Exploring TEIA: Designing Musical Textures for Live Electronic Music

Micael Antunes[1*]

[1]Aix-Marseille Univ., CNRS, PRISM, LIS, InCIAM
29 avenue Robert Schuman, 13621 Aix-en-Provence cedex 01, France

antunes@prism.cnrs.fr

Abstract. *This article presents TEIA (Stochastic Textures with Assisted Interaction), a Max tool developed for real-time texture generation in the composition Gestos: uma homenagem a Jaques Morelenbaum. The tool is inspired by György Ligeti's metaphor of spider webs, used to explore the notion of texture in composition. TEIA treats musical texture as a high-level perceptual phenomenon shaped by the interrelationships of sound components, focusing on their density, variety, and interactions. Drawing on psychoacoustic and compositional analyses of Ligeti and Xenakis, the tool generates complex sonic textures through pitch shifter configurations that manipulate sound masses. The article begins by discussing the creative context and compositional influences behind Gestos, exploring the intersection of composition, perception and computer music. It then delves into the design and functionality of the tool, highlighting its core textural behaviours, audio descriptors, and PCA-based analysis. Finally, the article reflects on the potential of TEIA to enable real-time manipulation of sound texture, thus contributing to the ongoing dialogue between composition, technology and perception.*

1. Introduction

This article presents *TEIA* (WEB in English), a Max tool designed for real-time texture generation in the composition *Gestos: uma homenagem a Jaques Morelenbaum*. The name of the tool stands for *Texturas Estocásticas com Interação Assistida* in Portuguese, or *Stochastic Textures with Assisted Interaction* in English. TEIA is inspired by György Ligeti's tale of spider webs [14, p. 164-165], which served as a metaphor for his compositional process with musical textures.

Musical texture is a high-level perceptual phenomenon in a composition that emerges from the interrelationships between the individual components of musical discourse [11, 4]. As such, it is often approached statistically, by observing its constituent elements [4]. However, what is most interesting for musical discourse is to understand how these relationships manifest themselves perceptually within a musical work [12, 11, 10, 8].

From a compositional perspective, we can think of musical texture as a conceptual space in which elements are articulated on the basis of their *density*, *variety*, and *interrelationships*. These relationships can occur at the spectrotemporal level. This perspective will guide the discussion of the tool presented here, which aims to explore and manipulate musical textures through these complex relationships.

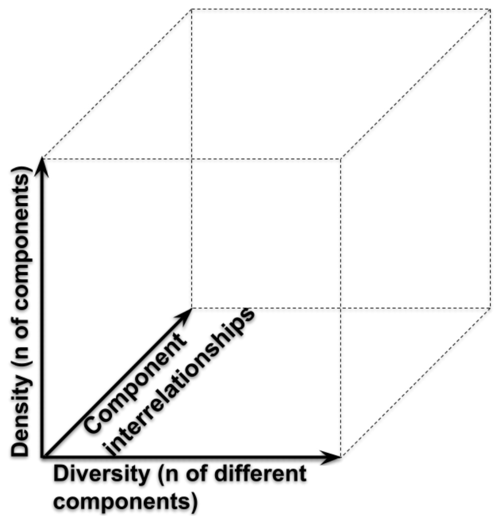

Figure 1: Illustration of the textural elements.

The core idea behind the tool is to create real-time textures using different behaviours modelled from pitch shifter configurations, based on analyses of works by György Ligeti [1] and Iannis Xenakis [3]. These analyses suggest that musical textures can be understood in terms of the density, variety, and interrelationships of their sonic components. They also show how composers organise their works around a limited number of sound textures, each of which is characterised by different psychoacoustic properties. These masses are built from smaller elements that can be classified according to gesture or instrumental technique. This perspective has led to the development of an instrument capable of integrating different sonic gestures. By layering and combining these gestures, TEIA allows the creation of complex sound masses with different characteristics and densities. As a result, we present a prototype version of this interactive instrument, implemented in Max, to explore these possibilities in real-time composition.

