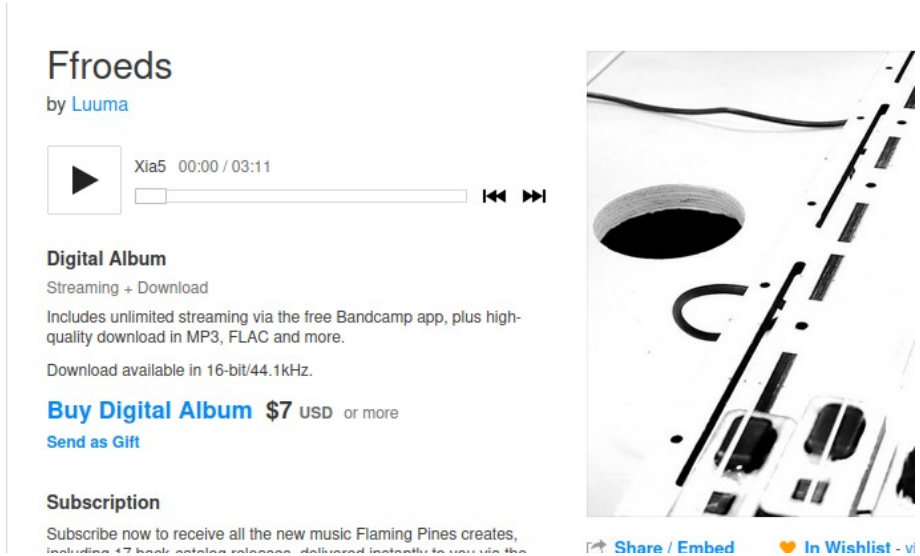

Musically Embodied
Machine Learning

# Introduction


FEEDBACK MUSICIANSHIP NETWORK

Making music with feedback instruments






UNIVERSITY OF SUSSEX

EMUTE LAB INSTRUMENTS

# Musically Embodied Machine Learning

- AHRC Fellowship Project
- 18 months
- People
  - Chris Kiefer – PI (Music / Emute Lab)
  - Andrea Martelloni – Research Fellow (Music / Emute Lab)
  - Nic Seymour-Smith - Researcher Software Engineer (SHL)

UKRI Arts and Humanities Research Council

# Expressive Potential of ML in Musical Instruments

- Gesture Processing
- Mapping design
- Sound synthesis
- Signal Processing
- Generative pattern / sound production

- Wider possibilities:
  - Generating organic complexity / encouraging serendipity
  - Creating adaptive (personalisable) instruments
  - Opening up complex DSP to musicians without technical experience
  - Shared agency
  - New creative possibilities e.g. latent space exploration, network bending

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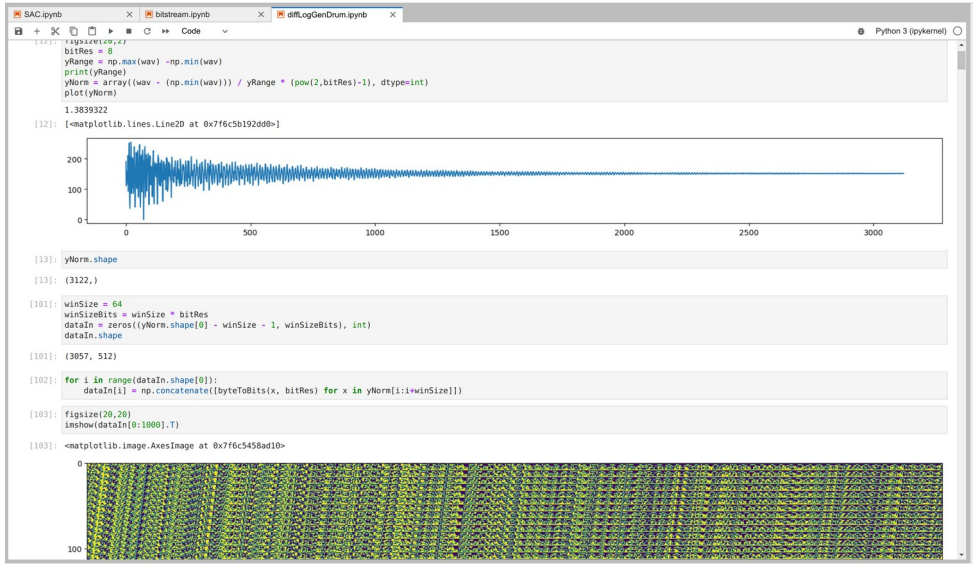
# Problems with ML and Musical Instruments

- Disembodied split between instrument and machine learning toolsets
- Focus on static pre-trained models (hardware creates contraints)

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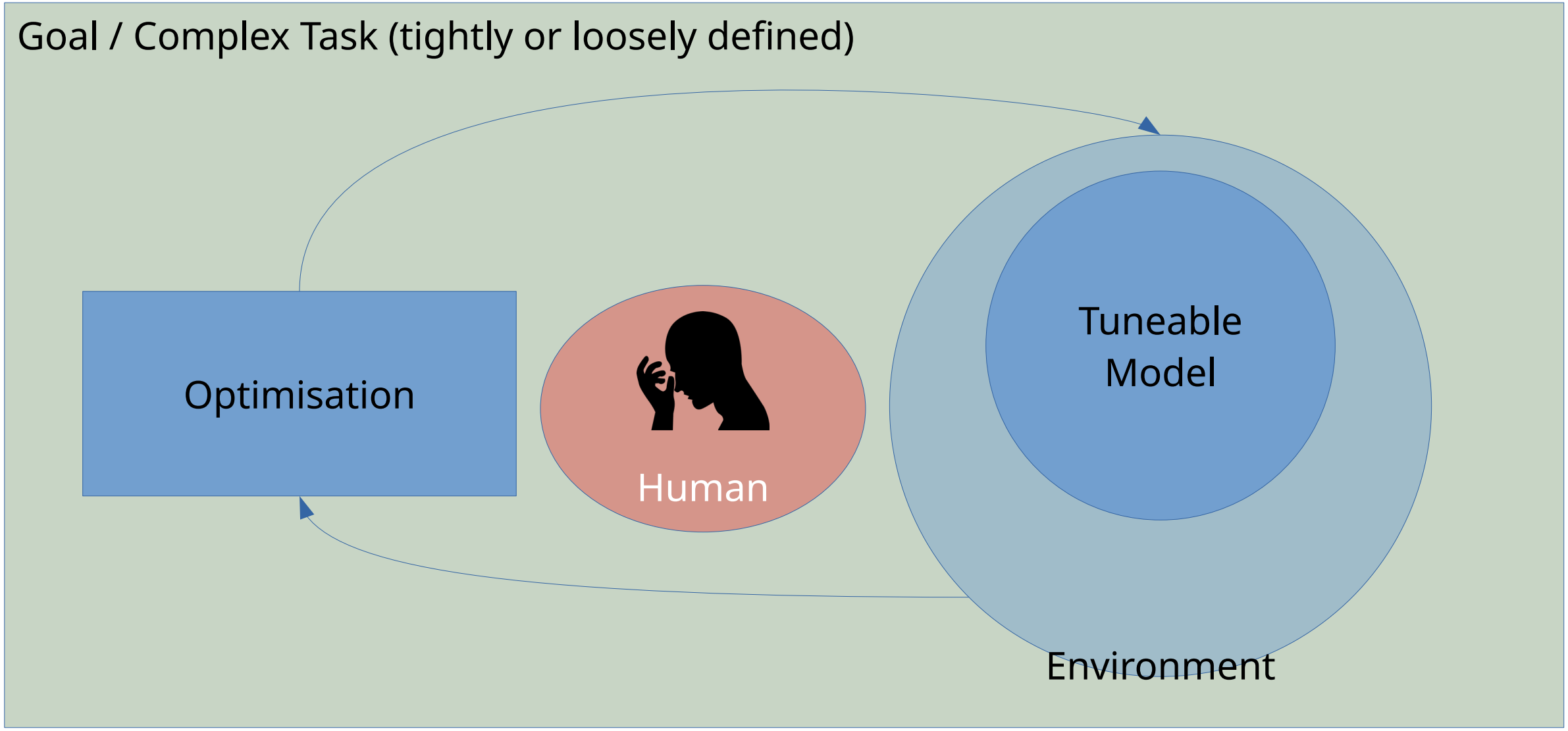
# Conceptualising Creative ML



# ITMLs

- Instruments with Tuneable Machine Learning
  - The entire process of training and running models is embedded within the instrument
  - Unified interface with the musical instrument
  - Using machine learning *musically*
  - Implications/challenges
    - Low-power portable computing
    - Simplified interface to machine learning
    - Instruments that adapt and evolve over their lifetime

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# Research Questions

- **Musical Practice** When musicians play ITMLs, what are the approaches they develop to playing and tuning the instruments?
- **Processes in Musical Machine Learning** What are musical, technical and ethical considerations that emerge when designers and musicians work with ML models that can be adapted during the ongoing life of an instrument?
- **Design and Technology** Considering the new creative possibilities opened up by instruments with tuneable ML, what design techniques and principles can support their development? Furthermore, how can the complexity of contemporary ML be encapsulated into simpler interfaces, that integrate with the playable feel (or ergodynamics) of an instrument?

