

# Telematic Music: Performance, Somax2, Co-improvisation, and Pedagogical Aspects

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**Abstract.** Between January 2023 and January 2025, we established the Telematic Music Center at the Faculty of Philosophy, Sciences, and Letters at the University of São Paulo (FFCLRP-USP), Brazil. This center supported the research project *Telematic Music: Connectivity in Virtual Environments*, funded by the São Paulo Research Foundation (FAPESP), which explored telematic performance through music, audio and video technologies, and artificial intelligence. The project culminated in a remotely produced audiovisual album featuring collaborative works by Cássia Carrascoza and Paulo C. Chagas, along with original compositions by Chagas for flute, live electronics, and video. In partnership with Mikhail Malt, we developed co-improvisations in a virtual space mediated by the AI-driven system Somax2, investigating sound spatialization and immersive audio environments. Simultaneously, we continued the pedagogical work of the Telematic Ensemble LaFlauta at USP. Together with composer Danilo Rossetti, we implemented an educational initiative on telematic chamber music, offering students practical experience with audio technologies and collaborative performance in virtual settings. The ensemble performed works composed specifically for them by Rossetti, Chagas, Iazzetta, and Carrascoza. This article presents key outcomes of the project, emphasizing the artistic collaboration with Malt and Somax2 and the educational impact of telematic ensemble practice.

## 1. Introduction

Telematic musical connections have continuously explored multimedia formats to enhance musical collaboration—often collaborative—incorporate not only acoustic and electronic instruments but also video, live image processing, lighting, and dance.

Scott Deal, in an interview with Cook [1], asserts that "telematics is not telematic music, but telematic art," proposing it as a new form of art involving audio, video, and live participants. Eric Lemmon [2] argues that telematic music and network music have different meanings that can also be interchangeable in some cases.

Telematic music entails two key points: first, musicians are not in the same location; and second, they perform together through telecommunication and electronic networks. In contrast, networked music refers specifically to the techniques and practices of producing music in a distributed manner [3].

Georg Hajdu, in his Quintet.net project [4], describes performances that occur both telematically and in physical space, involving a complex network of agents, including the audience. Notable works in this context include *MindTrip* (2000), by Hajdu, *Orpheus Kristall* (2002), by Manfred Ahnke, *Vamp.net* (2002), by Anne La Berge, and *Hamburg Revisited* (2003), a collective composition. These works incorporate multiple elements beyond music, such as spoken text, processed sounds, extended techniques, synthetic sounds, and video.

Additionally, several telematic groups focus solely on sound connections. Examples include the Quarantine Sessions at CCRMA, active since the COVID-19 pandemic, and the NowNet Arts Ensemble, led by Sarah Weaver, which has been performing live over the internet for 15 years.

Between January 2023 and January 2025, we established a Telematic Music Center at the Faculty of Philosophy, Sciences, and Letters at the University of São Paulo (FFCLRP-USP), Brazil. This center served as the foundation for the research project *Telematic Music: Connectivity in Virtual Environments*, funded by the São Paulo Research Foundation (FAPESP). The main goal of the project was to investigate telematic music as a medium for creation and performance in virtual environments, exploring new musical languages, technologies, and the spatialization of sound and image.

The project aimed to enhance the understanding of the virtual sound space, foster its technological development through transdisciplinary collaboration, and propose new methodologies for telematic chamber music performance, integrating art and technology. We began the project working with composer Paulo C. Chagas, engaging in creative processes that included collaborative composition, audio and video recordings, free improvisation, and performance—all mediated by sound processing using Max. This phase of the project

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\*Supported by São Paulo Research Foundation (FAPESP).

