability
- Flexibility

ANATOMY OF A LEAP OBJECT

Global receive for frame
update bang

r updateframe

Name of Leap
Abstraction (leap.*)

leap.get leftindextipposition

Dictionary
key of data

▶ 0.   ▶ 0.   ▶ 0.   0. 0. 0.

Outlets 1, 2, 3
Value or values (floats)

Outlet 4
Value or values as a list

Object Variant

r updateframe

leap.fingerbend left index

▶ 0.
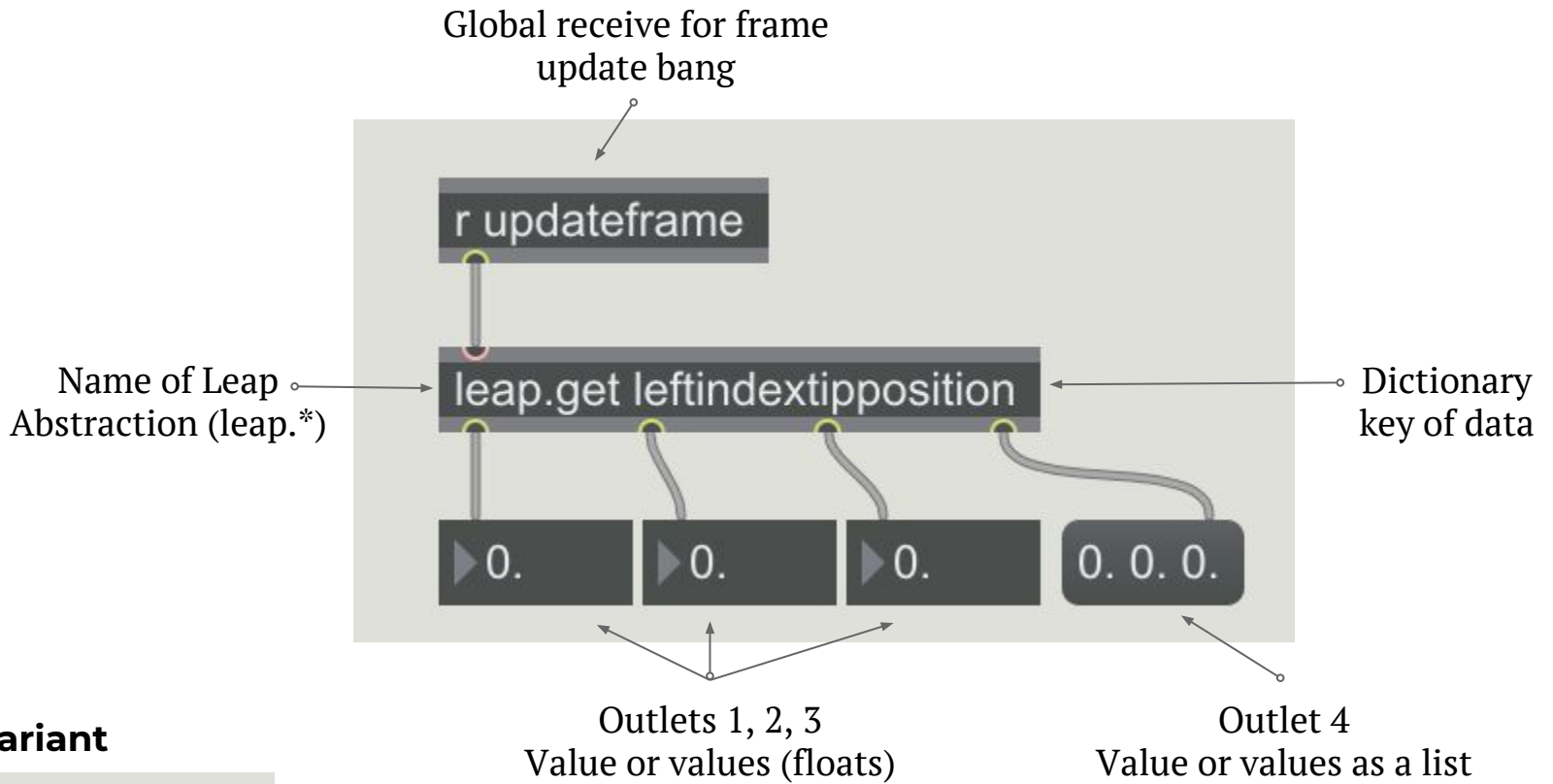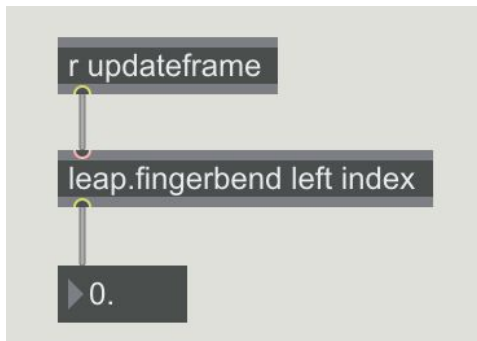
ENCAPSULATION AND MODULARITY