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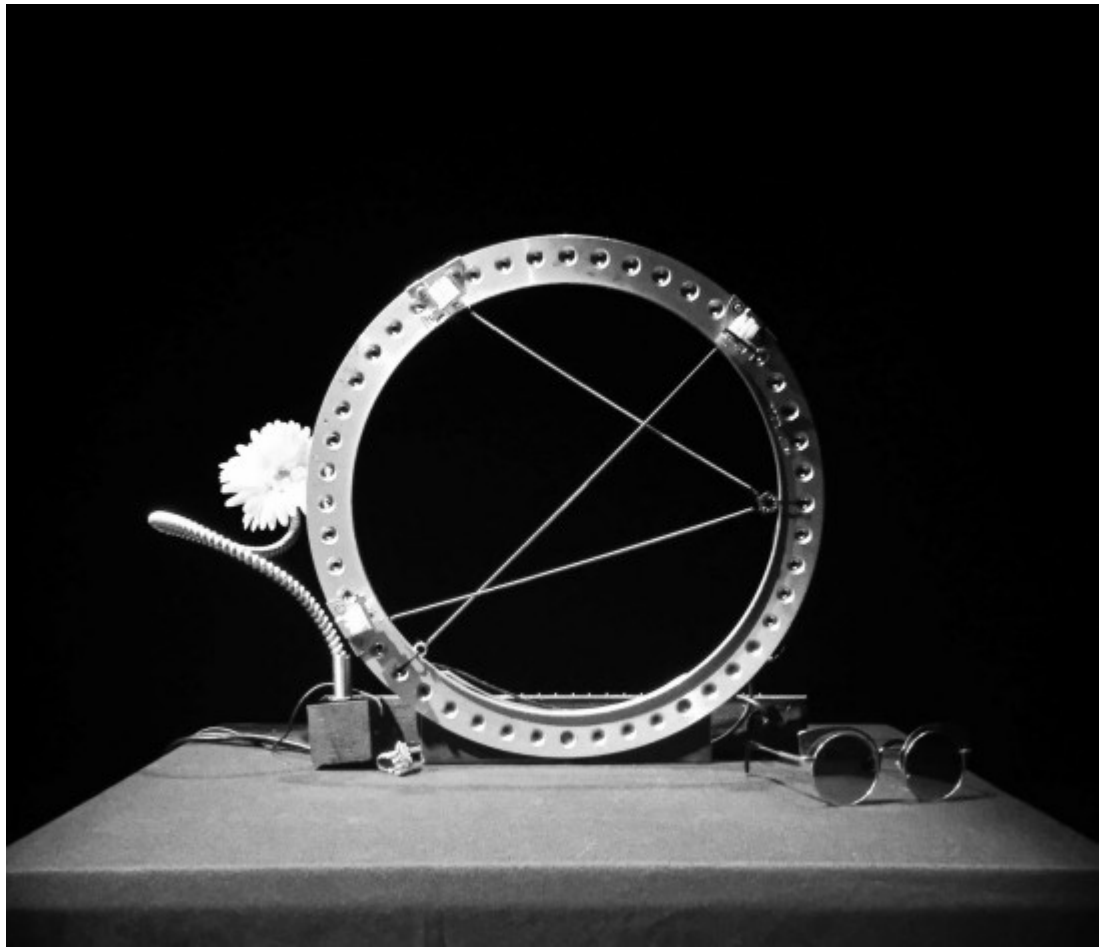
# Example Instrument: Spire/Wekinator (Sonami, Fiebrink)



Fiebrink, R., & Sonami, L. Reflections on eight years of instrument creation with machine learning. NIME 2020.

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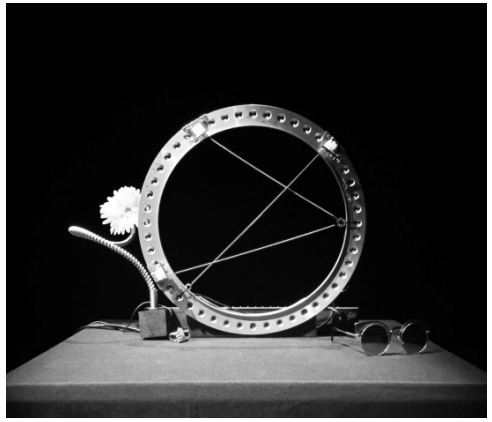
# Example Instrument: Spring Spire/Wekinator (Sonami, Fiebrink)

**Q: Can you say more about how you think about mapping in your instruments and compositions? How does ML impact on the task of creating a mapping?**

**A:** Mapping is the backbone of a composition. While it has been argued that in electronic instruments, controllers, sound generators and links (mappings) are independent units, I believe those to be tightly correlated. The choice of control inputs dictates the gestures, hence possible mappings and resulting musical events. While people using more standard controllers such as faders and buttons might apply control as an afterthought, mapping strategies have been an essential component in elaborating pieces with the *lady's glove* and now with the *Spring Spyre*. Mapping bridges the physical world to the sonic world. ML offers a way to easily configure mappings with a wide variety of behaviors, thus allowing the composer to focus on the sounds and compositions. I cannot envision at this point in time any other ways to map.



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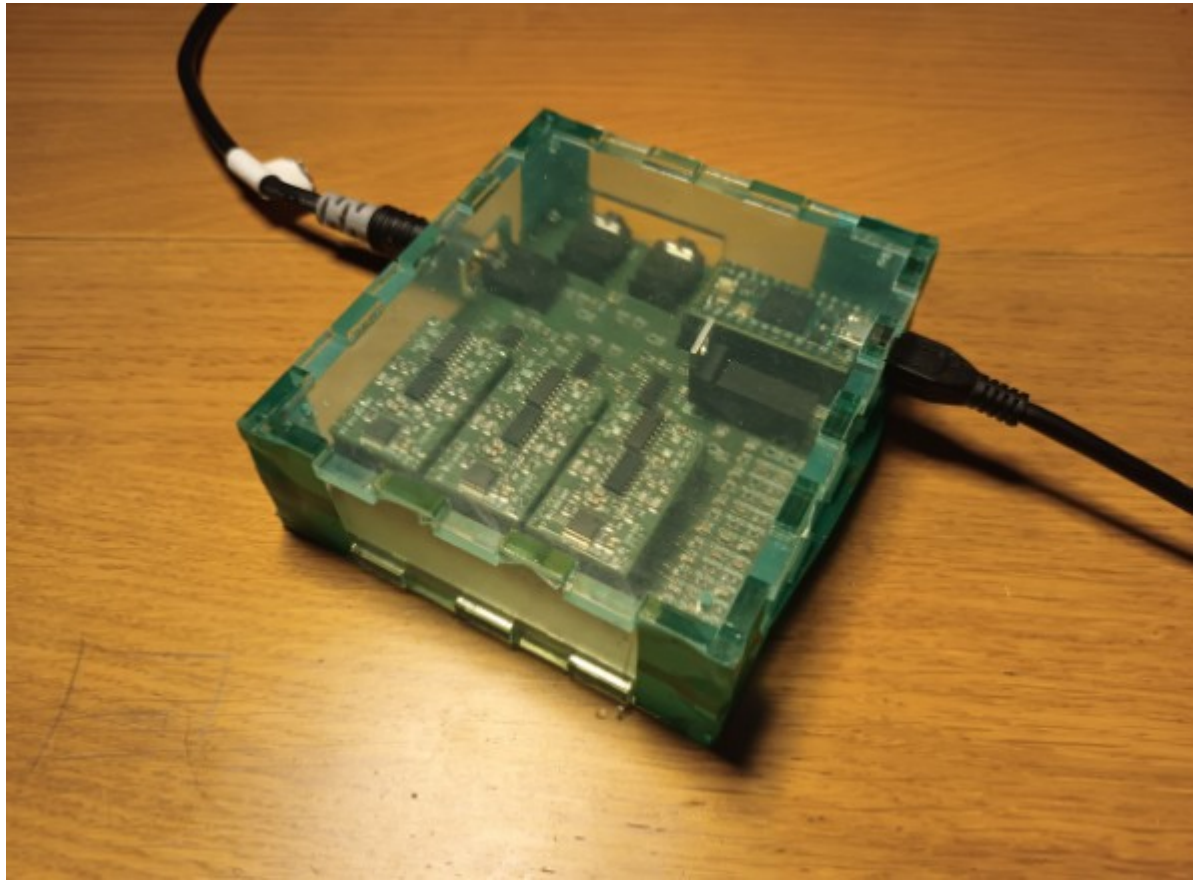
# Example Instrument: Digital No-Input Mixer (Elia & Overholt)



