VILLA VR: A FAUST-BASED MULTI-USER XR LABORATORY FOR COLLABORATIVE LEARNING OF SOUND SYNTHESIS

Tray Minh Voong, Stefan Balle, Michael Oehler

What is VILLA VR?

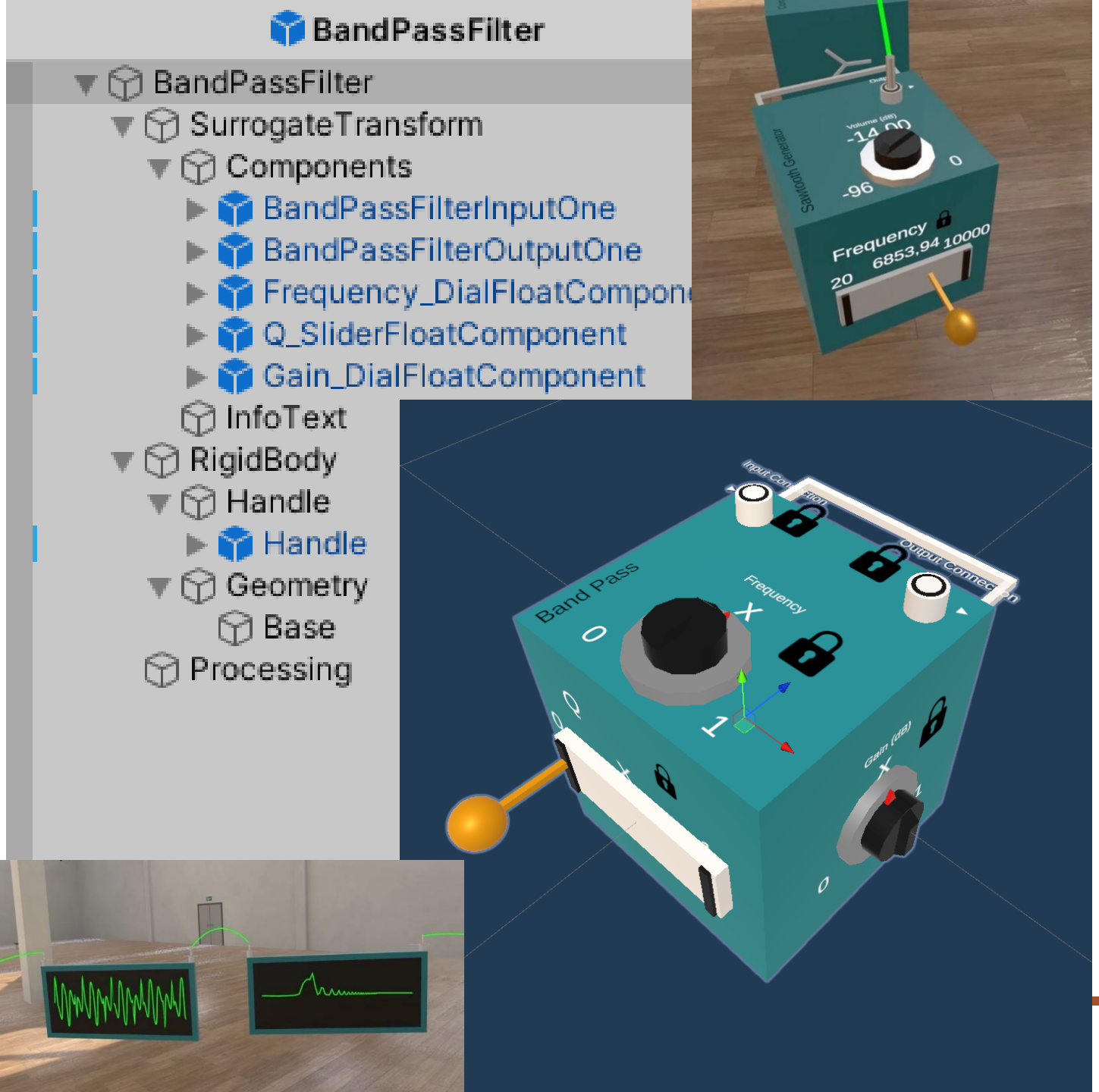
- Open-source XR environment for collaborative sound synthesis learning
- FAUST-based DSP modules inside a shared virtual lab
- Focus on modularity, collaboration, and educational scaffolding

Why build an XR synthesis laboratory?