leap.grab left

User input argument

leap.fingerbend #1 index   leap.fingerbend #1 middle   leap.fingerbend #1 ring   leap.fingerbend #1 pinky

0.   0.   0.   0.

pak 0. 0. 0. 0.

zl.sum

/ 4.

0.

Input is hand type (right or left)

Output is the averaged fingerbend (ie. "grab") of the hand being tracked from completely extended (0) to completely closed (1).

Leap Grab

by George Cooper Jones

gcjones1@asu.edu
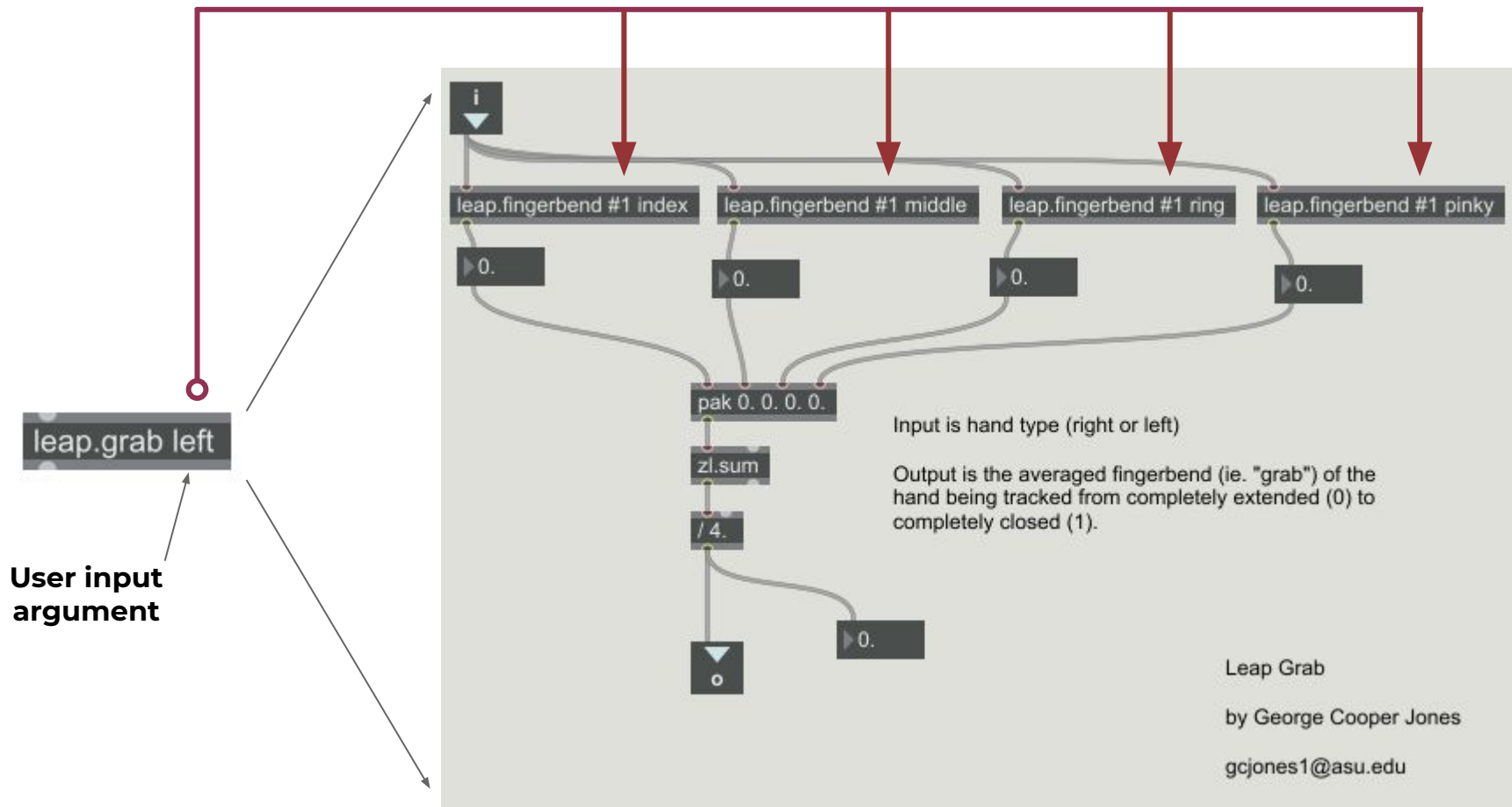
- Max object arguments are used to pass user specified data to encapsulated Leap library objects
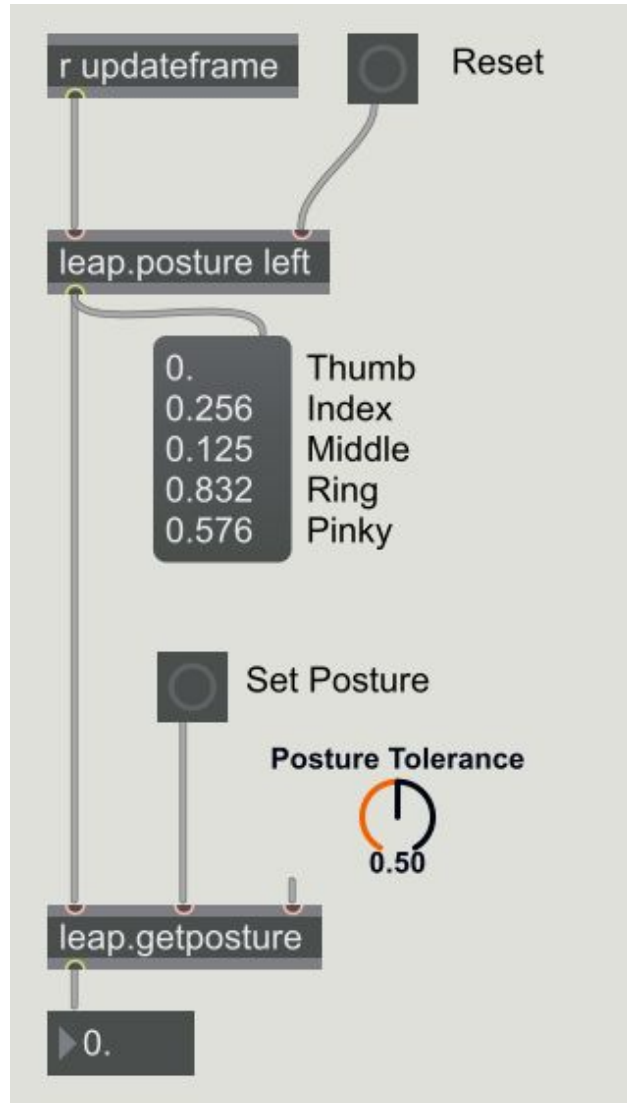
Goals: Simplistic yet effective