Elia, G., & Overholt, D. (2024, September). Musicking with dynamical systems: introducing a digitally-controlled analog no-input mixer. In Proceedings of the 19th International Audio Mostly Conference: Explorations in Sonic Cultures (pp. 22-36).

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# Example Instrument: Digital No-Input Mixer (Elia & Overholt)

the FluCoMa project [12], [24]. It works by manually assigning 2d coordinates to a number of interesting points from parameter space, and then training a Multilayer Perceptron to learn a non-linear mapping from 2d coordinates to parameter values in the instrument's higher-dimensional parameter space. The network can then be fed with 2d coordinates to provide instrument control parameters using the learned non-linear mapping.

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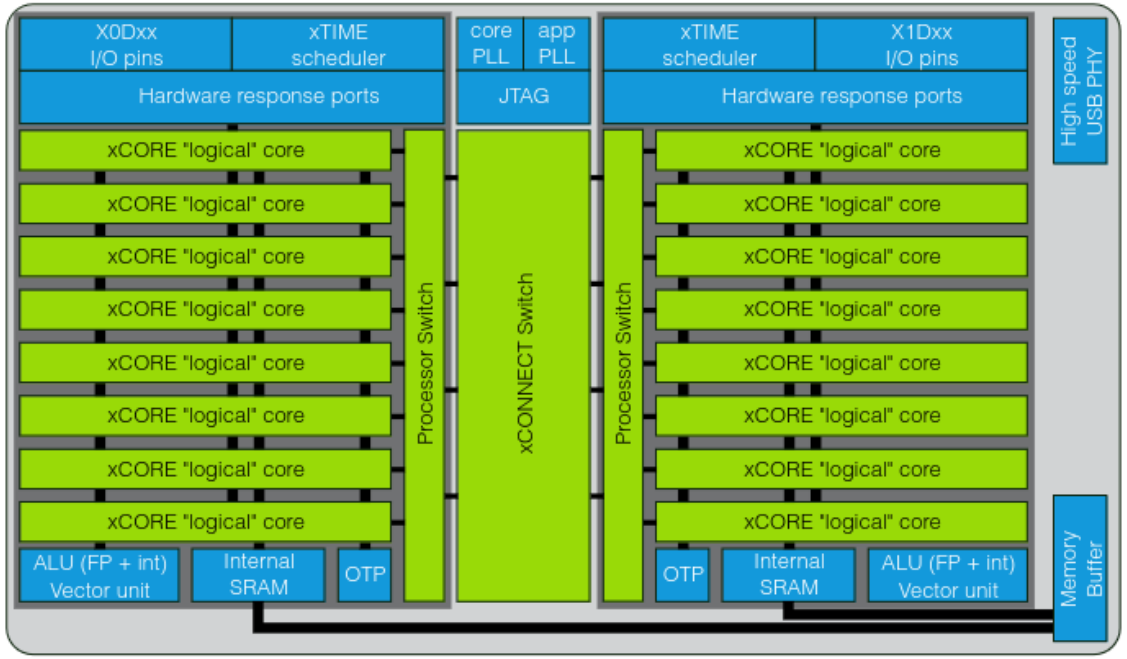
# Methods

- Long-term participatory design with practicing musicians
- Probe instruments
- Workshops
  - Sound and Music Computing, Aalborg Universitat Copenhagen  (PhD Course running in January)
  - Intelligent Instruments Lab, Reykjavik
- Autobiographical design
- Industrial collaborations
  - Schlappi Engineering
  - Emute Lab Instruments

