Re-Coupling Gesture and Sound in Digital Musical Instruments: A Timbre-Driven Mapping Strategy

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Abstract

In acoustic instruments, the control interface and sound generator are physically coupled; a shift in gesture creates a predictable, coherent shift in timbre. Digital Musical Instruments (DMIs), however, suffer from a fundamental decoupling, where mapping strategies between controller and sound engine are often arbitrary, forcing performers to memorize technical assignments rather than relying on aural feedback. This paper proposes a timbre-driven mapping strategy utilizing machine learning algorithms to bridge the gap between gesture and sonic outcome.

We generate a corpus of the synthesizer's timbral identity by linking instrument parameters to high-resolution Mel-Frequency Cepstral Coefficients (MFCCs) of the produced audio. A Variational Autoencoder (VAE) is employed as a dimensionality reduction tool, compressing the high-dimensional spectral data into a compact latent space that matches the dimensionality of the controller interface. This pre-computed latent space is then used to train a Multi-Layer Perceptron (MLP) to predict the original synthesizer parameters from these reduced coordinates. The system allows for the compression of dozens of synthesis parameters into a few intuitive control dimensions, effectively "exposing" the internal complexity of a digital engine to the performer's intuition.

In the performance phase, the system is computationally efficient: the VAE is removed, and the controller's output is fed directly into the MLP. This allows the performer to navigate the sophisticated timbral space using a low-dimensional interface, with the MLP reconstructing the complex synthesis parameters in real-time. The result is a highly responsive, deterministic instrument where the performer's gestures translate directly into spectromorphological movement. This creates a tight aural feedback loop, enabling the performer to develop virtuosity by exploring a continuous, perceptually organized soundscape.

Keywords

Digital Musical Instruments (DMI), Mapping, Machine Learning, Timbre, VAE, MLP, Spectromorphology