culminated in the 2024 audiovisual album *Sound Imagination: Telematic Immersion*<sup>1</sup>, featuring the following works: *Mojave* (2020–2021), *Virtual Studies* (2020–2021), *Sound Imagination* (2020–2024), and *I Hear You Breathe* (2022). Simultaneously, we continued the activities of the Telematic Ensemble LaFlauta, providing equipment and training undergraduate students to connect and perform in various telematic concerts and academics activities<sup>2</sup>. These performances focused on Brazilian compositions designed to support pedagogy in telematic chamber music performance. Works were composed for the ensemble by Danilo Rossetti, Paulo C. Chagas, Cássia Carrascoza and Fernando Iazzetta. In 2024, in collaboration with Mikhail Malt, we developed a project that investigates key concepts in telematics, such as sound space and the creation of virtual stage elements, while experimenting with binaural formats (SPAT), real-time electronic synthesis, and telematic interaction mediated by AI and machine learning tools like SOMAX2. We also worked with computer agents to construct musical narratives in real time.

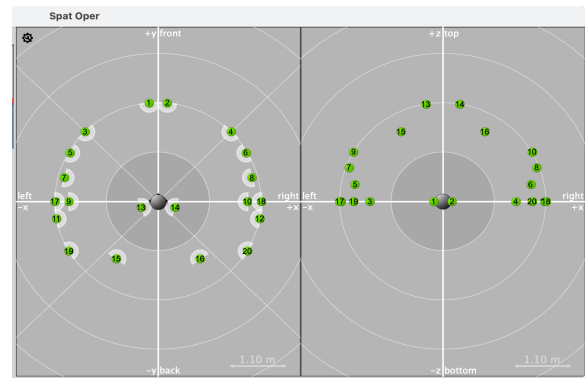
In this article, we focus specifically on the collaborative work developed in collaboration with Mikhail Malt and the pedagogical activities carried out with the Telematic Ensemble LaFlauta. We explore how these two dimensions—artistic experimentation with AI-mediated telematic performance and the educational engagement of undergraduate students—converge to expand the boundaries of musical creation, performance, and learning in virtual environments.

## 2. Five Elements: Telematic Performance, Co-Improvisation and Somax2

Mikhail Malt and Cássia Carrascoza have maintained an artistic collaboration since 2015, initially working together as composer and performer [5]<sup>3</sup>. In 2022, they began engaging in co-improvisation within the telematic environment using Somax2 and SPAT.

Somax2, designed by Gérard Assayag and Joakim Borg is a memory-based system. This is, it creates new content by forcing a new path through material it has learned offline or live, based on statistical sequence modeling; and music information dynamics [6]. SPAT is a tool for sound spatialization and artificial reverberation in real-time, integrated to Max/MSP. It can be adapted for different cases as live concerts, mixing, post-production, virtual reality, installations, among others, incorporating technologies such as high-order ambisonics, nearfield binaural synthesis and trans-pan [7]. See Figure 1 to the

Spatial positioning of the 20 virtual sources in the binaural space.



**Figure 1: Spatial positioning of the 20 virtual sources in the binaural space**

The ongoing artistic research explores several key concepts in telematics, including the sound space concept and the creation of immersive environments. This research involves experimenting with binaural formats (SPAT)<sup>4</sup> and real-time electronic synthesis, while also examining the role of telematic interaction, particularly as mediated by artificial intelligence (AI) and machine learning tools. Additionally, the research engages with computer agents, focusing on creating a musical narrative. It also emphasizes listening, feeling the response, and reacting without judgment.

### 2.1. Artistic Context – Performance

This is an improvisational work in which the interdependence between human performers and computational agents shapes the musical narrative. A collaborative environment is established in which listening, sensing, and responding in real time are central to the creative process. The created interdependence requires continuous exchange and adaptation, where each participant influences the actions and decisions of the others. The duo produced some live recording works<sup>5</sup> and performed telematically at events organized by the Flute Laboratory at FFCLRP-USP.<sup>6</sup> In 2024, they presented at the NowNet Arts Conference 2024: "Network Arts Aesthetics"<sup>7</sup> in a hybrid format, with Malt located in Paris and Carrascoza performing in person for the audience at Stony Brook University, New York. Building on this experience, we aim to further develop hybrid performance spaces by deepening both the technical and artistic dimensions required to support the coexistence of telematic and hybrid concerts—where audiences are present at both ends of the telematic connection.

