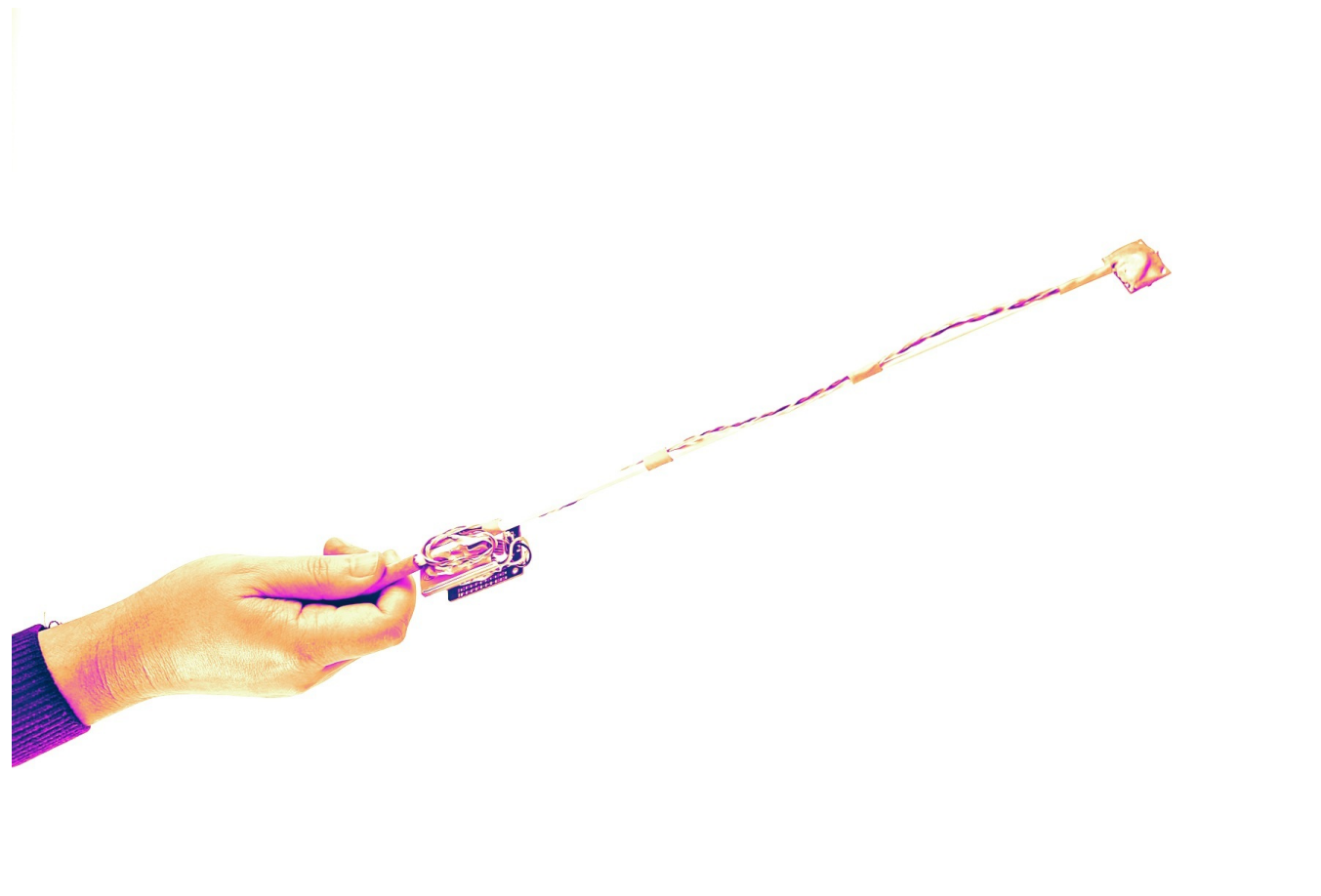


The Sonic Baton Project

Majella Clarke in collaboration with Intelligent Instruments Lab

Jan 2024





Background

The project started as part of studies within the Master of Music MMus in New Audiences and Innovative Practice (NAIP) at Iceland University of the Arts (2022-2024). In the program students are expected to experiment and explore innovative practice in their field of performance. As a conductor, my explorations of innovative practice were in sonifying gesture with the intelligent sonic baton developed in close collaboration with the Intelligent Instruments Lab at Iceland University of the Arts.

This document provides an overview of performances and the technical specifications that are currently in use within the sonic baton project.