This article is structured to provide a comprehensive understanding of the creation and analysis of TEIA. We begin by discussing the creative context, focusing on the composition *Gestos: uma homenagem a Jaques Morelenbaum*, which serves as the inspiration for TEIA's design (2.1). This leads to an exploration of the intersection of composition, perception and computer music, highlighting key theoretical concepts such as sound mass music (2.2, 2.3). The article then moves into a detailed examination of

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TEIA, starting with its patch used in *Gestos* (3.1) and continuing with the system's core textural behaviours (3.2). The article then moves into exploring TEIA's textures, with sections on navigating presets (4.1), analysing audio descriptors and their musicological interpretation (4.2), spectrogram representation (4.3), audio feature extraction (4.4), and a PCA-based comparison of musical textures (4.5). Finally, the article concludes with a discussion and reflection on the findings and contributions to the field (5, 6).

2. The Creative Context

This section explores the creative and conceptual underpinnings of TEIA's development. We begin by examining *Gestos*, a composition that pays tribute to Jaques Morelenbaum and his dynamic approach to cello performance, emphasising the interplay of live electronics and musical textures. The section then moves into the wider context of composition, perception and computer music, discussing the challenges composers face in integrating technological tools with artistic expression. Finally, the concept of sound mass music is introduced, highlighting its influence on the design of TEIA as a tool for generating complex musical textures.

2.1. Gestos: uma homenagem a Jaques Morelenbaum

The composition is a tribute to Jaques Morelenbaum, specifically to his performance of *Doralice* (1945)[1] with the *Cello Samba Trio*[2]. The composition for cello and real-time electronics was premiered on 10 September 2022 at the *Gaudeamus* Festival (Utrecht, Netherlands), with a performance by cellist Katharina Gross and my participation in the real-time electronics. [3]

What stands out in Jaques Morelenbaum's performances is his remarkable versatility as a musician, particularly in the way his cello takes on multiple roles throughout a concert. It is worth noting that in his performances with the Cello Samba Trio he plays a five-string cello, which expands the range and expressive possibilities of the instrument. As a result, his cello takes on a variety of roles, sometimes serving as an accompanying bass line, sometimes emerging as a soloist, contributing to the ensemble texture, or even functioning as a percussive instrument.

The composition seeks to translate this versatility into a dynamic interplay of musical textures. This is achieved through two main strategies: the *score*, which structures distinct musical gestures, and the interaction with *live electronics*, which extends and transforms these materials through the exploration of musical textures. While the notated aspects of the piece are examined in detail in our thesis [9], this article focuses on the design of the real-time electronics, analysing both its construction and its sonic manifestations.

[1] Composed by Antonio Almeida (1911-1999) and Dorival Caymmi (1914-2008)

[2] Available at: ssss

[3] The video of the performance can be viewed at the following link: sss

2.2. Composition, Perception, and Computer Music

The motivation for this paper stems from a fundamental challenge in the composer's métier: the need to compose, represent, and manipulate musical sounds through technological means. This is not an easy task, especially when it comes to musical lutherie - the design and creation of instruments for performance. The intersection of composition, perception and technology requires not only technical solutions, but also a conceptual framework that integrates these elements in a meaningful way [18].

In this regard, we identify an important space in the literature that bridges composition, musical perception, and computational representations of sound. Historically, this dialogue has been central to composers such as those of the Darmstadt School, who actively explored how compositional practices shape auditory perception and how technological mediation expands creative possibilities [6, 23, 15, 24]. This discourse remains relevant today, particularly in the study of timbre [17], music analysis [1] and contemporary compositional techniques [20].

By detailing the development of a musical instrument, we aim to contribute to this ongoing discussion and encourage reflection within the community on the role of technology as a creative and perceptual tool. In addition, the sharing of compositional tools and methodologies will encourage their extension and adaptation in different musical contexts, promoting a wider exchange of ideas and practices.

2.3. Sound Mass Music

The concept of sound mass serves as a key inspiration for the creation of this tool. The underlying idea is that even in the context of mixed music with a limited number of instruments, it is possible to design a tool that receives an audio input and generates sonic complexity inspired by the principles of sound masses. The definition of sound mass is as follows:

> "Sound mass exists when the individual identities of multiple sound events or components are attenuated and subsumed into a perceptual whole, which nevertheless retains an impression of multiplicity. Typically this involves one or more parameters of sound—for example, rhythmic activity, pitch organization, or spectral content—attaining a degree of density, complexity, and/or homogeneity that is perceived as saturation." [10, p. 287]

Sound masses are thus closely related to a state of auditory saturation, where the individual identities of the components in the musical fabric are overwhelmed by the higher level of musical texture. Furthermore, sound masses can be achieved through various compositional techniques, including the use of clusters, micropolyphony, granular synthesis, stochastic music, and others [10, p. 287].