# Embedded/Embodied Models and TinyML

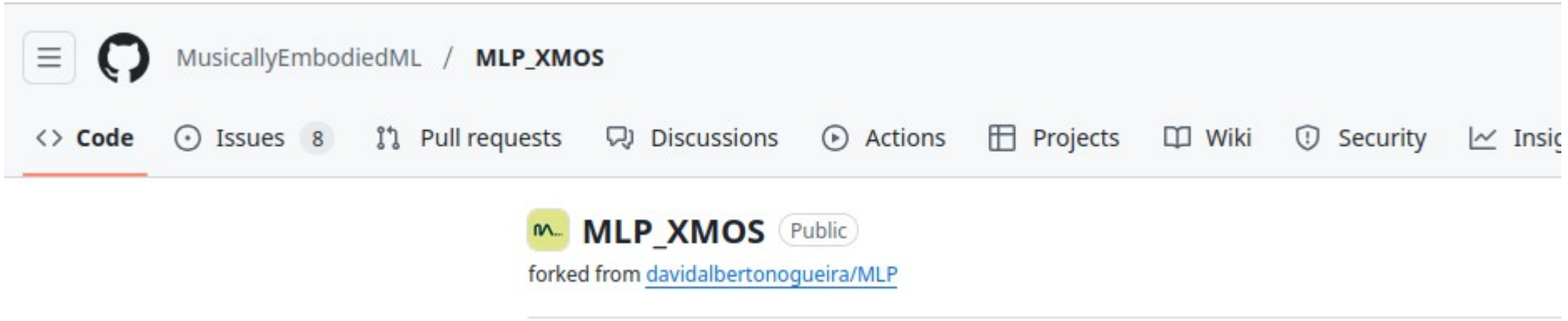

# Question:  What’s the value of hardware/hybrid instruments where machine learning is self-contained?

# Hardware Platforms: XMOS

# Hardware Platforms: RP2350

# Software: MLP Library for Microcontrollers



# Workshop Report

# CHIME Annual One-day Music and HCI Conference 2024

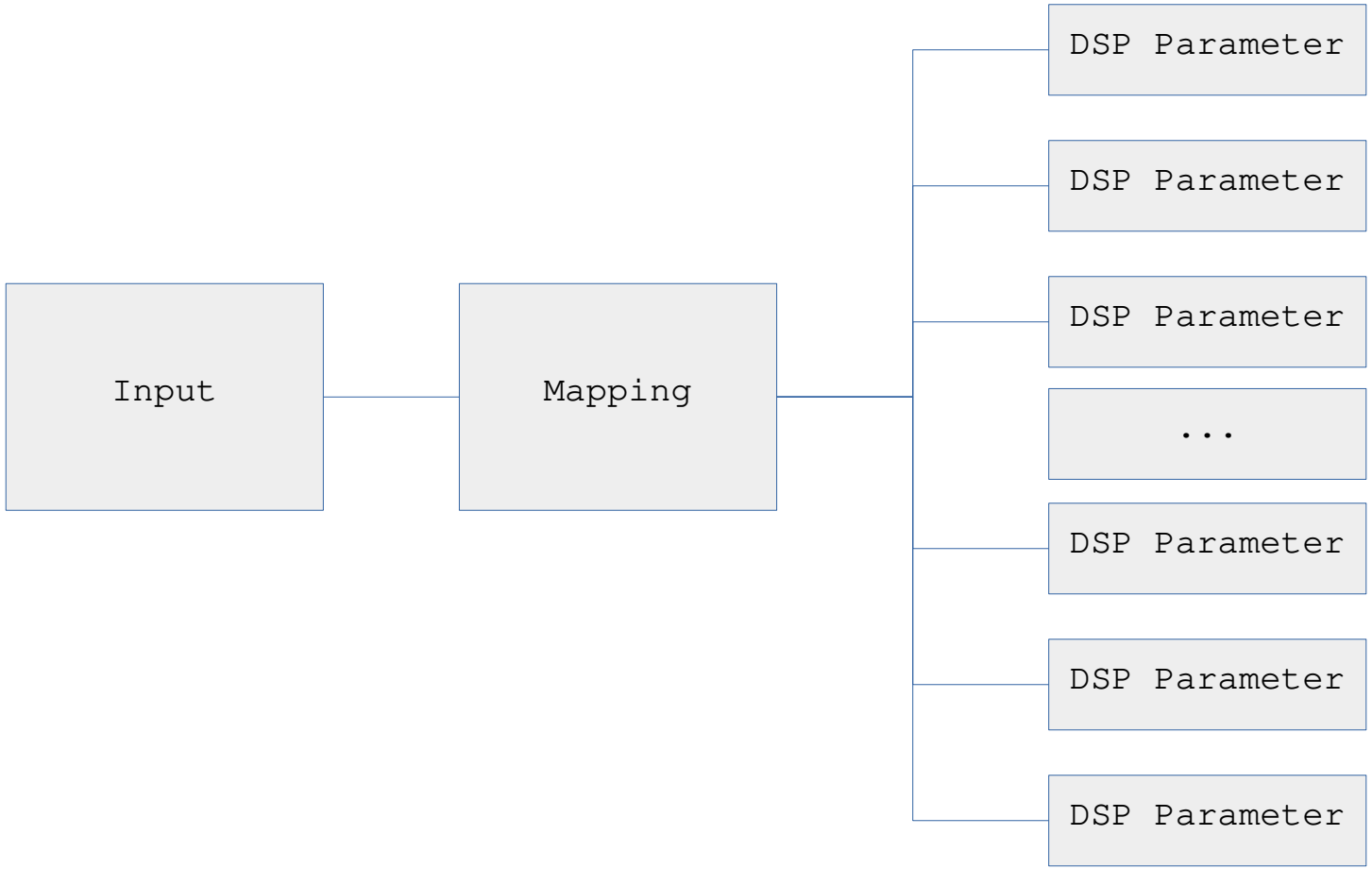

The Open University, in Milton Keynes, UK

One-day Conference: **Monday 2 December 2024**,

Workshops: **Sunday 1 December 2024.**

Question:  How do we embed training and inference into musical instruments in musical ways?  What interactive workflows are valuable?

# Testing Instruments with Parameter Space Mapping



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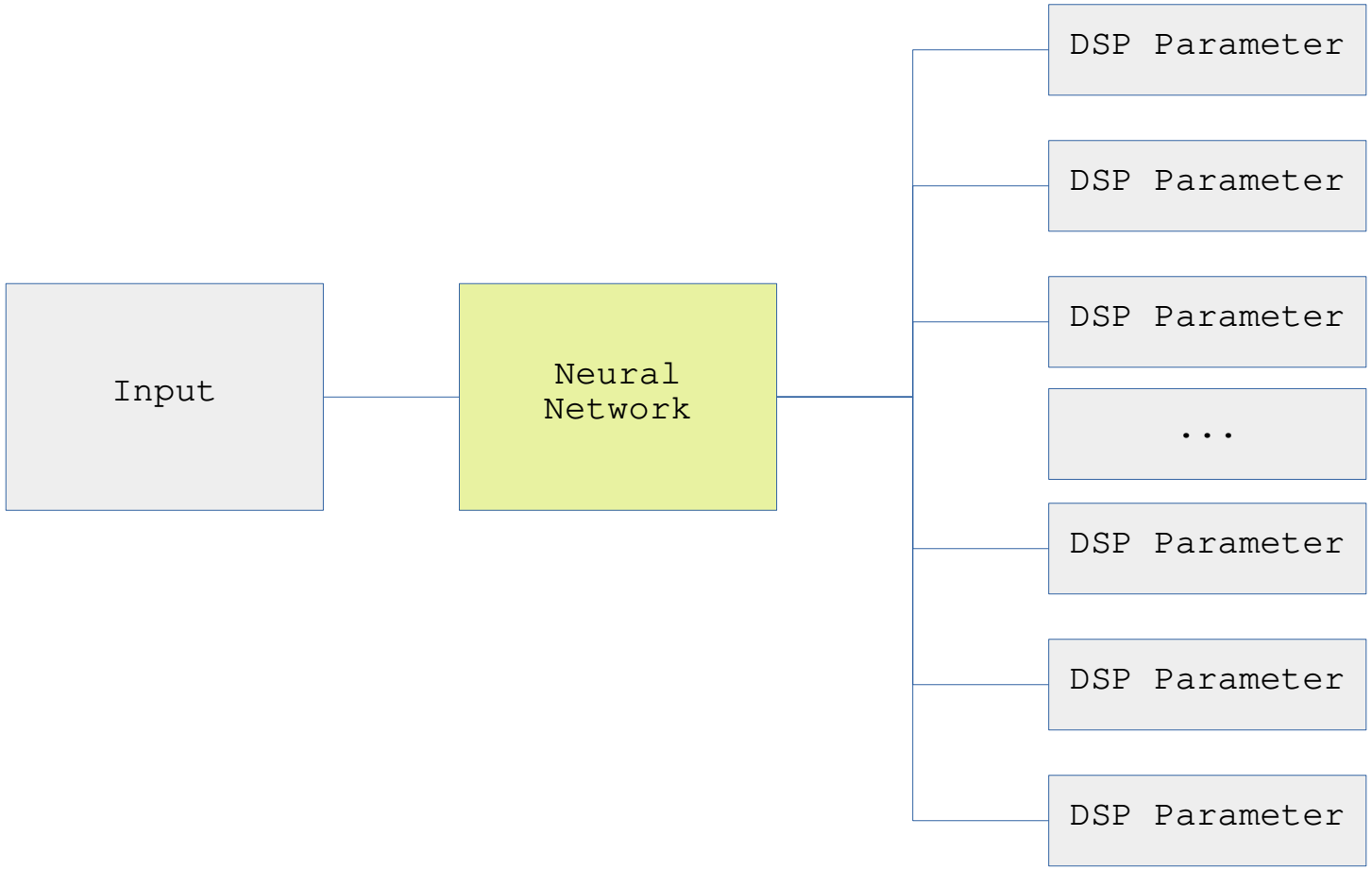