Digits: Linear relationship between finger joint angles
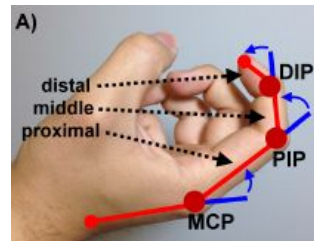
Measuring Posture
- List of 5 values
- Fingerbend (0-1) for each finger

Split into two objects:
leap.posture
leap.getposture

Non-discrete measurement
- Posture similarity value (0-1)

LeapMax Library Demo

LeapMax Gestural Interaction System

Building a use-case

Design Goals:

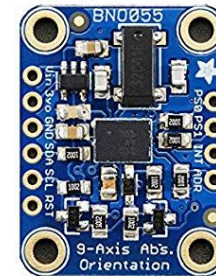- **Low Cost:** The starting cost of this system is around $150

- **Streamlined:** Only two sensors in use. High reliability and ease of use.
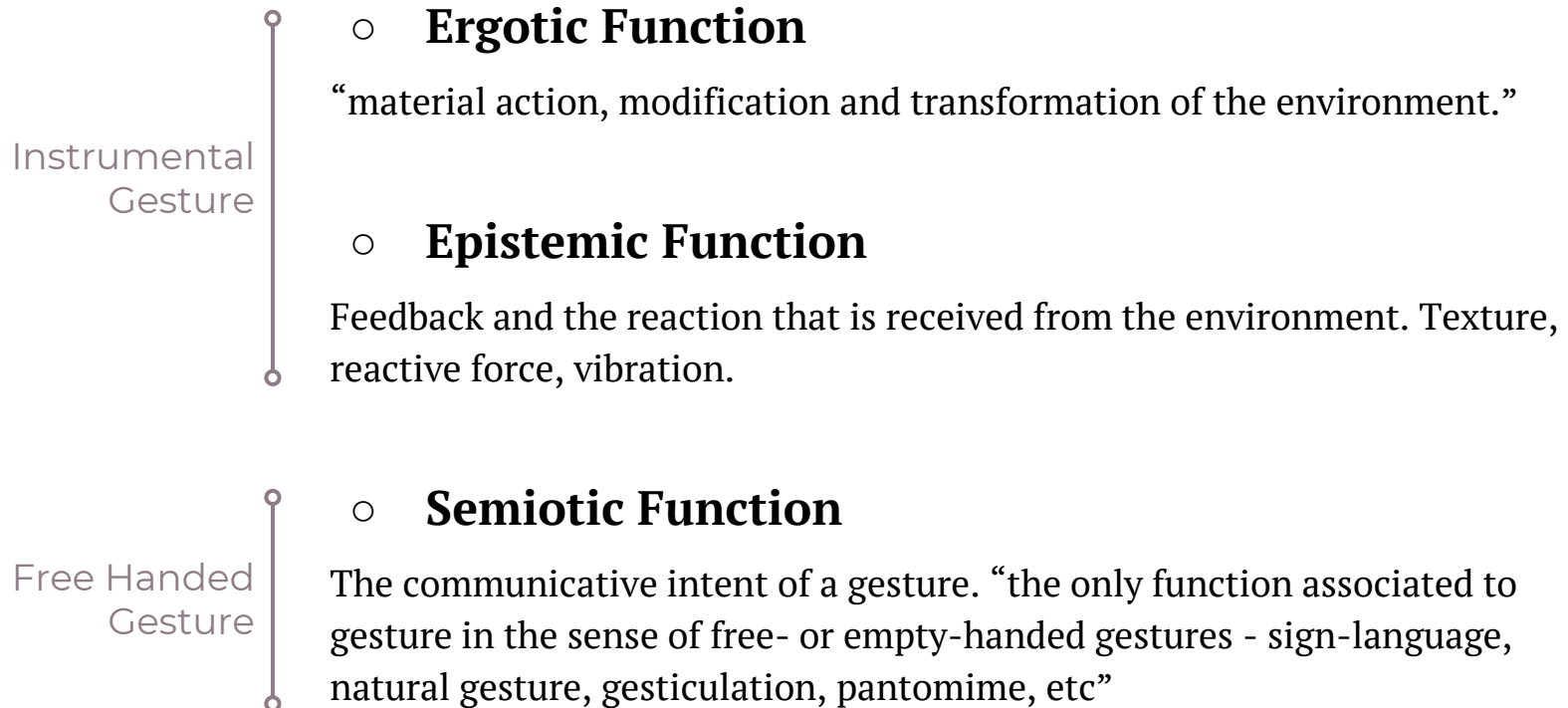
Leap Motion