Summary

The Sonic Conducting Baton is an intelligent musical interface designed to enable a direct correspondence between physical gestures performed with a conducting baton with sensors. The technology integrates accelerometer and gyroscope sensors, Arduino microcontrollers, wireless communication, Max patches, and Real-time Audio Variational autoencoder (RAVE) algorithms to create a unique, fast, high-quality neural audio synthesis drawing upon the work of Callion and Esling (2021).



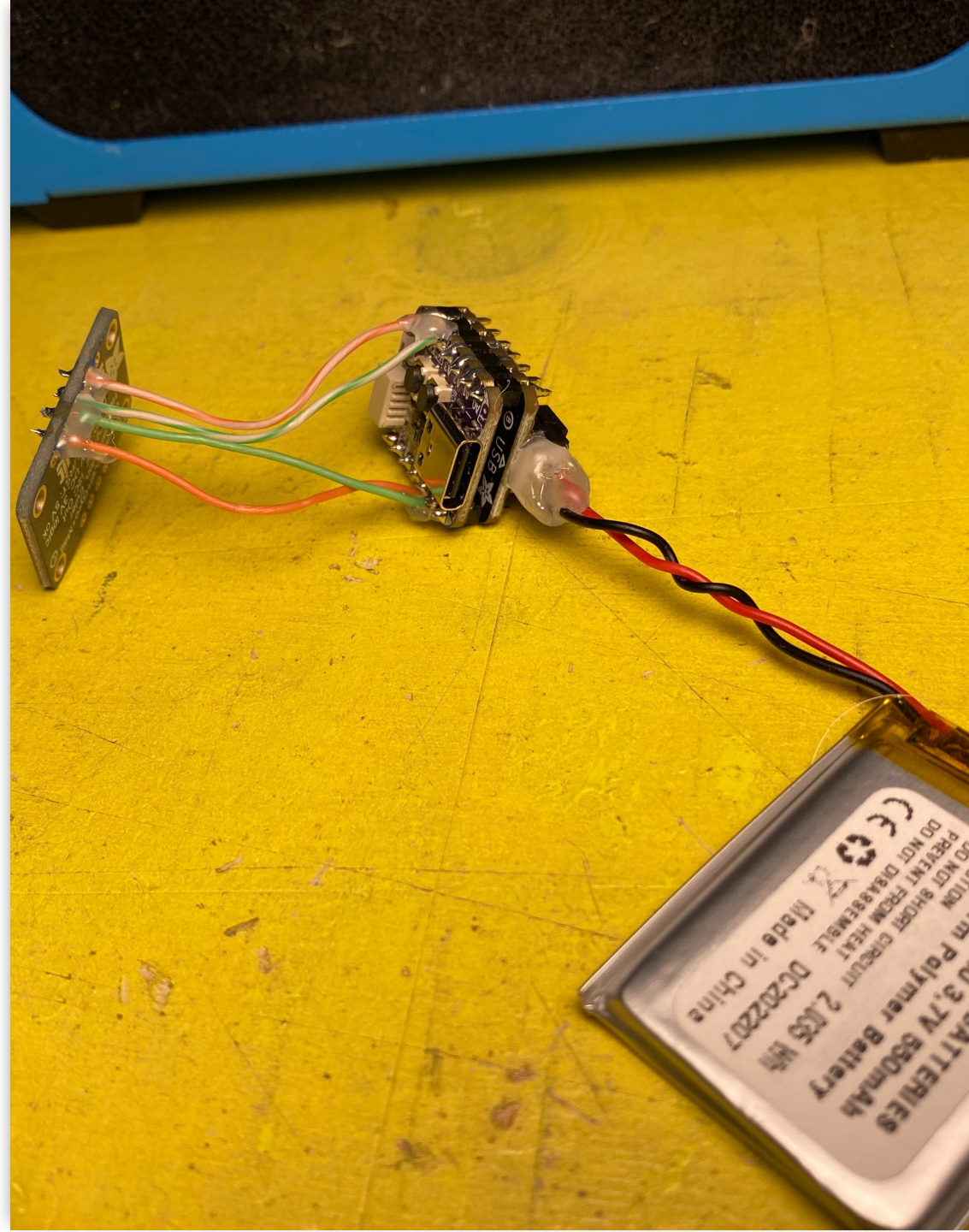
Image: Performance with three sonic batons at the Living Art Museum. From Left to Right: Nicola Privato, Victor Shepardson and Majella Clarke