What makes sound mass music particularly interesting is that it enables composers to conceptualise musical textures in terms of the articulation of these elements—density, variety, and interrelationships. It also provides a framework for integrating different compositional techniques and strategies, such as those explored by Ligeti and Xenakis, within a common conceptual model. We have therefore chosen to build the TEIA tool around the notion of sound masses.

3. About TEIA

This section introduces TEIA, focusing on its design and real-time texture generation. It outlines the *Gestos* electronic patch architecture, TEIA's modular structure, and its core texture behaviours (*Cluster*, *Glissando*, and *Extreme*), highlighting the system's ability to create and adapt diverse musical textures.

3.1. The patch of Gestos

Before describing TEIA, it is useful to outline the architecture of the electronic patch used in *Gestos* [4]. The patch is divided into four distinct modules: the *input* module, responsible for receiving the cello signal; the *TEIA* module; the synthesis module; and the output module. These modules and the flow of their connections are illustrated in Figure 2.

The input module captures the cello sound, which is then passed through a volume control directly manipulated by the electronic performer [5]. In the *real-time interaction* module, TEIA is introduced, followed by a *delay* effect. This delay, part of the *HOA* library in *Max*, is used to create different sound diffusion configurations in *ambisonic* space. The synthesis module contains sound files that are later processed by granular synthesis. These files are routed to audio output 3, which is also controlled by the electronic performer. This paper will focus on a detailed description of the TEIA module. Further details on other elements of the electronics are discussed in our dissertation [9].

3.2. Textural Behaviors in TEIA

The basic architecture of the instrument is replicated across all gestures, with variations arising from differences in parameter configurations. TEIA allows real-time texture generation via pitch shifters with three main behaviours: *Cluster*, *Glissando* and *Extreme*. These behaviours are inspired by analyses of the works of Ligeti and Xenakis.

All individual gestures are built using the same algorithm, implemented as *abstractions* in *Max*, as shown in the flowchart in Figure 4. The specific characteristics of each gesture are determined by variations in the parameters of the algorithm. These abstractions receive an audio input which is routed to an On/Off object. This object controls the audio flow and is connected to a *pitch shifter*, which is

[4] The patch is available at sss

[5] i.e. the person responsible for controlling the MAX patch during the performance

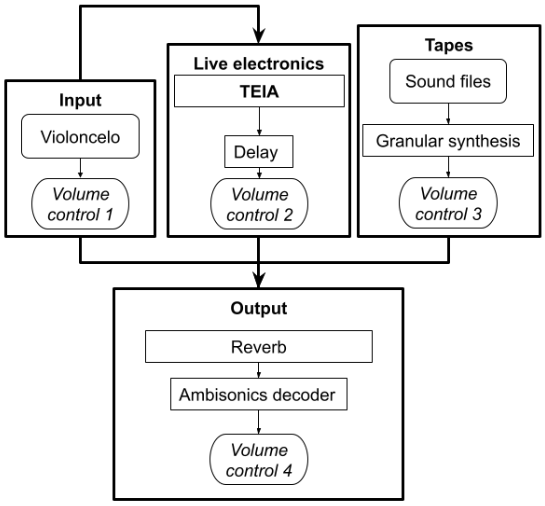

Figure 2: Sound processing workflow in *Gestos*, illustrating the transformations in audio signal.

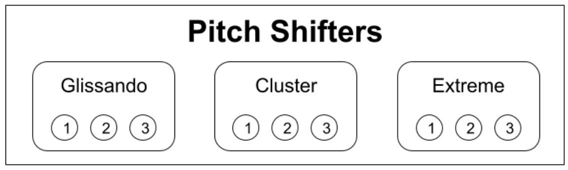

Figure 3: Configuration of the pitch shifters in TEIA, highlighting the three groups: cluster, glissando, and extreme.

responsible for changing the frequency of the input signal based on random values. The audio signal is then sent to a *delay*, which introduces time delays determined by additional random values. At the end of the processing chain, the audio passes through a random volume control, which adjusts the intensity of each individual voice to dynamically shape the texture. Finally, the processed signal is routed to the audio output.