BNO055 IMU

Teensy LC

Glasses

x2 15' USB extension cables

FREE HANDED GESTURE

Claude Cadoz describes several categorized functions of hand gesture:

Instrumental Gesture

- ○ **Ergotic Function**

  "material action, modification and transformation of the environment."

- ○ **Epistemic Function**

  Feedback and the reaction that is received from the environment. Texture, reactive force, vibration.

Free Handed Gesture

- ○ **Semiotic Function**

  The communicative intent of a gesture. "the only function associated to gesture in the sense of free- or empty-handed gestures - sign-language, natural gesture, gesticulation, pantomime, etc"

- ● Free handed gesture systems must be complex yet intuitive
- ● Feedback must be incorporated into the output produced

MAPPING GESTURE TO SOUND

Gestures are parameterized and used to control parameters of live audio generation systems.

Types of Synthesis: Granular and FM

Parameterized reverb and delay

Conceptual explorations

○ How can you build an interactive environment from sound?
○ How can stereo audio be associated to gestural space?
○ Can you 'grab' and 'throw' sound?
○ How can sound describe energy?

LeapMax Peformance Demo

Resources

[1]   https://giphy.com/gifs/leap-motion-KfbhbuWbE6gyk

[2]   http://www.strangecompany.org/leap-motion-orion-yes-the-leap-works-now/

[3]   http://akamatsu.org/aka/max/objects/

[4]   https://www.julesfrancoise.com/leapmotion

[5]   http://www.iainhetherington.co.uk/wp-content/uploads/2017/07/20170714_MaxMSP_SciFiEngineMessAbout_GIF.gif

[6]   https://developer-archive.leapmotion.com/gallery/lyra-vr

[7]   http://designingsound.org/2015/09/16/beyond-the-mouse-and-keyboard-the-role-of-touch-and-motion-in-sound-design/

[8]   https://www.leapmotion.com/technology/

[9]   https://mimugloves.com/tech/

[10]   https://en.wikipedia.org/wiki/Power_Glove

[11]   https://www.seththorn.net/altoglove

[12]   https://www.microsoft.com/en-us/research/project/digits/

[13]   https://www.amazon.com/Adafruit-Absolute-Orientation-Fusion-Breakout/dp/B017PEIGIG

[14]   https://www.amazon.com/gp/product/B017O0W5VA/ref=oh_aui_detailpage_o08_s00?ie=UTF8&psc=1

[15]   http://sonami.net/ladys-glove/

[16]
https://www.semanticscholar.org/paper/Leimu-%3A-Gloveless-Music-Interaction-Using-a-Wrist-Brown/776f90968b529b8d6237dfb
558e04818183753c0

[17]   http://dsky9.com/rift/vr-tech-6dof/

[18]   http://blog.leapmotion.com/hardware-to-software-how-does-the-leap-motion-controller-work/