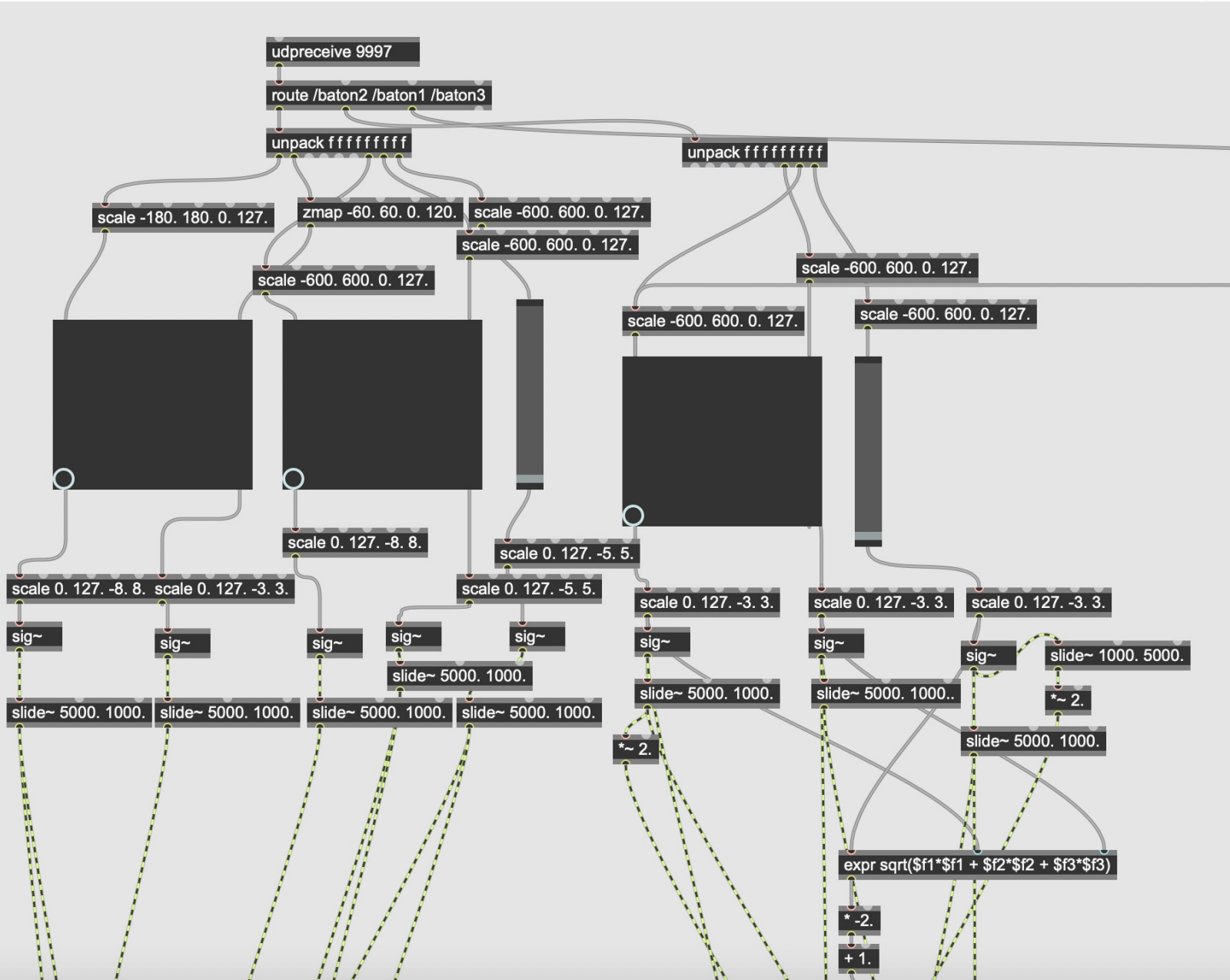
Technical Specifications: Hardware

Hardware Specifications: Each baton is equipped with the Adafruit 9-DOF Absolute Orientation IMU Fusion Breakout - BNO055, see attached data sheet at the end. The sensor module is designed for measuring orientation and motion-related data. It incorporates a Bosch BNO055 sensor, which is a System in Package (SiP) that integrates a triaxial accelerometer, gyroscope, and magnetometer, along with a microcontroller and sensor fusion algorithms.

The key feature of the BNO055 is its embedded sensor fusion algorithms. Sensor fusion combines data from multiple sensors (gyroscope, accelerometer) to provide more accurate and stable orientation data. The sensors provide real-time data on the baton's movements and orientation. The microcontrollers process sensor data while wireless communication facilitates seamless data transfer to Max patches via a secure wireless router this ensures real-time transmission of sensor data to the processing unit.