The random values are determined by a triggering process activated by a *onset detection descriptor*. This means that the speed at which the random parameters change is directly related to the attacks made by the cello. It is important to note, however, that random values are not applied to all gestures. Specifically, fixed values are used for the *delays* in the *cluster* gesture and for the *pitch shifters* in the *extreme* gesture.

The *cluster* gesture is defined by a pitch shifter value that covers a small range of variation, from -200 to 100 cents. In addition, the delay values are fixed and range from 50 to 125 milliseconds. A unique feature of this gesture is the unusual use of 6 voices instead of 3, distributed over three different audio outputs. This means that the voices in the clusters are always triggered in pairs—a design choice intended to evoke the desired auditory sensation of density.

The *glissando* gesture is characterised by a wide

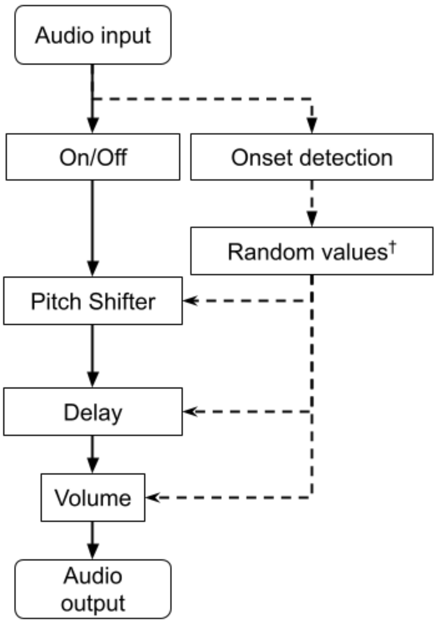

Figure 4: Structure of the TEIA module, showing the main components and their connections.

range of pitch shifter values, from -1300 to 400 cents. These values are always associated with a 2-second ramp that defines the intermediate pitch transitions, in order to create the characteristic glissando effect. In addition, each of the three voices in the glissando is subjected to random delays ranging from 0 to 2 seconds.

The *extreme* gesture is defined by fixed pitch shifter values, set at 3500, 4000 and 5000 cents. In terms of delay, its behaviour is identical to that of the glissando, with random delay values ranging from 0 to 2 seconds. This configuration produces extremely high-pitched sounds, resulting in audio artefacts that can be perceived as brightness or harshness.

4. Exploring TEIA's Textures

In this section, we explore the diverse textures generated by the TEIA system. We begin by examining the process of selecting and navigating TEIA's presets used in *Gestos* composition (4.1), which forms the foundation for understanding the system's textural capabilities. Following this, we describe the audio descriptors used to characterize these textures and their corresponding musicological interpretations (4.2).

To provide a deeper understanding of the textural characteristics, we employ spectrogram representations (4.3) to visualize the sonic content of the generated textures. The extraction of key audio features (4.4) plays a crucial role in quantifying these textures, offering a more technical insight into their construction. Finally, we utilize PCA-based comparisons (4.5) to illustrate the relationships and distinctions between the various musical textures created by TEIA, providing a comprehensive overview of its potential for dynamic and rich sound generation.

4.1. Navigating TEIA's Presets

To illustrate the characteristics of TEIA, a small set of configurations was selected based on their relevance within the context of the composition *Gestos: uma homenagem a Jaques Morelenbaum*. These configurations were chosen to demonstrate the versatility and expressive potential of TEIA, highlighting how different combinations of its modes (*Extreme*, *Glissando*, and *Cluster*) can generate distinct sonic textures. By focusing on these specific settings, we aim to provide a clear understanding of how TEIA's parameters influence the resulting sound, while also showcasing its application in a real-world compositional context. The following analysis delves into the acoustic and perceptual qualities of these textures, supported by visual and statistical representations.

Table 1: TEIA Configurations for Each Texture

Texture	**Extreme**	**Glissando**	**Cluster**
Original	Off	Off	Off
Texture 1	On (D1, V-3)	Off	Off
Texture 3	On (D2, V-3)	Off	Off
Texture 5	On (D3, V-3)	Off	Off
Texture 16	On (D3, V-30)	On (D3, V-10)	On (D3, V0)
Texture 21	On (D3, V-30)	On (D3, V-5)	On (D3, V-10)
Texture 31	Off	On (D3, V-10)	On (D3, V-10)

The table 1 summarizes the configurations of TEIA for each texture, highlighting the activation and parameters of the three main modes: *Extreme*, *Glissando*, and *Cluster*. Each texture is associated with specific settings for these modes, where **D** represents density (ranging from 1 to 3) and **V** represents volume in decibels (dB).