<sup>1</sup><https://sites.usp.br/laflautamusicatelematica/category/videos/>

<sup>2</sup>[https://sites.usp.br/laflautamusicatelematica/category/en-semble-laflauta/](https://sites.usp.br/laflautamusicatelematica/category/ensemble-laflauta/)

<sup>3</sup><https://open.spotify.com/intl-pt/track/345qVoTRDc3AyHvio5rz2J>

<sup>4</sup> A brief example of the use of SPAT in our telematic connection: <https://youtu.be/U4M8awEcwhI>

<sup>5</sup> [https://reach.ircam.fr/index.php/2024/05/27/hommage-](https://reach.ircam.fr/index.php/2024/05/27/hommage-to-boulez-george-lewis-douglas-ewart/andfor5elements)

[to-boulez-george-lewis-douglas-ewart/andfor5elements](https://reach.ircam.fr/index.php/2024/05/27/hommage-to-boulez-george-lewis-douglas-ewart/andfor5elements)

<sup>6</sup><https://sites.usp.br/laflautamusicatelematica/2024/12/02/6o-ciclo-internacional-de-convergencias-sonoras-concerto-2-de-dezembro-2024>

<sup>7</sup>[https://static1.squarespace.com/static/58c764e3725e25b97bd382e6/t/68590ea93f5fdd1e5d8cb94c/1750666923349/NowNet+Arts+Conference+2025\\_Western+Hemisphere\\_Daily+Schedule\\_v2.pdf](https://static1.squarespace.com/static/58c764e3725e25b97bd382e6/t/68590ea93f5fdd1e5d8cb94c/1750666923349/NowNet+Arts+Conference+2025_Western+Hemisphere_Daily+Schedule_v2.pdf)

## 2.2. Five Elements<sup>8</sup> -Artistic Context

The performance is a pre-structured improvisation in a very free manner (see Figure 2) and consists of two layers: audio and video. The emotional environment is based on the poetics of Tibetan/Bön cosmology<sup>9</sup>, which asserts that the universe is constituted by five fundamental elements and posits that the outer elements constitute all matter and from them arise all phenomenal worlds, space, air, fire, water and earth.

We selected different musical and visual materials to relate to each of the elements.

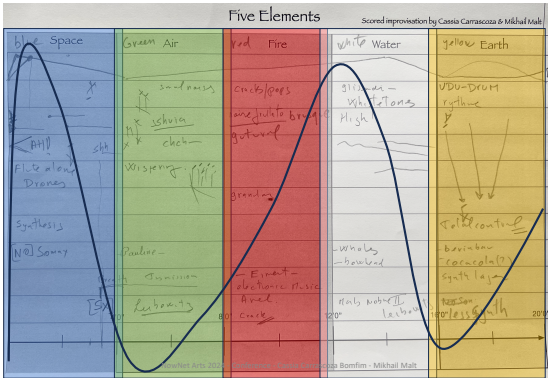


Figure 2: Improvisation Score

Playing with the Somax2 interaction is like walking through a landscape of diverse sound choices, including drones, noise, extended techniques, spoken voice, and singing. In fact, there comes a point where we stop focusing on controlling the musical narrative and go into the flow that is resulting by the co-improvisation.

Somax2 agents are loaded with a local stylistic knowledge space (called a corpus) providing a dynamic musical memory at run time. They weave a “co-improvisation” by navigating their musical memory while being sensitive and reactive to the external context (i.e., live musicians or other agents) [6]

The following audio materials (Table 1) serve as corpus elements for feeding the Somax2 agents, providing a diverse array of sound sources that contribute to the development of the narrative. These materials encompass experimental compositions, field recordings, and distinctive instrumental performances. Sluchin and Malt proposed a reflection on the distinction between what they define as “playing music”—in which, during the performance of composed works, the musician seeks fidelity to the score in order to interpret the composer’s musical ideas—and “playing with music”, a concept that, according to the authors, is introduced by Somax2, “which adds another layer of exploration that goes beyond the scope of conventional performance.” [8]. As performers, we experience feedback from the cues that motivates experimentation with sound, rhythm, timbral variation, and dynamics. This process often leads to a fusion of musical ideas, where we are not always able to discern whether the source of a given gesture originated

from the performer or from Somax2.