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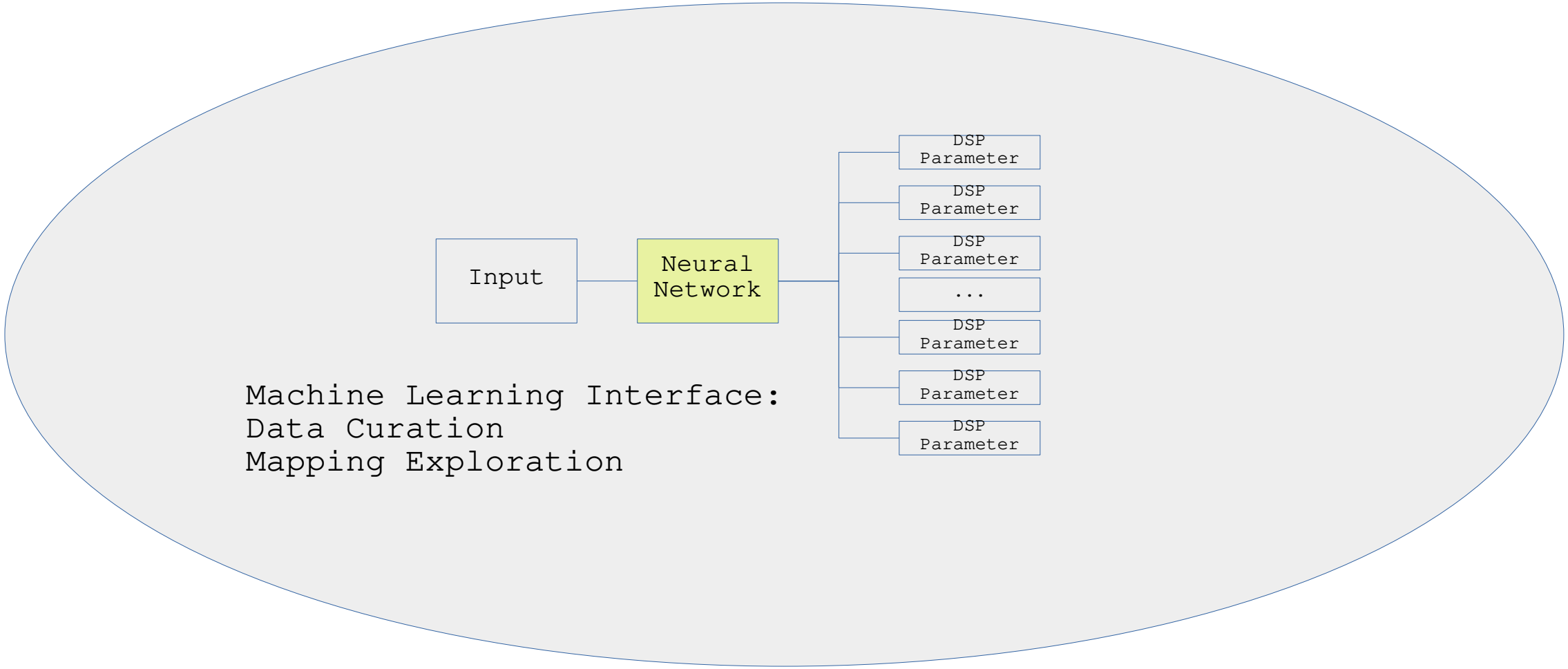