Photo by Majella Clarke: Adafruit 9-DOF Absolute Orientation IMU Fusion Breakout - BNO055 with Battery





Software Specifications:

Max Patches: Multiple Max patches are developed to process sound data from different sources – sea mammals, human voice and electric guitar.

RAVE* Autoencoder Integration: Sound data from each source is used to train a RAVE autoencoder following Caillon and Esling (2021). RAVE autoencoder enables efficient encoding and decoding of complex sound patterns.

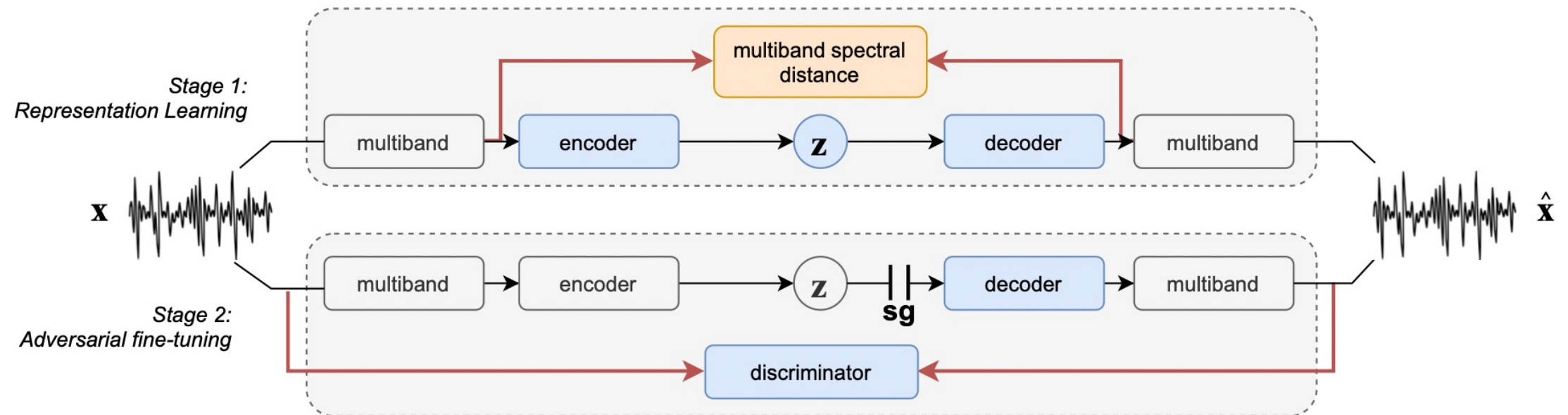
Acceleration Mapping: Acceleration data from the batons is mapped to vectors in the learned latent space. This provides a robust representation of physical gestures in the sonic domain.

RAVE Decoder: The RAVE decoder is employed to convert the stream of acceleration values into a stream of audio. It ensures a direct and dynamic relationship between baton gestures and sound production.

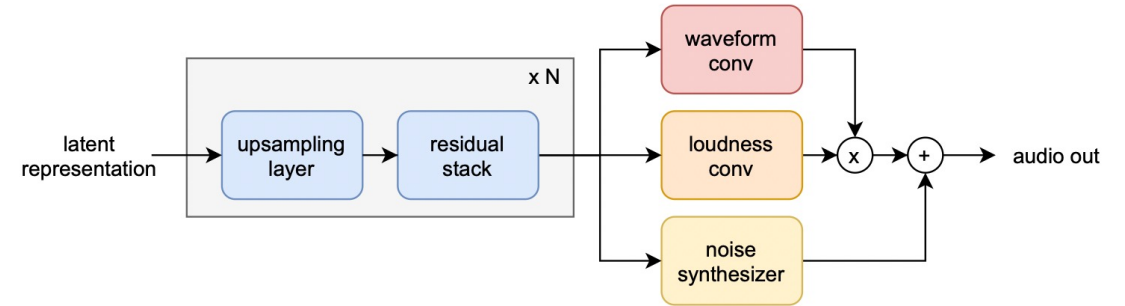
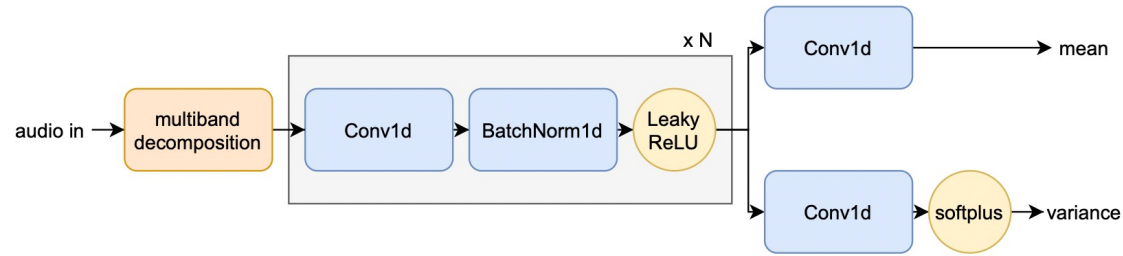
RAVE: Real-time Audio Variational autoEncoder