The *Original* texture serves as the baseline, with all modes turned off. *Texture 1*, *Texture 3*, and *Texture 5* exclusively use the *Extreme* mode, with increasing density (D1, D2, and D3, respectively) and a fixed volume of -3 dB. In contrast, *Texture 16* and *Texture 21* combine all three modes (*Extreme*, *Glissando*, and *Cluster*) with varying densities and volumes. For example, *Texture 16* uses the *Extreme* mode at D3 and V-30 dB, the *Glissando* mode at D3 and V-10 dB, and the *Cluster* mode at D3 and V0 dB. Finally, *Texture 31* excludes the *Extreme* mode and combines *Glissando* and *Cluster* at D3 and V-10 dB.

4.2. Audio descriptors and their musicological interpretation

Audio descriptors are commonly used in computational musicology for musical analysis, especially in contexts where timbre is a relevant element of the musical discourse [16, 7, 19]. Therefore, we chose to explore the musical textures generated by TEIA using audio descriptors.

The spectral centroid represents the center of mass of the spectrum, indicating the average frequency weighted by the magnitude spectrum [13].

$$\mathrm{c}[t] = \frac{\sum_k S[k,t] \cdot \mathrm{freq}[k]}{\sum_j S[j,t]}$$

where $S[k,t]$ is the magnitude spectrum at frequency bin k and frame t, $\text{freq}[k]$ is the frequency corresponding to bin k and $\sum_j S[j,t]$ is the total spectral energy at frame t.

The spectral bandwidth measures the spread of the spectrum around the centroid, reflecting the variability of frequencies [13].

$$\text{b}[t] = \left(\sum_k S[k,t] \cdot (\text{freq}[k,t] - \text{c}[t])^p \right)^{1/p}$$

where $\text{c}[t]$ is the spectral centroid at frame t and p represents the order of the bandwidth. When $p = 2$, this corresponds to a weighted second-order moment of the spectrum, which is related to the standard deviation but does not include normalization.

The onset strength detects increases in spectral energy, identifying the beginning of musical events (onsets) [5]

$$\text{os}[t] = \sum_k \max\left(0, S[k,t] - \text{ref}[k, t - \text{lag}]\right)$$

where $S[k,t]$ is the magnitude spectrum at frequency bin k and frame t, $\text{ref}[k, t - \text{lag}]$ is the reference spectrum (e.g., local max-filtered) at frequency k and frame $t - \text{lag}$, and lag is the time delay (in frames).

Loudness is computed as the energy of the signal raised to the power of 0.67, following Stevens' power law to model human perception of loudness [22].

$$\text{l}[t] = \left(\sum_{n=t\cdot N}^{(t+1)\cdot N-1} |x[n]|^2 \right)^{0.67}$$

where $x[n]$ is the audio signal at sample n, and N is the total number of samples.

We summarise the audio descriptors used in the analysis, highlighting their musicological interpretations. The first descriptor, *Spectral Centroid*, is associated with the 'brightness' of the sound, with higher values indicating a dominance of high frequencies and lower values indicating a focus on low frequencies [16, 17]. The second descriptor, *Spectral Bandwidth*, reflects texture density, with a wider bandwidth indicating a more complex texture and a narrower bandwidth indicating a purer sound [2]. *Onset Strength* measures the intensity of note onsets, highlighting the level of articulation or rhythmic intensity in the musical texture [21]. Finally, *Loudness* captures the perceived intensity or energy of the sound, contributing to the dynamic range of the musical texture [1]. Together, these descriptors provide a comprehensive framework for the musicological analysis of the sound textures generated by TEIA.