- (Analogue) synthesizer learning often depends on costly or space-demanding hardware setups
- Conventional software remains screen-bound and limits embodied spatial interaction
- XR can support immersion, collaboration, and new teaching formats
- We wanted a shared environment for building, hearing, and discussing synthesis structures

Main contributions of VILLA VR

- FAUST-centered authoring pipeline for reusable XR audio modules
- Interactables as a modular interaction architecture
- Real-time multi-user patching and parameter synchronization
- Educator-focused moderation and scaffolding tools
- Positioning within XR sound labs and music education research

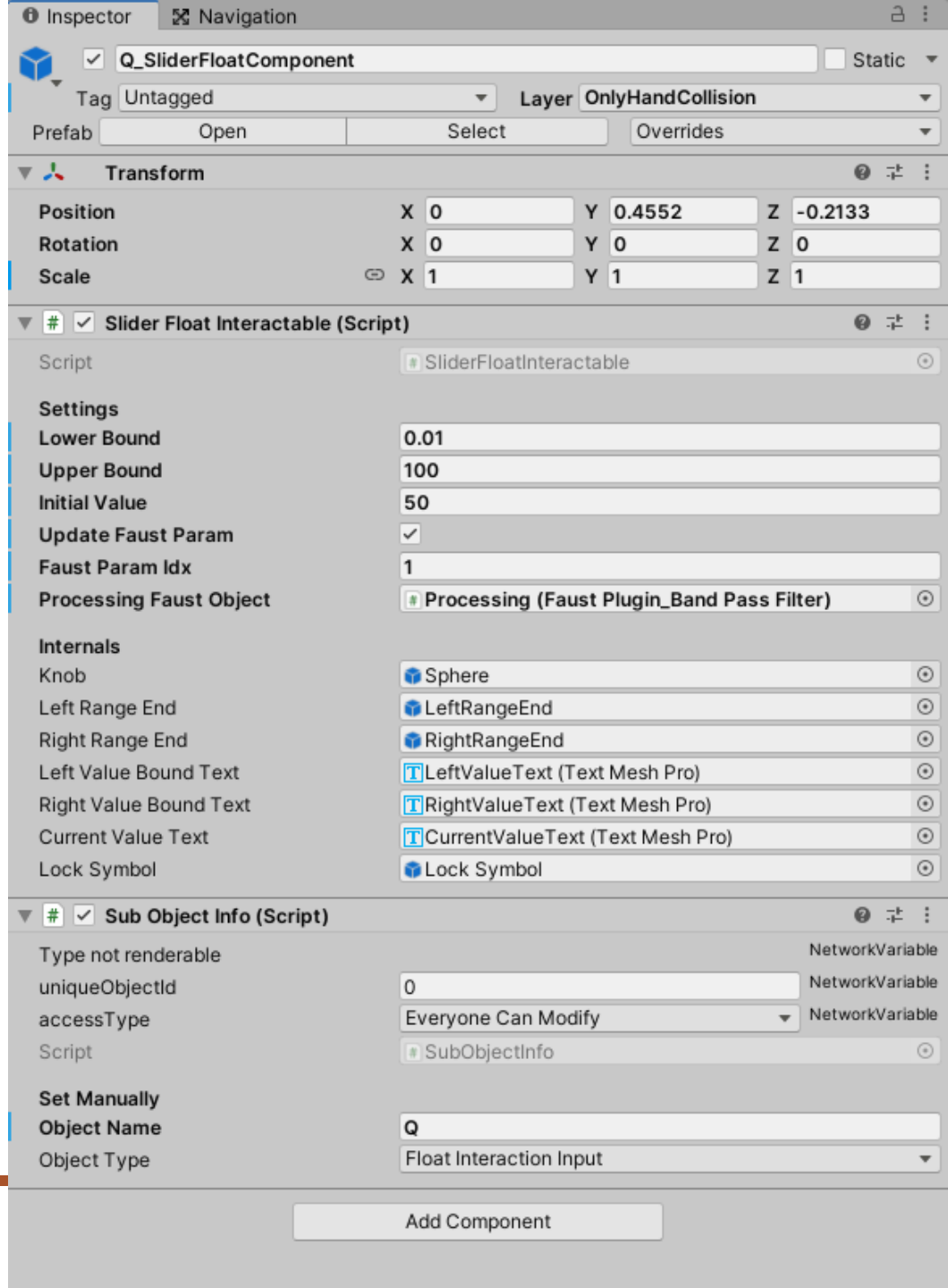


System overview

- Implemented in Unity 2021.3.12f1
- Current module types: oscillators, filters, gain and routing utilities
- Also includes spatial output and analysis modules
- Waveform and spectrum displays provide immediate feedback

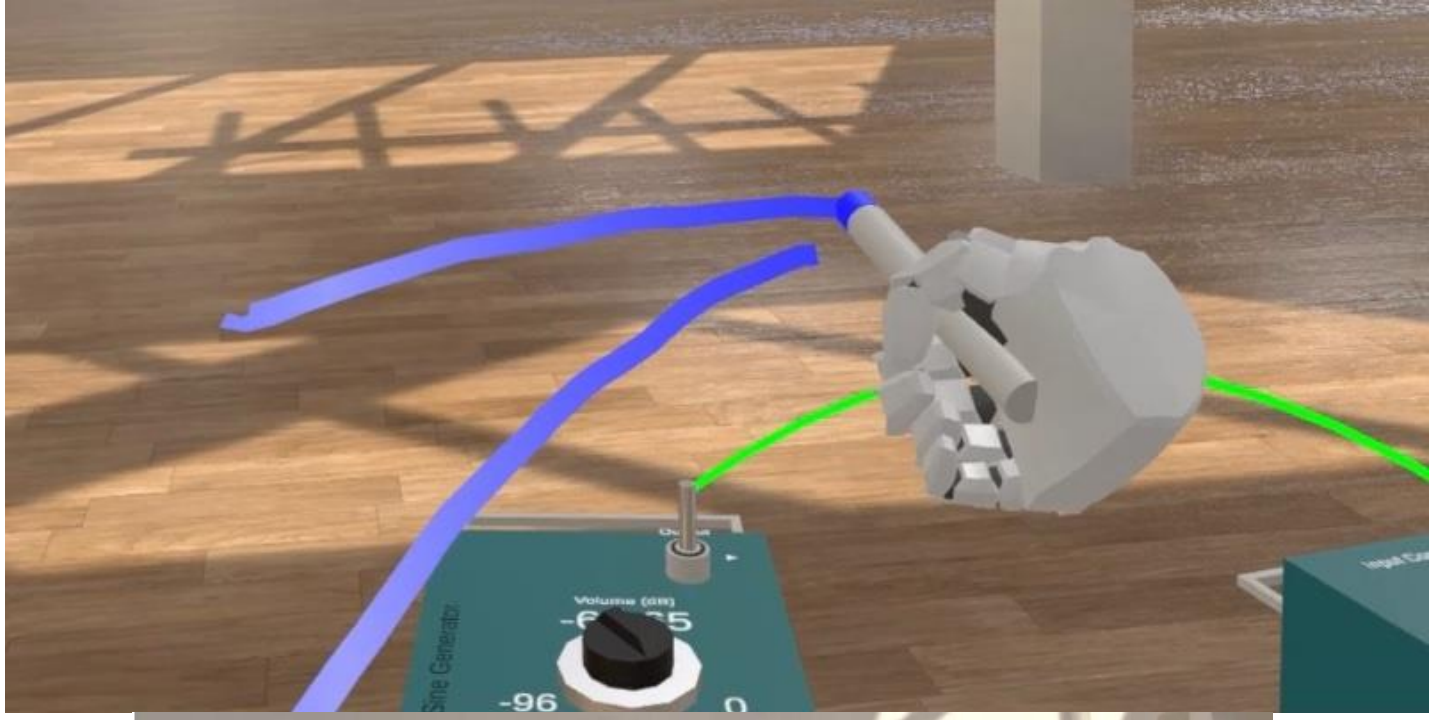
Why FAUST?