Overall Architecture for Unsupervised Modelling

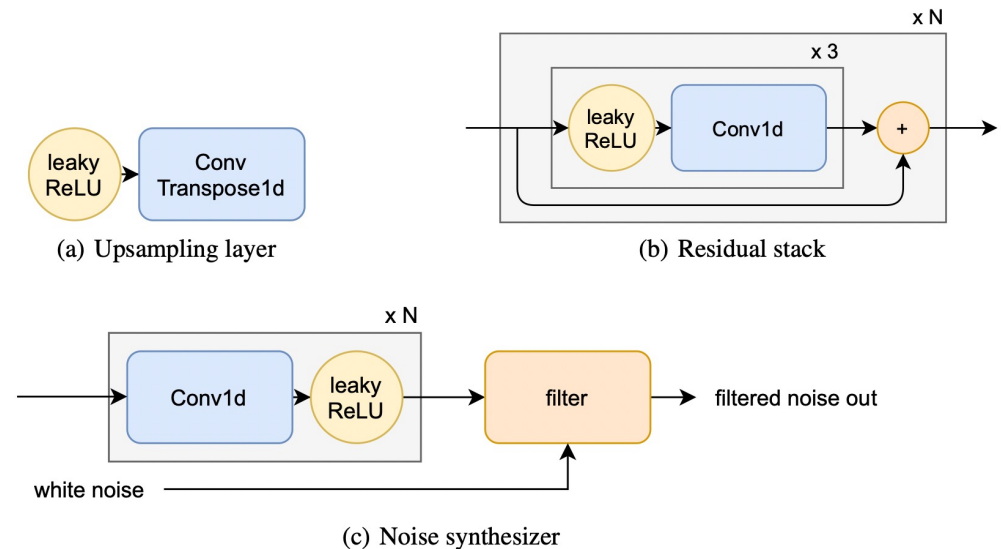
Following Caillon and Esling (2021) two stage training with model trained as a regular Variational AutoEncoder (VAE) then fine tuned with an adversarial generation objective.



Detailed Architecture of Encoder and Decoder Used in RAVE Model



Clockwise from above: Architecture of the Encoder used in the RAVE Model; Overview of decoder with latent representation unsampled using alternative upsampling layers and residual stack; Detailed architecture of the decoder blocks used in the RAVE Model. Reproduced from Caillon and Esling (2021).