We selected different musical excerpts for Somax2 and corresponding flute gestures to relate to each of the five elements of Tibetan cosmology: space, air, fire, water, and earth.

For each element, we selected two distinct corpuses. On the flute, we pre-established a sonic vocabulary for each section, serving as auditory bridges for co-improvisation, Somax2, and Malt’s choices in triggering structural transitions. We begin the piece with an aeolian glissando on the flute that culminates in a tongue ram, while the image displaying the spatialization graph from SPAT is projected. With this, we aim to orient the audience’s perception toward the dimension of spatialized sound.

| Elements | Excerpts                                                                                                                                                              | Instrument                                                         |
|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|
| Space    | - Pauline Oliveros – <i>Sound Patterns</i> (1961)<br>- Different Breathing Patterns, Recorded at IRCAM                                                                | <b>Flute:</b> long sounds, Tongue ram, circular breathing, breath. |
| Air      | - Mario Davidovsky – <i>Synchronism No. 1</i> (1962) for flute and pre-recorded electronic sounds.<br>- Bülent Arel – Electronic Music No. 1 (1962)                   | <b>Flute:</b> Noises, whispering, voice.                           |
| Fire     | - Flute Whistle tones, Recordings<br>- György Ligeti – <i>Glissandi</i> (1957)                                                                                        | <b>Flute:</b> Trillos, frullatos.                                  |
| Water    | - Bow Head Wale Recordings from "Watkins Collection of Marine Mammal Sound Recordings, Australia"<br>- Flute Pizzicato, Staccato, and Other Articulations, Recordings | <b>Flute:</b> Whistle tones, glissandos, singing and playing.      |
| Earth    | - Flute Pizzicato, Staccato, and Other Articulations, Recordings<br>- Nana Vasconcelos, <i>Berimbau Performance, Africadeus</i> (1973)                                | <b>Voice:</b> speaking and singing<br><b>Udu-drum</b> Percussion.  |

Table 1: Musical Excerpts Related to the 5 Elements of Tibetan Cosmology

## 2.3. Video

A video backdrop is used in Zoom to complement the musical narrative and enhance the immersive telematic experience. The video was conceived based on the symbolic colors of each element referenced in the score (Figure 2), with image prompts generated by text input

<sup>8</sup><https://sites.usp.br/laflautamusicatelematica/2024/12/25/60-convergencias-sonoras-cassia-carrascoza-e-mikhail-malt-25-12-2024/>

<sup>9</sup>[https://www.rigpawiki.org/index.php?title=Five elements](https://www.rigpawiki.org/index.php?title=Five_elements)

starting from the expression “resonant space” (Figure 3). The video consists of two layers: one created using the AI model Haiper, a perceptual foundation model-driven AI (<https://haiper.ai>), and another composed of images of Brazilian landscapes representing the five Tibetan Buddhist elements. The narrative also seeks to connect virtual and natural worlds by incorporating visual elements such as Indigenous peoples of the Amazon (Figure 4), the Negro River, pink river dolphins, and landscapes from central Brazil. The final section expands this vision through the inclusion of artificially generated landscapes. During the live stream, scenes are alternated using Open Broadcaster Software (OBS), including images of the duo (Figure 5), devices functioning in real time (SPAT and Somax2), and video with live music audio.