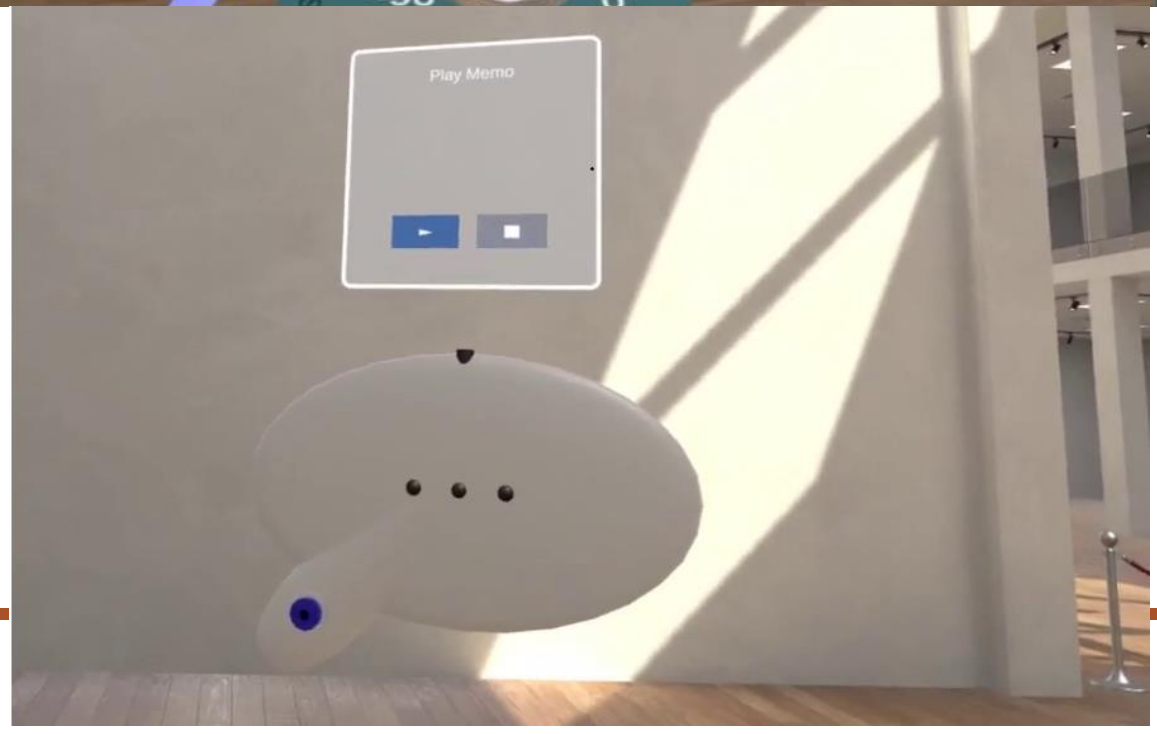
- Audio generation and processing modules are authored in FAUST
- Compiled for Unity using tools such as faust2unity
- Module parameters are exposed for interaction, visualization, and networking
- Clear separation between DSP authoring and XR interaction design



