

# Tiny trainable instruments

by

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Submitted to the Program of Media Arts and Sciences  
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## **Abstract**

Tiny trainable instruments is a collection of instruments for media arts, using machine learning techniques and deployed in microcontrollers.

Thesis Supervisor: Tod Machover

Title: Muriel R. Cooper Professor of Music and Media

# Acknowledgments

UROPs Peter Tone, Maxwell Wang

Opera of the Future

Future Sketches

Family and friends

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# Chapter 1

## Introduction

### 1.1 Context

This thesis is the capstone project of my master's program, between the academic years 2019-2

The work presented here has been developed mostly working remotely during the COVID19 pandemic.

TODO: include photograph of my desk at home.

As part of the research that directly informed this thesis, I highlight the classes I took, including:

1. Comparative Media Studies, by Sasha Costanza-Chock
2. Recreating The Past, by Zach Lieberman

Some other projects I created during these years include:

1. SiguesAhi
2. Open Drawing Machine, with Gaurav Patekar
3. Introduction to networks for artists

[1, John Maeda, 2001]

Opera of the Future Future Sketches 2019-2021

## 1.2 Section sample

Nulla sed sem finibus, vehicula quam at, vulputate tellus<sup>1</sup>

### 1.2.1 Subsection sample

1. Item 1.

---

<sup>1</sup>Here is a sample footnote referencing figures ?? and B-1.

# Chapter 2

## Background

### 2.1 Instruments

#### 2.1.1 BASTL

BASTL Kastle, two iterations and a spinoff: Kastle, Kastle v1.5, Kastle Drum.

Based on Arduino, GitHub repository with alternate firmware.

Breadboard patching with jumper cables, inputs and outputs robust enough to allow for mistakes in connections.

#### 2.1.2 Critter & Guitari

Organelle computer for sound, scriptable, Linux operating system + Pure Data software.

ETC and EYESY computers for visuals, scriptable, Linux operating system + Python

/ pygame environment or openFrameworks.

### **2.1.3 monome**

Aleph: sound computer

Norns: sound computer, currently on its second iteration, with expanded hard drive. Also there is a DIY version which is cheaper and runs on a Raspberry Pi. Norns is a Linux machine, running SuperCollider for the sound engine, and Lua scripts.

### **2.1.4 Shbobo**

Peter Blasser's Shbobo

Shnth and Shtar

Shlisp language and Fish IDE.

[github.com/pblasser/shbobo](https://github.com/pblasser/shbobo)

## **2.2 Education**

Mitch Resnick's book Lifelong Kindergarten

Low floor, wide walls, high ceiling

Peers, projects, passion, play

Gene Kogan and Andreas Refsgaard

## 2.3 Machine learning

ml5.js

Runway

TinyML Professional Certificate HarvardX

## 2.4 Digital rights

Electronic Frontier Foundation

Edward Snowden

Design Justice Network

# Chapter 3

## Early experiments

### 3.1 Microcontrollers

Arduino

Teensy: MIDI plug in.

### 3.2 Machine learning

Class at School of Machines by Gene Kogan and Andreas Refsgaard

# Chapter 4

## Tiny trainable instruments

### 4.1 Design principles

1. Cheap
2. Privacy

### 4.2 Technology

Arduino microcontroller

Arduino library KNN

TensorFlow Lite Micro

## **4.3 Programmable / remix**

## **4.4 Philosophy and experience**

## **4.5 Inputs**

Enumerate sensors from the Arduino Nano 33 BLE Sense

## **4.6 Outputs**

The different outputs were picked, because of their low cost, ubiquity, and possibilities of expansion and combining them.

### **4.6.1 Buzzer**

This output creates pitched sound, by using a PWM output.

### **4.6.2 Servo motor**

This output creates movement and through that, rhythmic sounds.

### **4.6.3 MIDI**

We wrote functionalities to manipulate MIDI instruments, and included examples to interface with some popular and cheap MIDI instruments, such as the Korg volca



beats.

#### 4.6.4 Thermal printer

A thermal printer is the basis for creating written and literary output, inspired by the field of computational poetry.

### 4.7 Development

This thesis has been developed with the invaluable help of undergrad researchers Peter Tone and Maxwell Wang.

They have cloned both repositories, the main one and the Arduino library one, and have continuously submitted pull requests with their contributions.

Peter Tone has helped with research in data structures, library writing, and we have shared back and forth code, going from experimental proofs of concepts, and has also helped with the design of the user-facing library.

Maxwell Wang has proofread our code, has ran the examples, and has helped with the writing of the documentation for self-learners and for the workshops.

We all share Google Drive folder, where we all share notes about our research and development of the library and the educational material.

## 4.8 Opera of the Future projects

During the development of this thesis, I have been fortunate to collaborate on different capacities with other thesis by classmates at Opera of the Future, which has directly informed my work.

Squishies, Hannah Lienhard’s master’s thesis, novel squishable interfaces for musical expression. We shared discussions about low-level sound design, code reusability, sound art education, digital instruments.

Fluid Music, Charles Holbrow’s PhD thesis, library design, documentation for contributors.

# Chapter 5

## Project evaluation

### 5.1 Digital release

This thesis lives on the internet on repositories, and at the MIT library.

The repositories are hosted on GitHub, to promote collaboration, and people can file issues and pull requests.

GitHub repository

Arduino library

PDF zine for explaining, reference as the PDF booklet for monome norms

## 5.2 Audience engagement

## 5.3 Workshop

Applied to grant at CAMIT for teaching the workshops in English in USA, and in Chile in Spanish, remotely over Zoom.

Each workshop consists of 2 sessions of 3 hours each, spread over a weekend.s

## 5.4 Multimedia show

Livestreamed show with multiple artists incorporating Tiny Trainable Instruments to their practice.

# Chapter 6

## Conclusion

This thesis project is a

### 6.1 Future work

#### 6.1.1 Education

I hope that this thesis project is adopted by educators, to introduce students to machine learning, physical computing, media arts, and ethics.

#### 6.1.2 Artist workflow

Training instead of programming.

### 6.1.3 Packaging

Low hanging fruit is to package a Tiny Trainable Instrument with a set of particular outputs, on a perfboard or PCB.

The next step would be to create enclosures.

### 6.1.4 Gallery

# Appendix A

## Tables

Table A.1: Armadillos

Armadillos	are
our	friends

# Appendix B

## Figures

Figure B-1: Armadillo



# Bibliography

- [1] John Maeda. *Design by Numbers*. The MIT Press, first paperback edition, 2001.