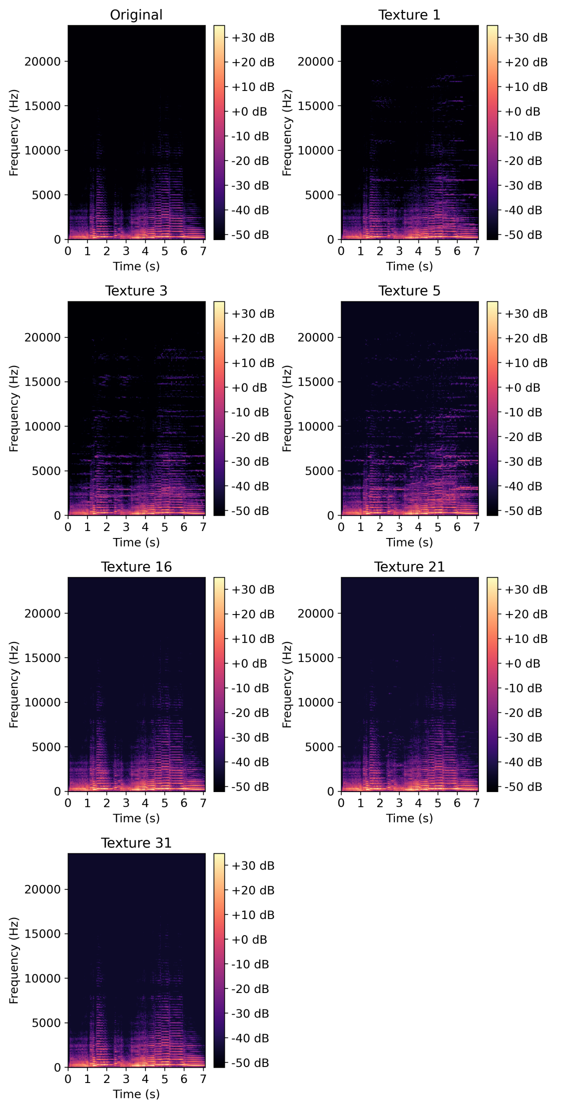

Figure 5: Spectrograms of sound textures generated by TEIA, showing the transformations applied to the original sound.

The audio analysis [6] was conducted using two Python libraries: *Librosa*[7] and *Essentia*[8]. The analysis was performed on audio signals with a sample rate of *48,000 Hz* and a bit depth of *24 bits*, ensuring high-resolution processing. For feature extraction, a common set of FFT parameters was applied across all descriptors to maintain consistency. The parameters used were a frame size of 1024 samples and a hop size of 512 samples, resulting in a 50% overlap between consecutive frames.

4.3. Spectrogram representation

The spectrograms of Figure 5 highlight distinct differences between the two groups of textures. In Textures 1, 3, and 5, higher partials are progressively added, with each successive texture incorporating more spectral components than the previous one. In contrast, Textures 16, 21, and 31 show a significant increase in energy in the lower frequency re-

[6]The notebook with analyses and the sound files are available at ssss.
[7]`https://librosa.org/`
[8]`https://essentia.upf.edu/`

gion of the original sound, while higher partials remain less prominent. This suggests that Textures 1, 3, and 5 have a broader spectral spread, whereas Textures 16, 21, and 31 concentrate energy in specific frequency ranges. These findings illustrate how different configurations of TEIA's modes shape the spectral properties of the textures, offering distinct sonic possibilities for composition.

4.4. Audio feature extraction

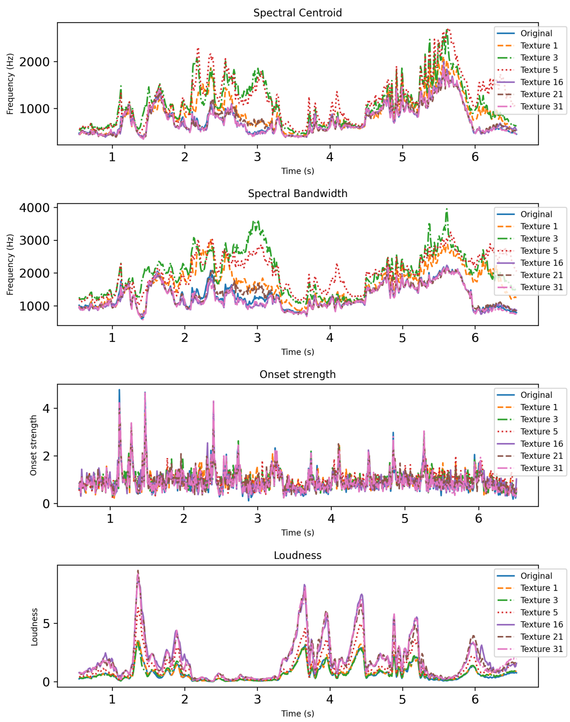

Figure 6: Feature curves (spectral centroid, bandwidth, loudness, and onset strength) of sound textures generated by TEIA.