Interactables

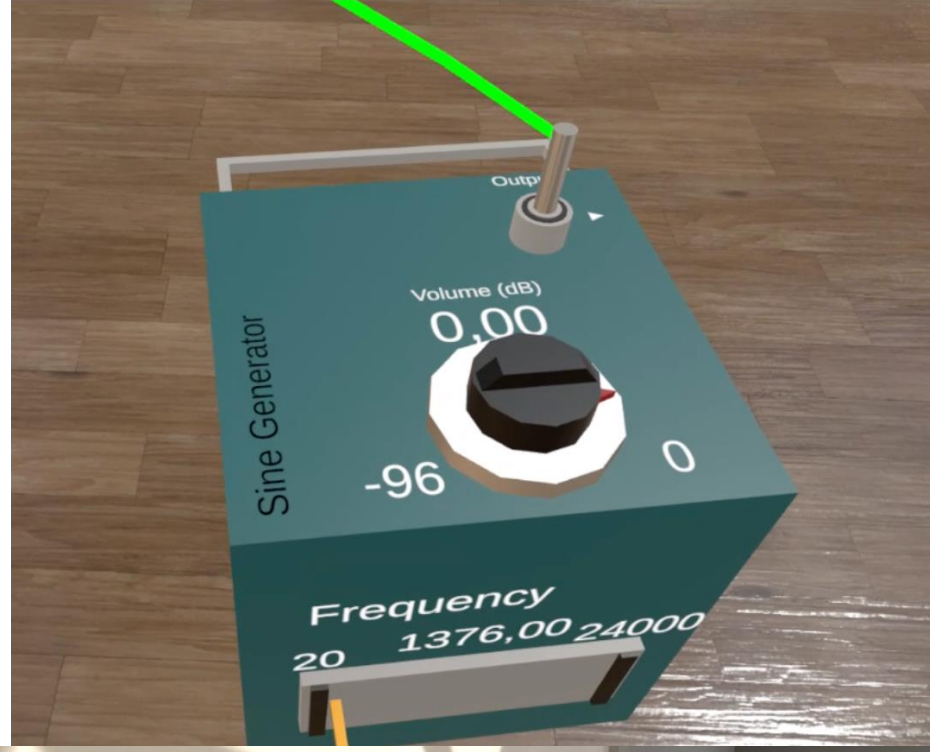
- A pen feature to write instructions or as pointers to different parts etc.
- A voice bubble to record messages





Interactables

- Parameters are controlled via reusable components such as sliders, dials, and toggles
- Interactables are bound to parameter types and ranges
- The layer separates semantics, synchronization, and interface affordance
- This simplifies both reuse and extension