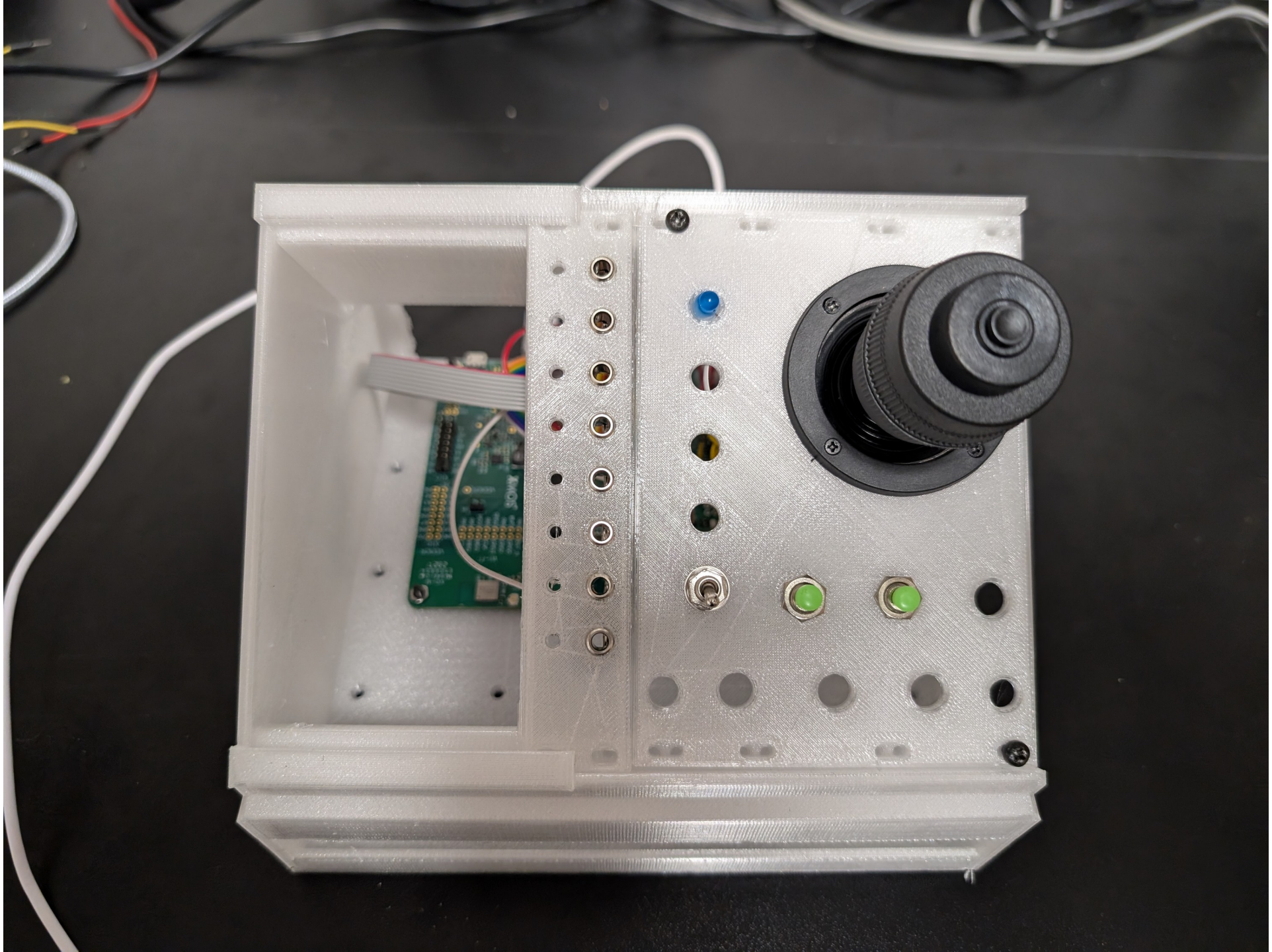
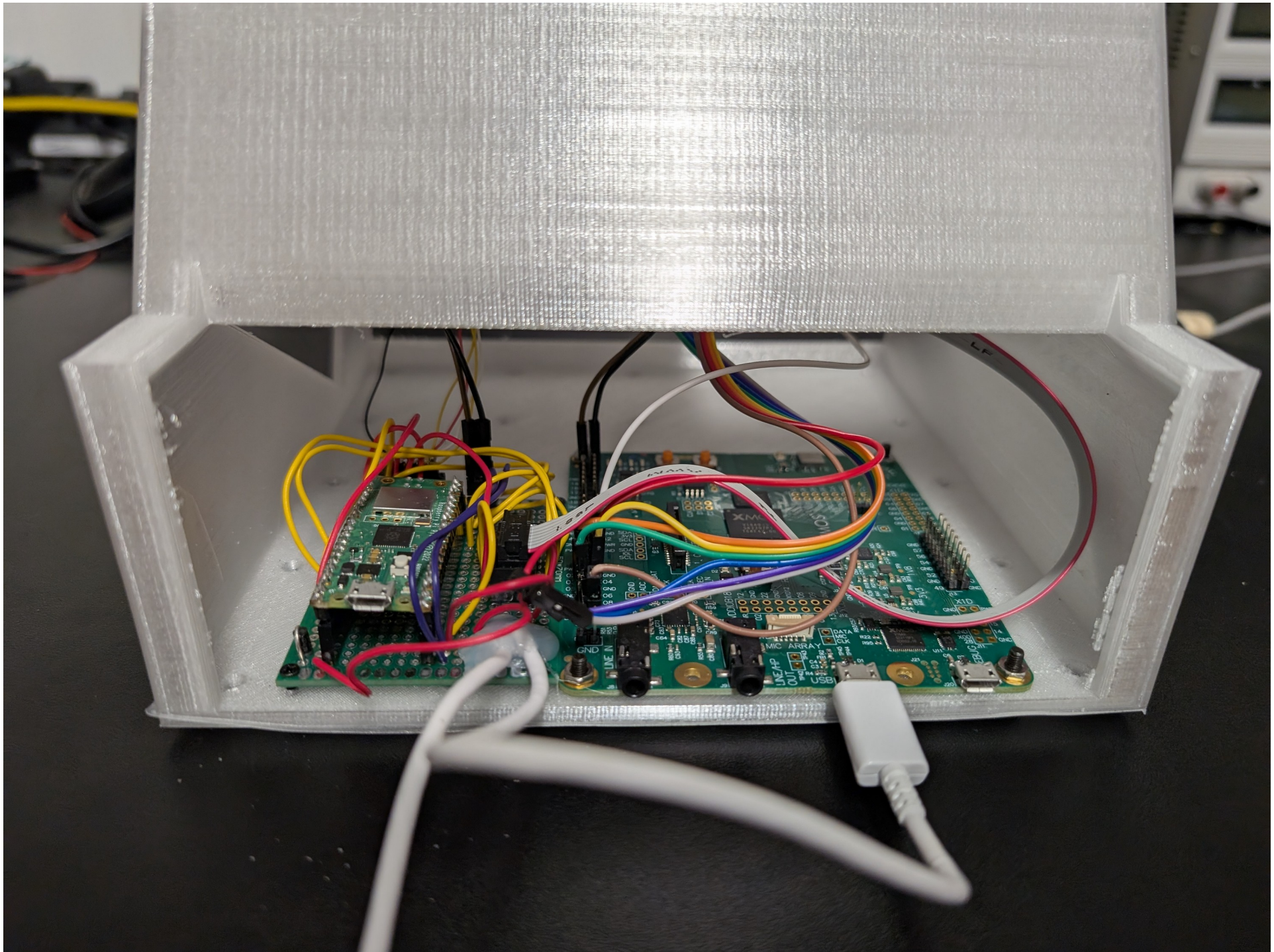
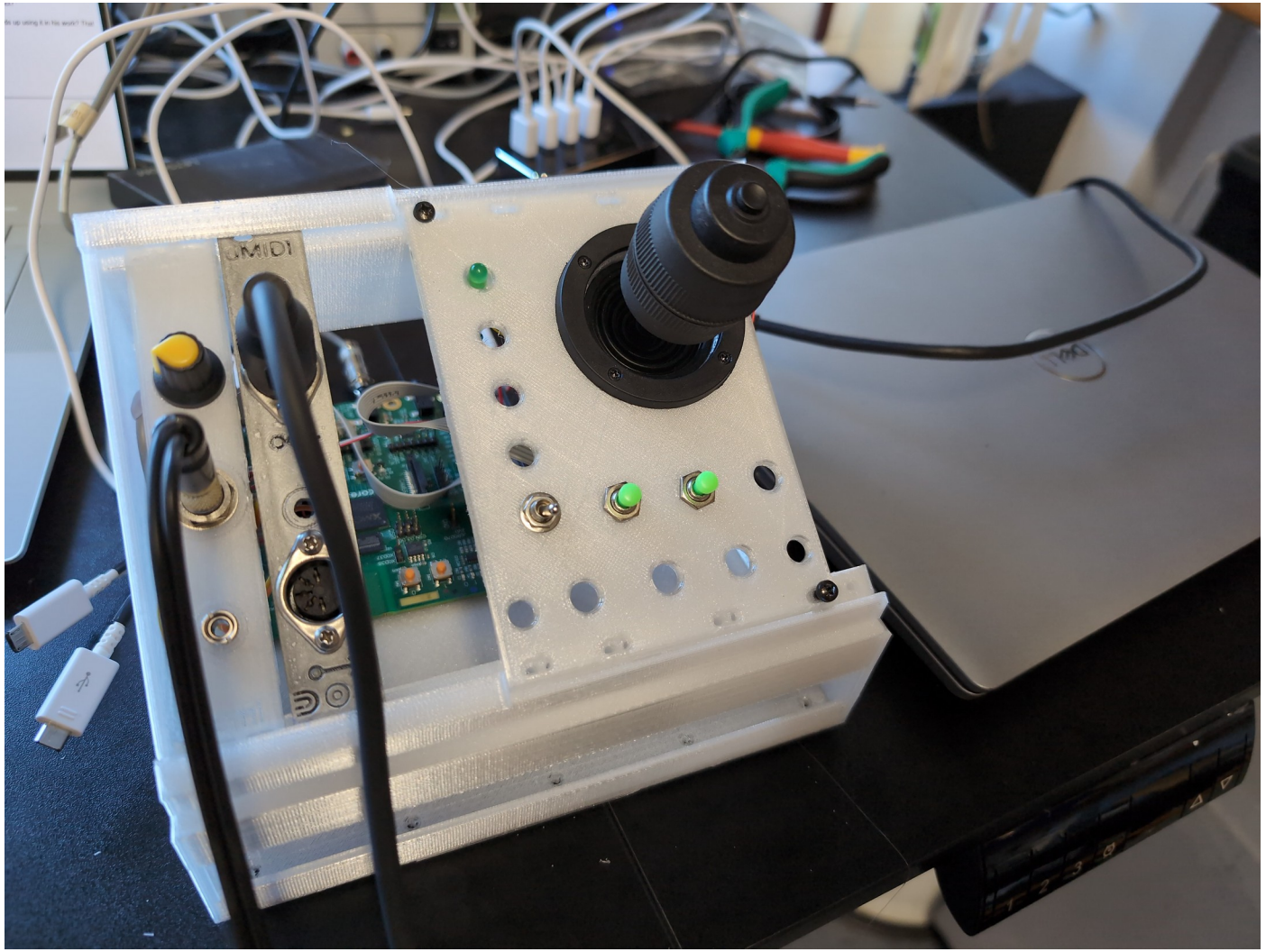