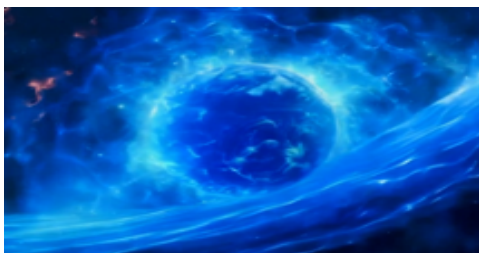


Figure 3: IA Image for Video Backdrop<sup>10</sup>



Figure 4: Images of the Environment that Blend with the Virtual Imagery

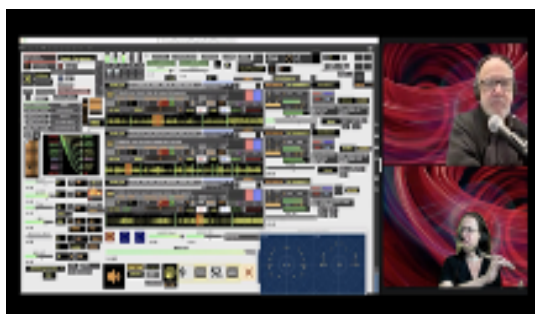


Figure 5: Performance: Video Backdrop in Zoom, the duo and Somax2

## 2.4. Technological Details

Carrascoza and Malt are engaged in co-improvisation mediated by Somax2 over the internet, from different locations: Carrascoza in São Paulo, Brazil, and Malt in Paris, France. The audio connection is established via the JackTrip, a software that transmits uncompressed audio over the network [9]. We use a cloud-based server. To ensure high-quality sound and prevent feedback, Malt

devised a solution involving the use of six audio channels in JackTrip (Figure 6). The signal from the flute and the udu-drum is routed into the Virtual Sound Card (VSC) and sent to Max, Somax2, and SPAT (in Paris) through channels 1 and 2. The processed audio—now a binaural mix of flute, Somax2, synthesis, and SPAT/ICST output—returns via channels 3 and 4 to JackTrip (Figure 7). Meanwhile, in Brazil, the VSC routes the signal from channels 5 and 6 into OBS, which then outputs it through channels 1 and 2.

The video component was managed via Zoom, where we used the virtual background tool to project a pre-recorded video as a visual backdrop behind us. Additionally, we used OBS (Open Broadcaster Software) for live streaming, working with different visual possibilities throughout the performance to enhance the immersive experience.

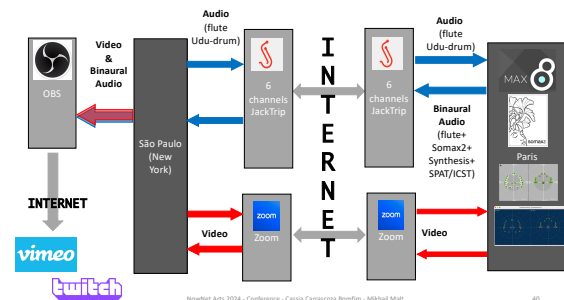


Figure 6: Audio Signal Flow

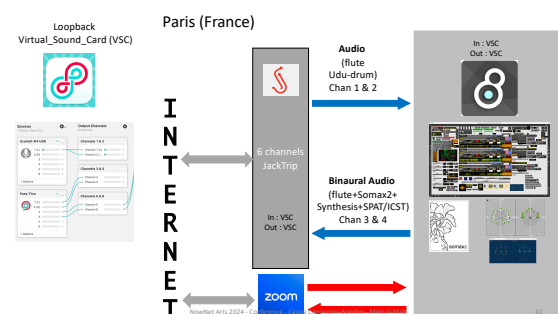


Figure 7: Audio Details from France

Through this work, we achieved significant results:

1. The resolution of a major technical issue—by opening six channels, we were able to eliminate feedback, resulting in clean, high-quality sound;
2. The creation of an immersive virtual sound space through the use of sound spatialization and binaural diffusion;
3. In the context of the artistic experience, we developed a relationship between colors and visual elements that enhanced the ritualistic aspect of the concert on the virtual stage and provided a dynamic visual dimension to the performance.

<sup>10</sup> Text input: Resonant blue space with intense and slow movement.