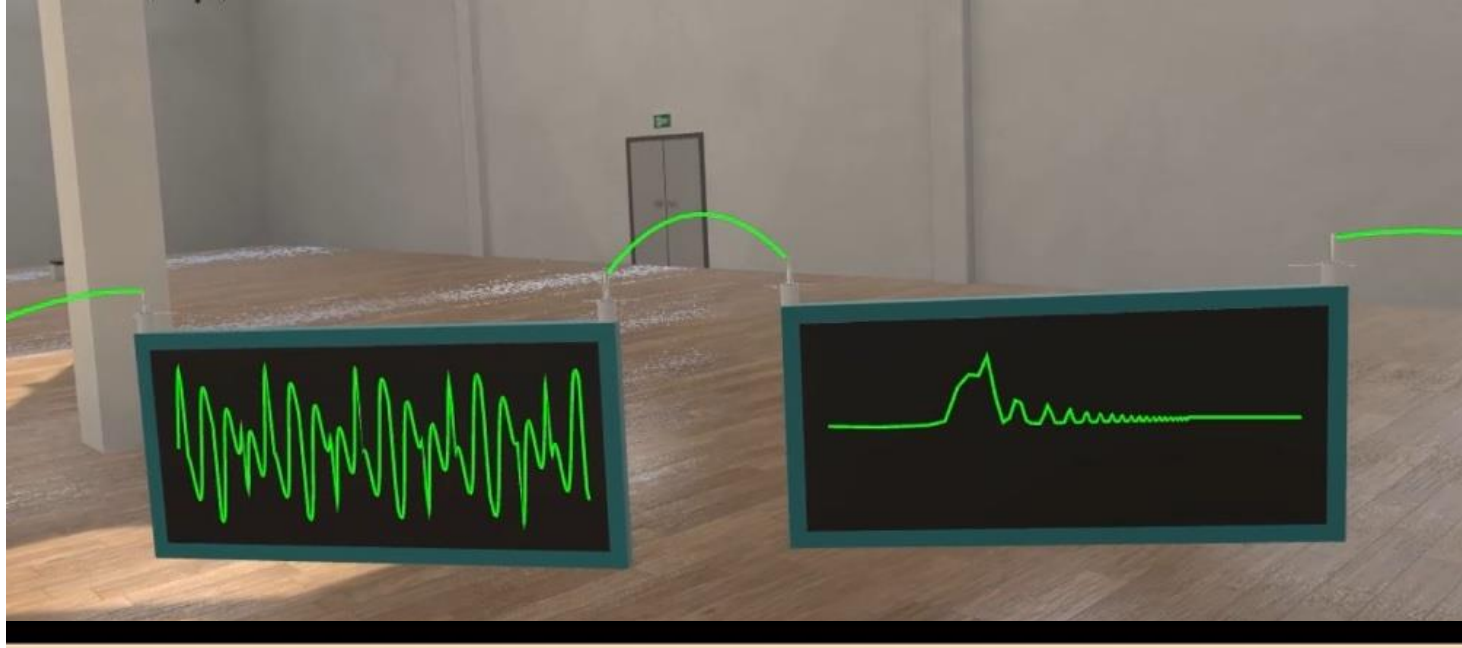


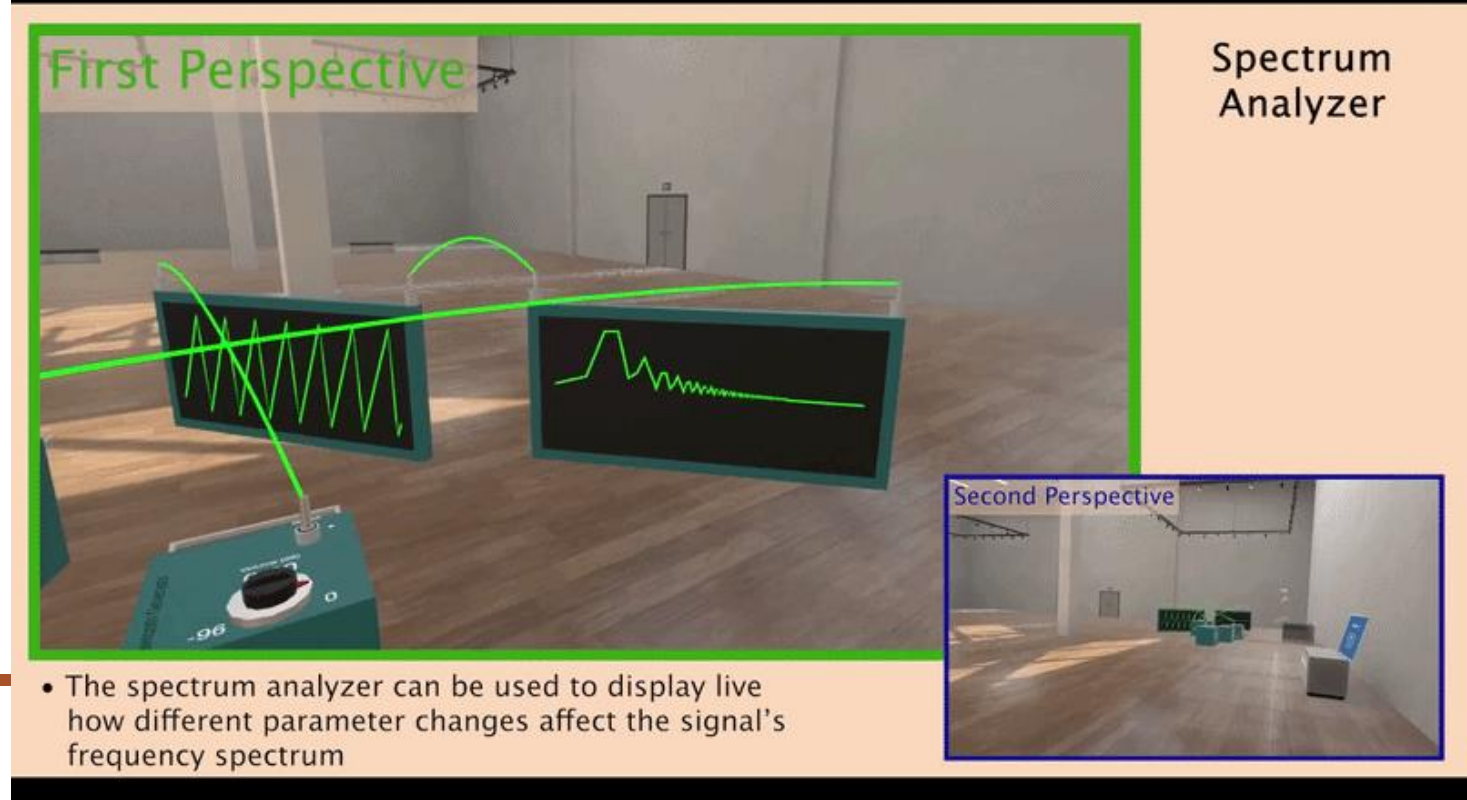
Patch routing and audio feedback

- Modules expose audio inputs and outputs at runtime
- Audio follows the module chain toward an output speaker

Patch routing and audio feedback

- Modules expose audio inputs and outputs at runtime
- Audio follows the module chain toward an output speaker
- Spatial audio supports perceptual feedback