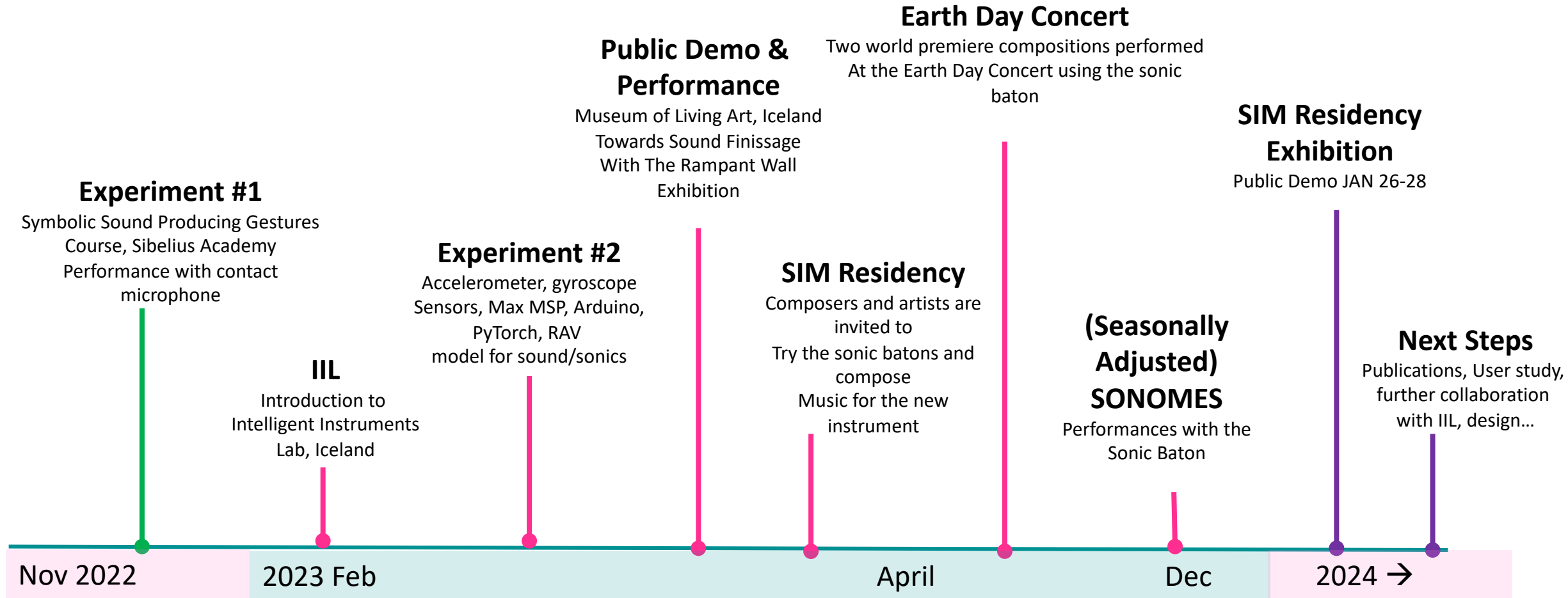




Outcomes

The Sonic Conducting Baton with Real-time Audio Variational autoEncoder Integration allows for real-time gesture based responsiveness with low latency. The sonic possibilities are as broad as the audio data sources, and in the first series of experiments with the sonic baton, included sea mammals, the human voice, and electric guitar. The use cases of the sonic baton include live musical performances with acoustic instruments and the intelligent sonic baton, experimental music compositions with graphic scores, and sound art installations.

Historical Timeline of the Sonic Baton Project to Date



Performances and Documentation

Date: 27th Jan 2024

Venue: Samband Íslenskra
Myndlistarmanna Exhibition,
Iceland

Performance: “Temperaments”
for Flugelhorn, Modular
Synthesizer and Sonic Baton

Duration: 10'00”

Performers:

Peter J. Østergaard

Majella Clarke



Photo: Francesco Giordano

Performances and Documentation

Date: 18th Dec 2023

Venue: Harpa Concert hall

Performance: May the Whole Universe for Open Ensemble

Composer: Bergþóra Ægisdóttir

Duration: Open

Performers:

Bergþóra Ægisdóttir – Soprano, Jack Armitage – Sonic Baton, Majella Clarke - Conductor / Sonic Baton, Sarah Dabby – Violin / Viola, Sigurður Halldórsson - Cello , Eydís Kvaran – Violin, John McCowen – Bass Clarinet, Peter J. Østergaard – Trumpet, María Pétursdóttir – Alto, Michael Richardt – Voice, Hlynur Sævarsson – Double Bass , Arndís Rán Snæþórsdóttir – Alto, Gabriella Snót Schram – Violin, Anna Maria Tabaczyńska - Flute / Piccolo, Olof Sigridur Valsdottir - Cello / Alto



Video link: <https://www.youtube.com/watch?v=Wly0IHtMM4>

Performances and Documentation

Date: 18th Dec 2023

Venue: Harpa Concert hall

Performance: Through Stillness I found
Death for Sonic Baton and String Orchestra

Composer: Composed by Juan David
Bermúdez

Duration: Open

Performers:

Jack Armitage – Sonic Baton

Majella Clarke - Conductor / Sonic Baton

Sarah Dabby – Violin

Sigurður Halldórsson - Cello

Eydís Kvaran – Violin

Hlynur Sævarsson – Double Bass

Gabríella Snót Schram – Violin

Olof Sigridur Valsdottir - Cello



Video link: <https://www.youtube.com/watch?v=rPACyw0rioU>

Performances and Documentation

Date: 22nd April 2023

Venue: Music Department, Dynjandi, Iceland University of the Arts

Earth Day Concert 2023

Three World Premieres with Sonic Baton

Through Stillness I found Death for Sonic Baton and String Orchestra, composed by Juan David Bermúdez

May the Whole Universe for Open Ensemble, composed by Bergþóra Ægisdóttir

BÚSQUEDA for Voice, Flute, Cello and Sonic Baton, composed by Santiago Rueda García

Program available here: https://www.majella-clarke.com/_files/ugd/729add_1f13e38d9dc944abbe75b548a9fcea66.pdf



(2023)

Through Stillness I found depth.