# Research Instruments: Three Variations on a Theme

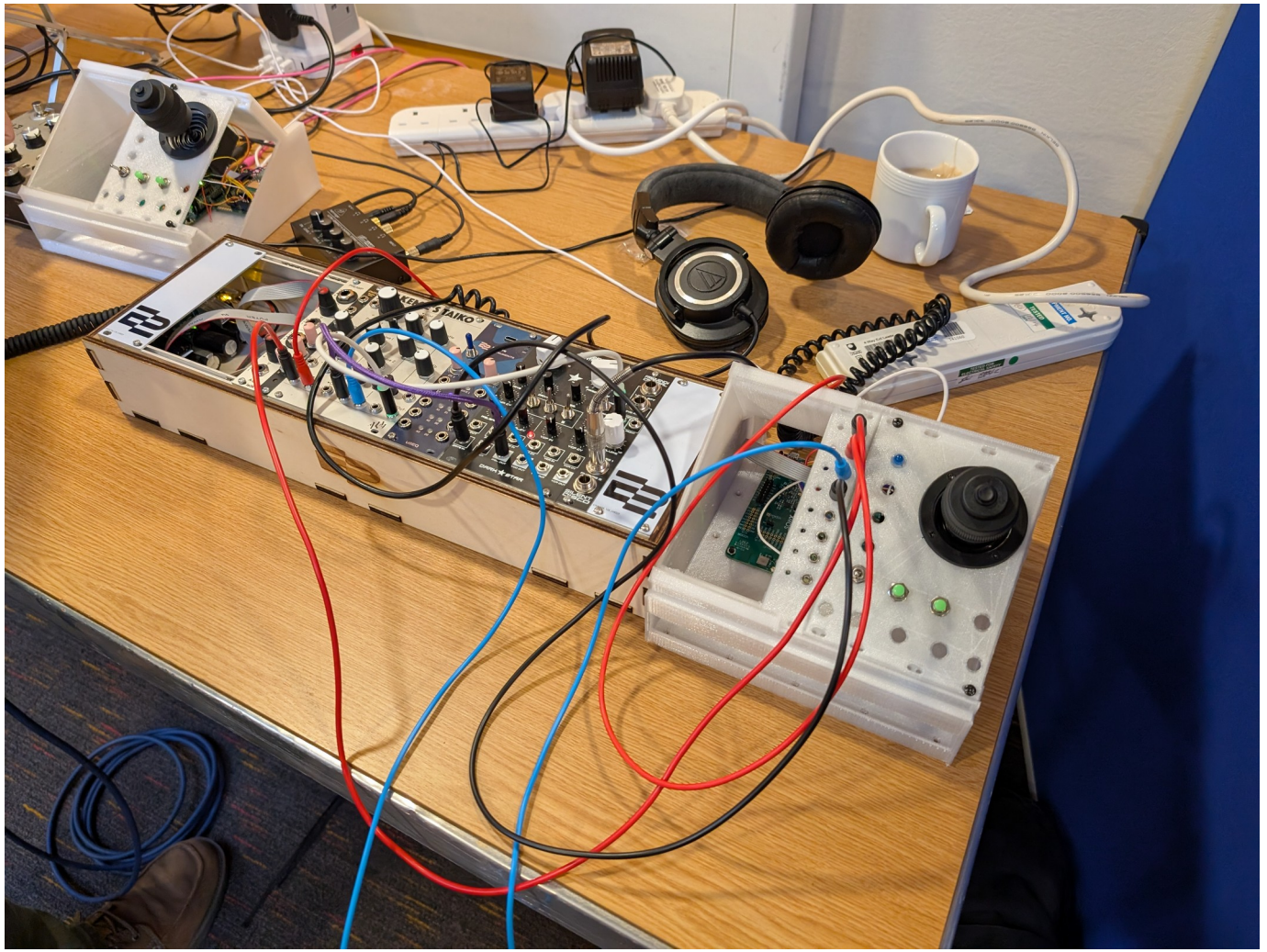



GND
LINE IN
LINE/HP OUT
MIC ARRAY
USB

# FM Synth



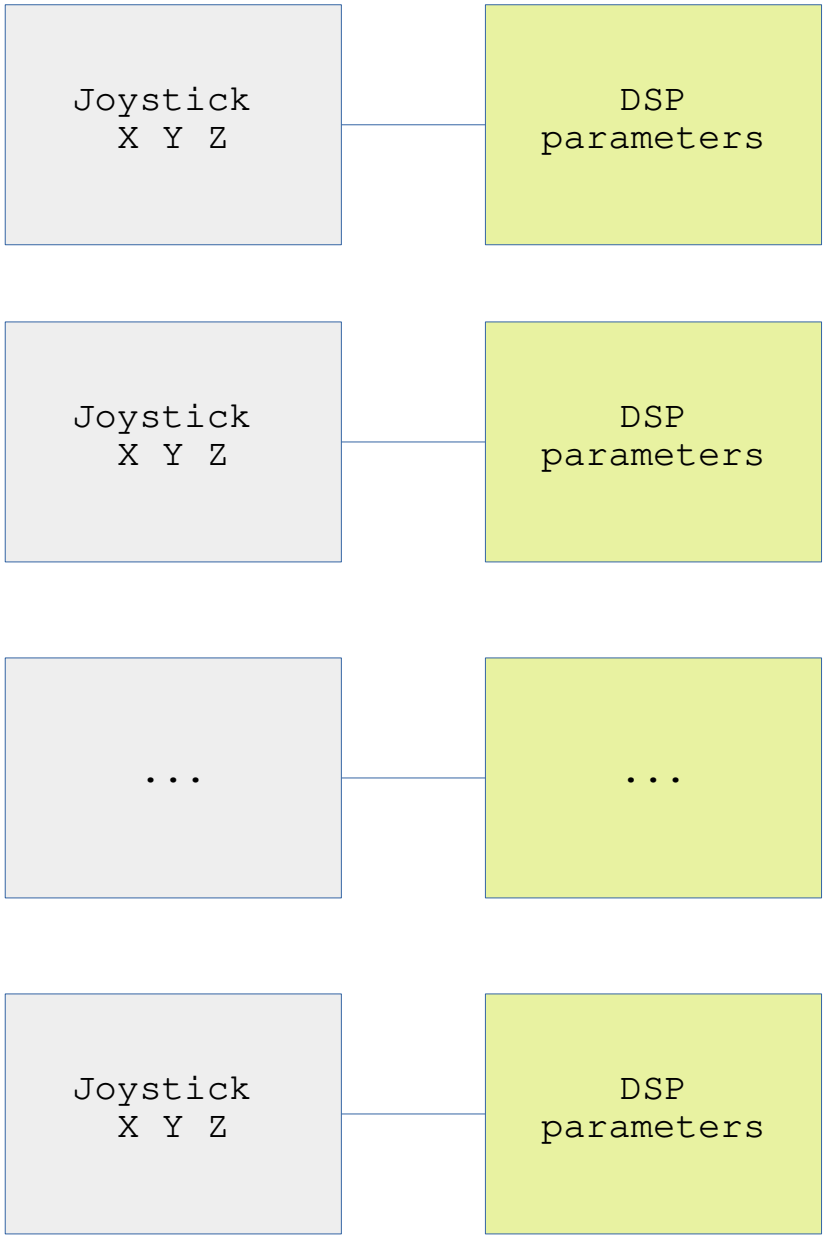
# Multi-euclidean Sequencer



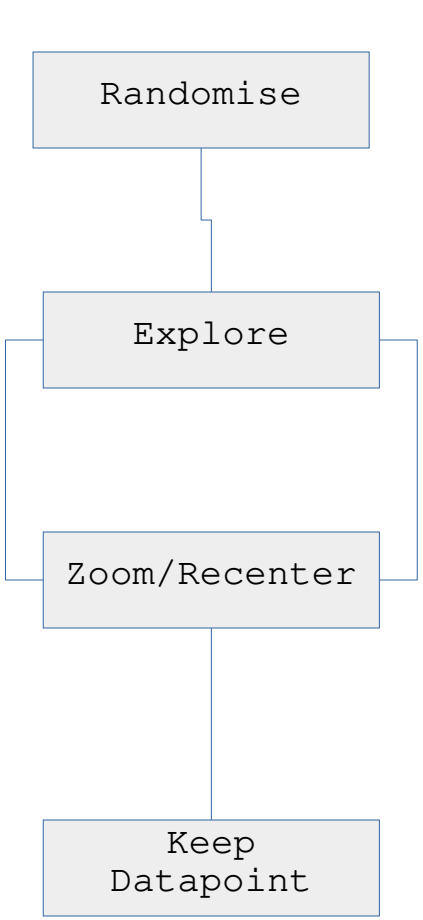
# Multi-Fx

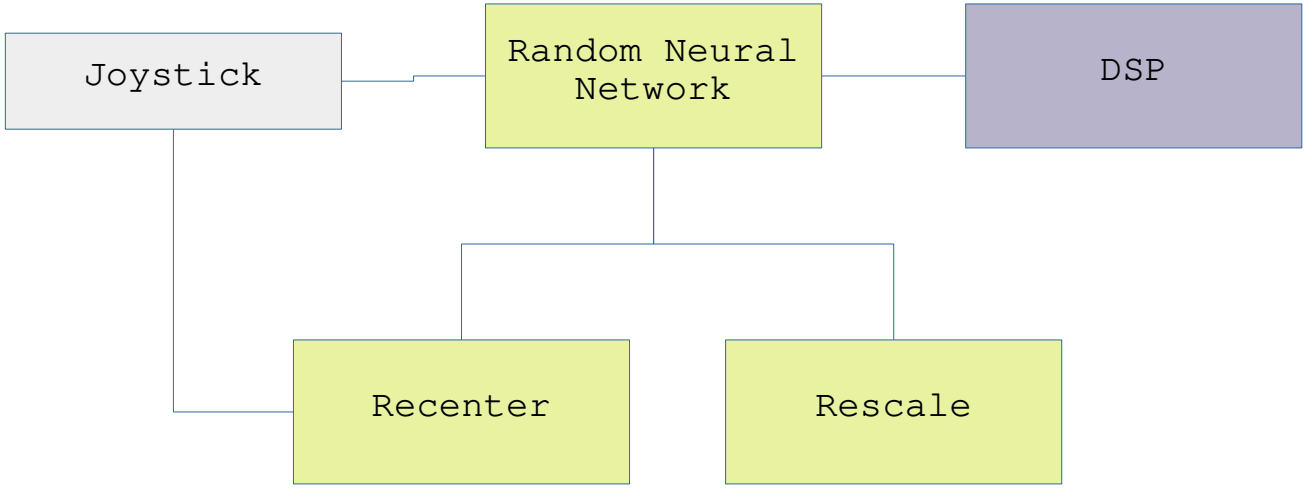
# Question: how do we train these models in a *musical* way?

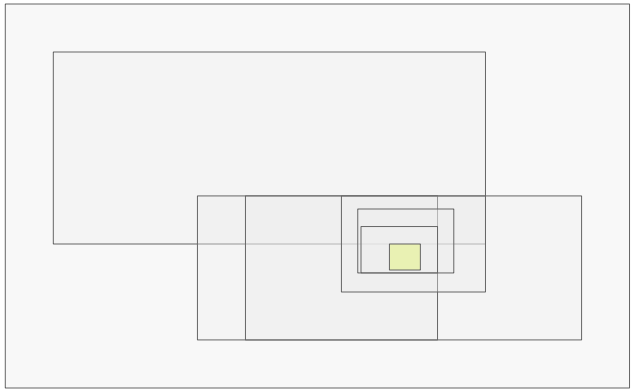
# Data


Joystick
X Y Z
DSP
parameters
Joystick
X Y Z
DSP
parameters
...
...
Joystick
X Y Z
DSP
parameters