- Analyzer modules such as waveform and spectrum displays support conceptual understanding





Multi-user collaboration

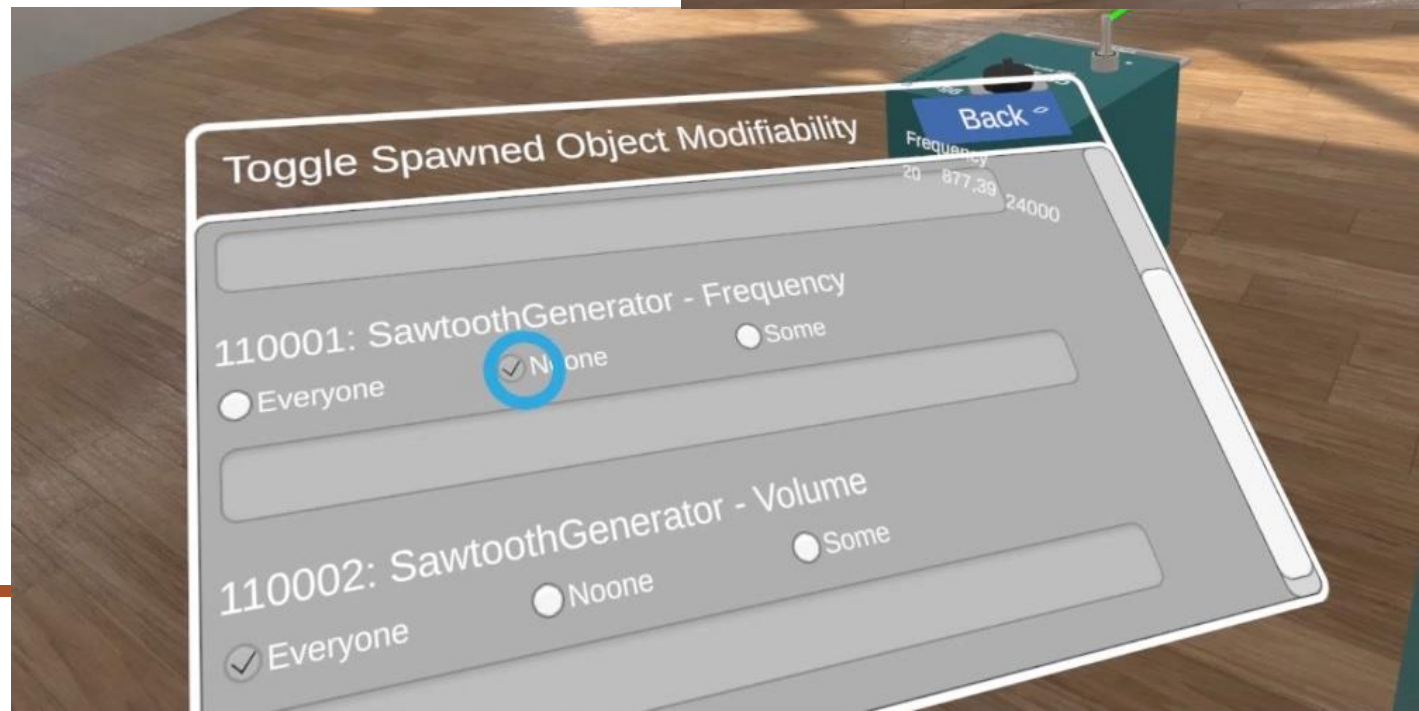
- Supports synchronous sessions across multiple machines
- Networked state includes module spawning and transforms
- Also synchronizes patch connections and parameter updates
- Supports both co-located and remote collaborative exploration