Sonic baton

very slow (the swaying of the mountains)

♩ x 50

① Japan

Interceptable moments
In the sand, the bodies, and the planet

PP MF G.P.

② PafocitéptL

Decelerating Triangles

G.P.

③ San Francisco

Delicate Lull

FP FP G.P.

④ Iceland

Rit.....

G.P.

Free From the ensemble (for reference only)

Slower

PPP

Sonic baton
1/4

Natural Harmonic
Gliss

ORD → S.P.

S.P. → on the bridge

PP MP

MF

ORD.

PPP

Senza Tremolo

PPP

Performances and Documentation

Date: March 2023

Venue: Living Art Museum, Iceland

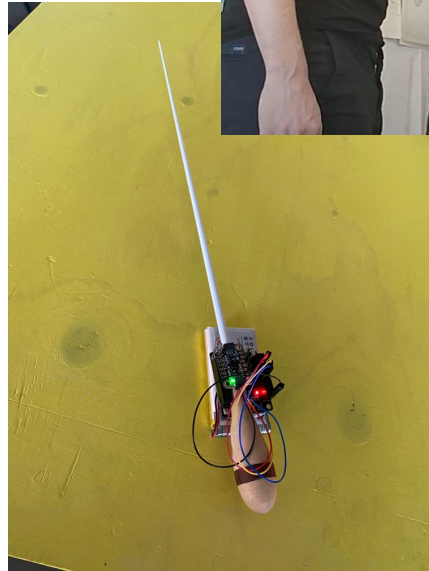
Performance: May the Whole Universe with three sonic batons,

Composer: Bergþóra Ægisdóttir

Duration: 7'00"

Details: Performed at the Finissage Towards Sound Exhibition Curated by composer Ruth Wiesenfeld and visual artist Gunnhildur Hauksdóttir. Included public demo.

<https://www.nylo.is/en-us/events/17002>



Images: Above Performance with three sonic batons at the Living Art Museum. From Left to Right: Nicola Privato, Victor Shepardson and Majella Clarke. Left: First baton with Intelligent Instruments Lab, Iceland University of the Arts – with Nicola Privato, Victor Shepardson and Sean Patrick O'Brien.