The variety of curves observed in the descriptors (Figure 6) suggests an effective creation of different sound textures. Instances of decorrelation between textures, visible in the spectral centroid and bandwidth curves, indicate that spectral transformations unfold at different rates over time. This means that changes in brightness (spectral centroid) and textural spread (spectral bandwidth) occur at different rates or in different ways over time, contributing to the unique character of each texture.

Additionally, the differences in the number of peaks and their amplitudes in the Onset Strength curves reveal that each texture exhibits distinct temporal behaviors. Some textures exhibit sharp, frequent attacks, while others feature smoother, more gradual transitions. This variability is further emphasized by the loudness profiles, which cover a wide range of amplitudes. Each texture demonstrates a unique loudness profile, highlighting the dynamic diversity achieved through TEIA's configurations. Together, these observations underscore the tool's ability to generate a rich variety of sound textures, each with its own spectral and temporal characteristics.

4.5. PCA-based comparison of musical textures

Given the complexity of comparing multiple descriptor curves simultaneously, we decided to use Principal Component Analysis (PCA) to create a more compact and intuitive visualisation of the sound textures. The aim of this approach is not to develop a classifier or to establish statistical significance, but rather to illustrate the relationships and distinctions between the textures in a simplified way. By reducing the dimensionality of the data, PCA allows us to highlight the most relevant features of the textures, making it easier to observe patterns and differences. This visualisation serves as a practical tool for understanding the spectral and temporal characteristics of the textures, without implying any broader statistical or analytical claims.

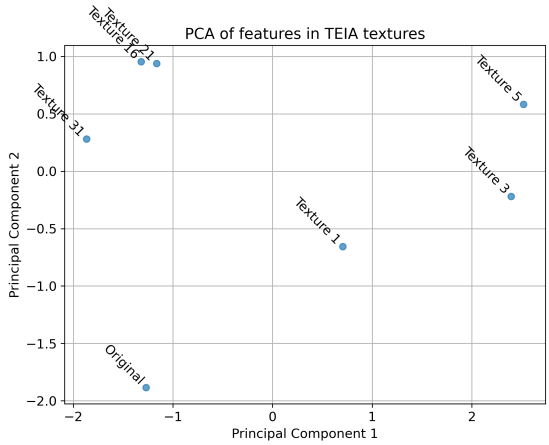

Figure 7: PCA of features in TEIA textures, showing the distribution of sound textures in the 2D PCA space.

Table 2: PCA Results: Explained Variance and Feature Contributions

Component	Variance	Top Features (Weights)
PC1	0.7419	Spectral Bandwidth (0.5777), Spectral Centroid (0.5650), Onset Strength (0.4824), Loudness (-0.3380)
PC2	0.2230	Loudness (0.8482), Onset Strength (0.5230), Spectral Centroid (0.0817), Spectral Bandwidth (-0.0204)

The PCA results show that PC1 (74.19% of the variance) is strongly associated with spectral bandwidth (0.5777), spectral centroid (0.5650) and onset strength (0.4824). These parameters together describe the brightness, spread and temporal activity of the sound textures. Interestingly, loudness (-0.3380) has a smaller but negative effect on PC1, suggesting that brighter textures tend to be less intense in this context. This inverse relationship highlights the trade-off between spectral richness and loudness in the design of these textures.

On the other hand, PC2 (22.30% of variance) is dominated by loudness (0.8482) and onset strength

(0.5230), indicating that this component captures variations in sound intensity and temporal changes over time. The spectral centroid (0.0817) and bandwidth (-0.0204) have minimal influence on PC2, confirming that this axis is primarily related to the dynamic aspects of textures.

Textures 1, 3 and 5 use only the Extreme mode, with increasing densities (1, 2 and 3 respectively). Their progressive shift along PC1 (from 0.70 to 2.52) shows how higher density increases spectral dispersion and brightness, consistent with the role of the Extreme mode in creating spectrally rich textures. In contrast, textures 16 and 21 combine all three modes (Extreme, Glissando and Cluster) with high density and varying volumes. Their positions in the PCA plot (PC1 around -1.3 to -1.1 and PC2 around 0.95) suggest that this combination results in textures with moderate spectral dispersion but high dynamic intensity. The inclusion of Glissando and Cluster probably contributes to the increased loudness and onset strength observed in PC2. Finally, texture 31 uses only Glissando and Cluster, without Extreme. Its position (PC1: -1.87, PC2: 0.28) indicates lower spectral spread and brightness compared to textures that include Extreme. However, its moderate PC2 value suggests that it retains some dynamic intensity, probably due to the influence of Glissando and Cluster.