How synchronization currently works

- Built on Unity Netcode for GameObjects
- VILLA VR synchronizes interaction state, not audio streams
- DSP runs locally on each client
- Ownership rules reduce manipulation conflicts
- In concurrent interaction, the latest synchronized parameter state is authoritative
- Persistent scenes can be serialized and restored

Moderation as pedagogical scaffolding

- Moderators can enable or disable selected Interactables
- Complex patches can be progressively unlocked
- Complete scenes can be saved and reloaded
- Moderation structures attention and reduces complexity



Educational deployment and DBR alignment

- Initial deployment in workshop-like settings
- Learners jointly construct and explain synthesis patches
- Spatial annotations and analyzers help externalize reasoning
- Relevant for teacher training and design-based research cycles
- Connected to the LEVIKO-XR context

How VILLA VR differs from related systems

- Builds on prior XR sound labs such as SoundStageVR and OpenSoundLab
- Shares some modular XR ideas with systems such as SynthSpace and PatchWorld
- Related immersive audio environments also use FAUST-generated components and collaborative workflows
- Emphasis on reusable XR interaction abstractions plus educator-oriented moderation and structured pedagogical workflows

Current limitations

- Research prototype rather than a formally validated educational system
- No controlled user study yet
- No quantitative evaluation of learning outcomes, usability, latency, or synchronization robustness yet
- Current focus is exploratory synthesis, not MIDI-based instrument performance
- Dependency on specific Unity versions and third-party assets
- XR setup, comfort, and classroom orchestration remain practical challenges

Future work

- Controller-free hand tracking (?)
- Hybrid XR modes combining real and virtual space
- Improved spatial audio personalization through individualized HRTFs
- Systematic evaluation of learning outcomes and collaboration quality
- Evaluation of latency and synchronization robustness
- Event-based interaction and additional instrument interfaces, including planned MIDI-related extensions

Take-away

- VILLA VR combines FAUST, XR, and multi-user collaboration in one modular framework
- The specific contribution is not XR patching alone
- The key contribution is the combination of reusable DSP authoring, reusable interaction abstractions, and pedagogical scaffolding
- We see it as both a teaching tool and a research platform

Interested In More VILLA VR?

VILLA VR Demo Video ->

<- Github Repository