# Sculpting Large Parameter Spaces: Neural Network Mapping Mode



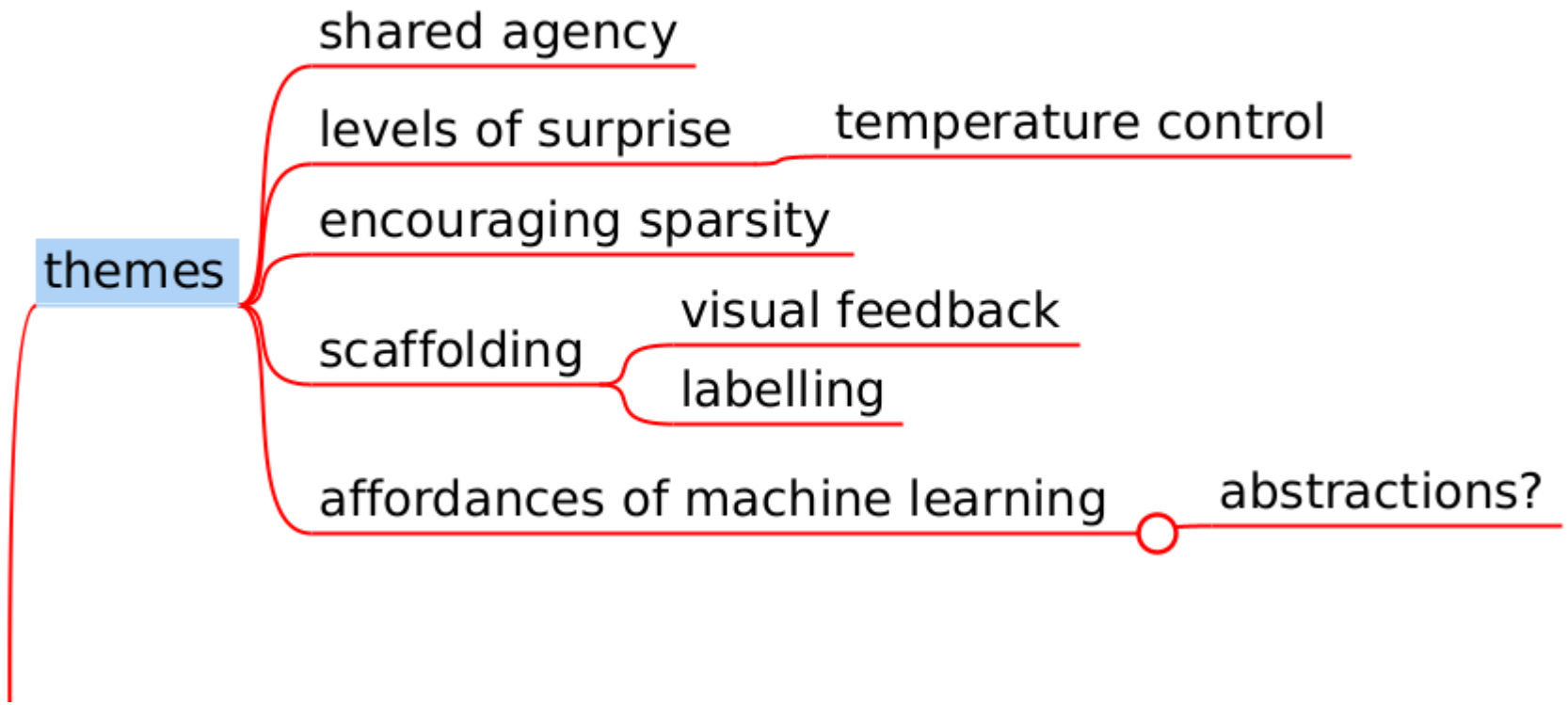



# Training Processes

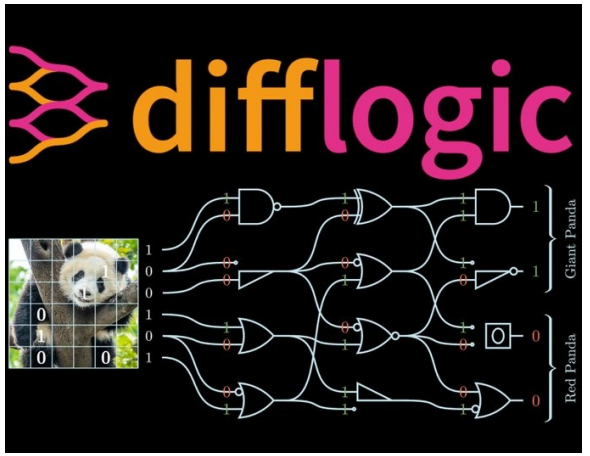
Features:

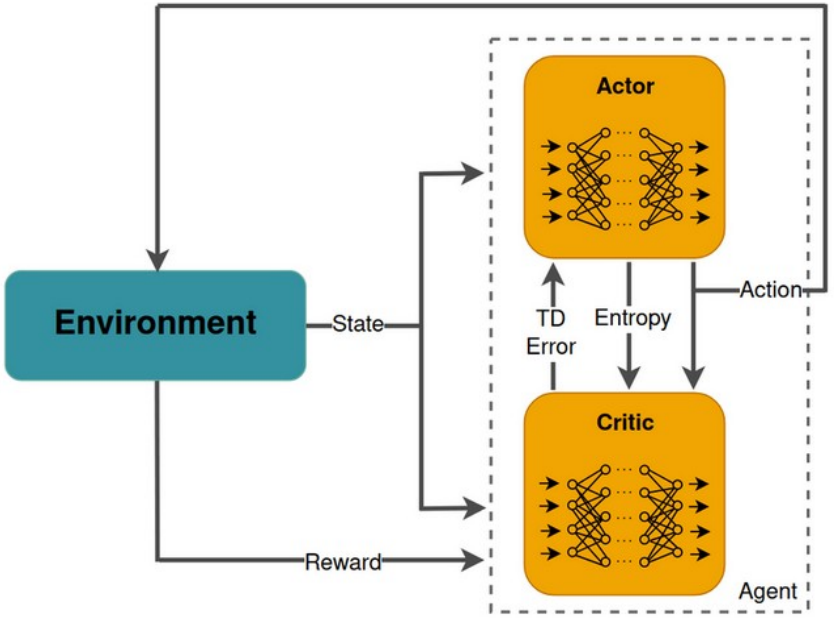
- Switch between training models
- Store data in multiple datasets
- Train models with combinations of datasets
- Structured exploration of parameter spaces
- Influence training quality

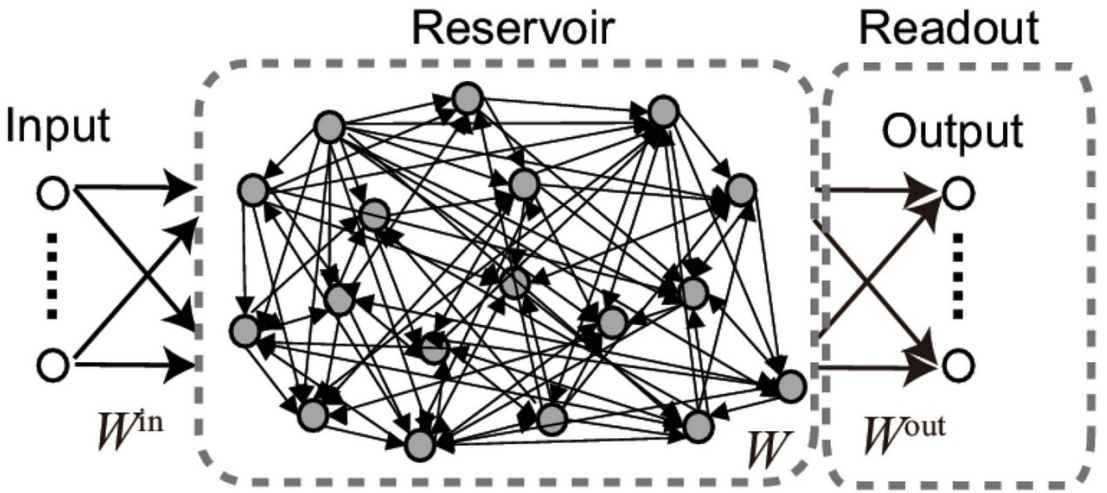

themes
shared agency
levels of surprise
temperature control
encouraging sparsity
scaffolding
visual feedback
labelling
affordances of machine learning
abstractions?

# Future
# Machine Learning Approaches

- Soft Actor-Critic Reinforcement Learning
- Reservoir Computing
- Differentiable Logic Networks



# Future Instruments:
# ML Multi-fx in Production

# Future Instruments:
# ML in the Xiasri (autobio design)

# Questions?

https://users.sussex.ac.uk/~ck84/meml/

https://www.emutelabinstruments.co.uk/

https://luuma.net/

http://www.emutelab.org/