Performances and Documentation

Date: 12th Nov 2022

Venue: Vapaan Taiteen Tila, Finland

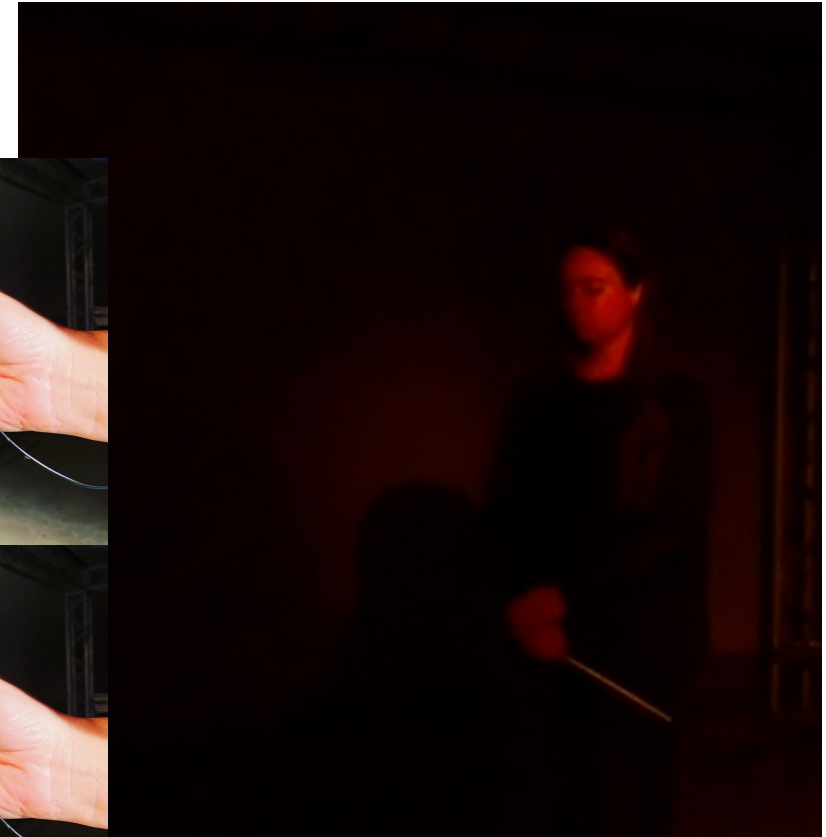
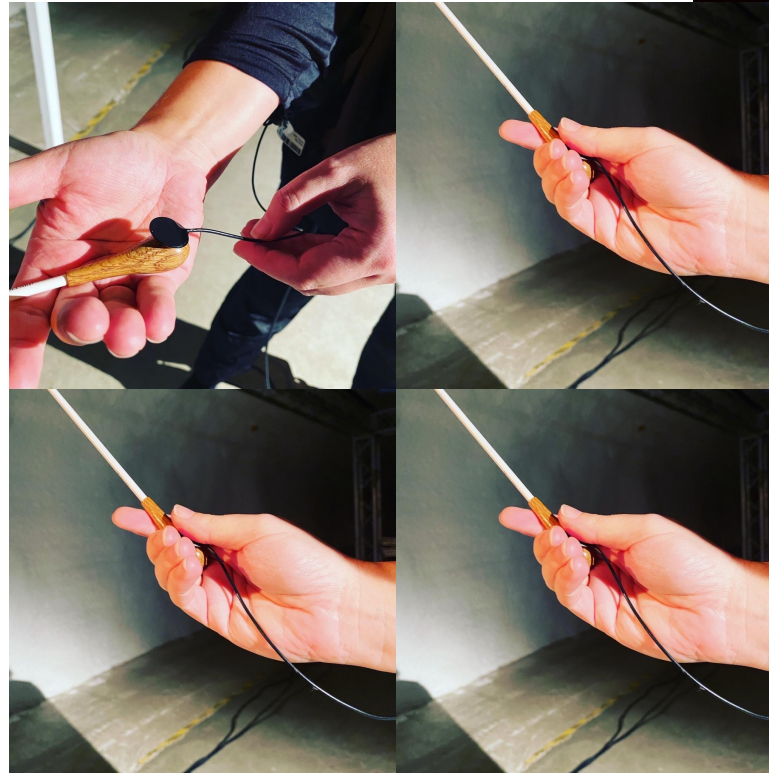
Performance: Shimmer Shimmer Boom!

Composer: Majella Clarke

Duration: 7'00"

Details: First experiment with Sonic Baton using a contact microphone, Alberton PUSH, 15 tuning forks. Algorithmic composition in Sonic Pi, with excerpt of Tchaikovsky's 1812 Overture.

Performed during the course
Symbolic Sound Producing Gestures,
Sibelius Academy, Finland

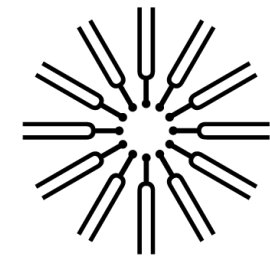


Video link: https://www.youtube.com/watch?v=jWG_Oxv5_io

Collaborations To Date



Intelligent Instruments Lab
Iceland University of the Arts
The Living Art Museum, Iceland (NYLO)
Sibelius Academy, Uniarts Helsinki
SIM Residency
Towards Sound
Harpa Concert Hall



HARPA

Acknowledgements and Collaborators

Three personnel of the Intelligent Instruments Lab, Iceland, were part of the team that collaborated in the second experiment and performance demo. **Nicola Privato** provided technical expertise in the set-up using Max MSP, **Victor Shepard** produced sound files with RAV models with PyTorch and **Sean Patrick O'brien** placed the sensors and batteries on the baton. Nicola and Victor were also part of the performance demonstration at the Towards Sound Finissage at the Living Art Museum in Reykjavik.

Charles Quivillion facilitated the Open University Course Symbolic Sound Producing Gesture Course through the Sibelius Academy in November 2022. Charles was involved in the set-up of the first experiment with using a contact microphone on the baton and produce sound through Ableton PUSH. Charles also organised the final performance from the course for which Majella first used the sonic baton in performance.

Thomas Pausz Head of the Masters in Design Program at the Iceland University of Arts, is advising on the design of the sonic baton.

Composers **Juan David Bermondez**, **Bergþóra Ægisdóttir** and **Santiago Rueda Garcia** composed scores for the sonic baton and ensemble. The compositions were premiered at the Earth Day Concert in Reykjavik.

Curated by composer **Ruth Wiesenfeld** and visual artist **Gunnhildur Hauksdóttir**, the sonic baton was used to demo and perform in the Towards Sound Exhibition at the Living Art Museum, Reykjavik.