5. Discussions

The results show how different textural behaviours emerge from the combination of modes in TEIA. Textures that integrate Extreme, Glissando and Cluster (e.g. Textures 16 and 21) occupy a distinct musical space, balancing spectral density with dynamic presence. This interaction suggests an intricate interplay between gestural articulation and sound mass, where transformations unfold in layers, creating a sense of movement and depth. In contrast, textures that rely solely on Extreme (e.g. Textures 1, 3 and 5) emphasise spectral brilliance and expansion, creating sonorities that privilege brightness and high-frequency energy.

There is a clear structural logic to TEIA's design, with each mode making a distinct contribution to the perception of texture. The Extreme mode promotes an expansive and energetic spectral profile, enhancing the perception of shifting, dense masses of sound. Increasing the density intensifies this effect, creating textures with greater spectral weight and presence. Meanwhile, Glissando and Cluster modes introduce dynamic gestures that shape the evolution of textures over time. Their interaction with Extreme results in a synthesis of spectral richness and kinetic complexity, creating a heightened sense of internal movement.

In addition, loudness relationships between gestures play a crucial role in defining textural contrasts and articulation. Variations in the amplitude of individual gestures affect not only the perceived intensity of textures, but also their overall balance between density and clarity. This aspect of mix balance deserves further exploration in future work, particularly in relation to how dynamic shaping influences textural perception within compositional contexts.

The aim of this initial study with TEIA was to analyse its application in a compositional context and to examine how the resulting sonic textures behaved within a comparative framework using audio descriptors. This approach allowed us to observe the sonic characteristics resulting from TEIA's processing and to assess its potential for generating different textural results.

Based on this initial study, we recognise that there is significant potential for further exploration of TEIA's parameters. The system demonstrates the ability to produce textures of remarkable spectral richness, influenced by the type of gesture used, as well as dynamic variations that depend not only on the gestures themselves, but also on the mixing parameters - in particular, the individual volume of each gesture.

In the future, a second phase of research with TEIA could focus on a broader exploration of its parameter space, including alternative mixing strategies not used in the original composition. By combining these variations with representations and measurements from audio descriptors, it becomes possible to develop new presets that expand the range and variety of textures generated by the system. This step aligns with compositional interests related to sound textures and provides a structured way to refine and extend the expressive capabilities of TEIA.

In addition, it would be valuable to explore the possibility of using the texture representation space - particularly the PCA-based approach used in this study - as a control interface for sound texture parameters. In such a system, the composer or performer could navigate an intuitive and compact representation space to manipulate TEIA parameters in a more direct and exploratory manner.

In parallel, alternative representation methods, more focused on psychoacoustic models, could be explored to better understand how the textures generated by TEIA interact with auditory perceptual characteristics. This line of research could provide deeper insights into how different texture configurations influence the listener's experience and offer new compositional strategies that integrate perceptual principles into the design of sound textures.

6. Conclusions

TEIA provides a flexible framework for real-time texture generation, integrating the concepts of Ligeti and Xenakis with computational tools. The tool demonstrates how real-time processing can be used to create complex textures from simple inputs, inspired by the concept of sound masses. The combination of different behaviours (*Cluster*, *Glissando* and *Extreme*) allows for a wide range of textural possibilities in coherence with a conceptual framework based on textural parameters such as density, diversity and component relationships. Its design allows composers to explore, manipulate and extend sound masses and complex textures, adapting the tool to their specific creative needs while maintaining a high degree of control over the resulting sonic material.

By demonstrating how real-time processing can transform simple inputs into complex textures, TEIA highlights the potential of interactive electronics in shaping compositional strategies. Beyond its immediate application, TEIA opens up avenues for further research, including the integration of psychoacoustic models to refine perceptual control, and the exploration of alternative mapping strategies that enhance performer interaction. These aspects reinforce TEIA's role not only as a compositional tool, but also as a platform for exploring new forms of musical expression through the real-time composition of musical textures.

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