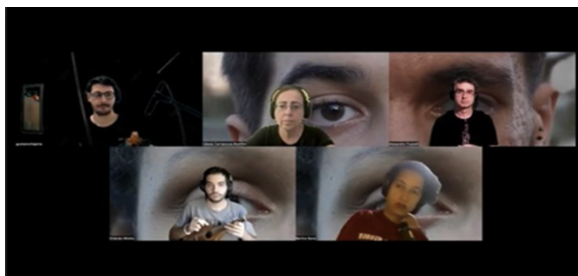
### 3. Pedagogical Experience

In an article from 2024, we described a pedagogical experience with telematic music involving composers and students belonging to the Telematic Ensemble LaFlauta of FFCLRP-USP, as well as addressing the notions of connectivity, presence and time in this virtual environment [10]. The Telematic Ensemble LaFlauta participated in the project on two occasions: the first in 2023, presenting pieces by Carrascoza, Chagas and Rossetti at the NowNet Arts Conference 2023, and the second in 2024, with the premiere of pieces by Rossetti and Iazzetta at the 6th International Sound Convergences Cycle 2024.

The Telematic Ensemble LaFlauta is a group of FFCLRP-USP students and professional musicians, both composers and instrumentalists, coordinated by Cássia Carrascoza. Since 2023, the group utilizes the Pretty Good JackTrip Toolkit (PGJTT) [11], developed by Mike O'Connor, a server with the technical capacity to accommodate the group in a virtual environment. This server provides consistent sound quality and encourages interaction between the musicians. PGJTT was installed on a Linode server controlled by Carrascoza during the performances.

With funding from FAPESP for the project “Telematic Music: Connectivity in Virtual Environments”, it was possible to purchase equipment that enabled students to connect to music in a telematic environment using the JackTrip software. Among the equipment provided to the students belonging to the Telematic Ensemble LaFlauta, we highlight: 4 Scarlett Focusrite 2i2o audio interfaces and 4 Shure SM57 microphones, as well as microphone stands and cables.

The pieces performed by the Ensemble at the NowNet Arts Conference in 2023 were: *Modules 2* by Carrascoza, *Virtual Studies* (2020), by Paulo C. Chagas, and *Estudos Texturais*, by Danilo Rossetti. The three pieces featured live electronics using Max software, which was performed by Carrascoza in the concerts and rehearsals. To this end, an audio setup was developed incorporating JackTrip, PGJTT, Loopback and Max/MSP software.



**Figure 8: Rehearsal of the Telematic Ensemble LaFlauta in 2023, with the Video Developed in Background**

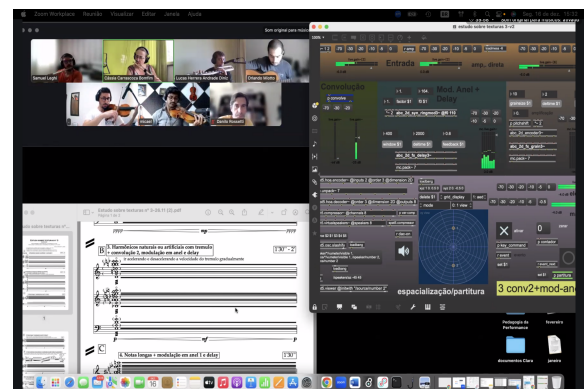
The visual composition was projected during the performances on the Zoom software backdrop, seeking a non-linear narrative with fragmented images, divided into three parts, focusing on the students' eyes, hands, and movements. The images were played at different speeds, with repetitions, multiplications, and directional

inversions. The videos were played individually on the musicians' computers, leading to a lack of synchronization between the images, a characteristic of the telematic environment.

During the Ensemble's performance in 2024, some of the original members changed, but without the group losing its consistency. Moreover, it was observed that the musicians have gained unity in the way they played, enabling them to overcome technical issues of connection in a telematic environment quickly. In addition, the group proved to be familiarized to the sound and time features of this environment, which involves emission and listening of the other members. It was clear that the group members had absorbed and internalized these characteristics, improving these aspects in their musical performance.

As a result, the group's performance at the 6th International Sound Convergences Cycle, in December 2024, was very consistent, improving the sonic result achieved by the group. This telematic concert featured the premieres of the works *Estudos sobre Texturas 3* (2024), by Danilo Rossetti, and *Onde estava esse som* (2024), by Fernando Iazzetta, both with real-time electronics.

Unlike the 2023 performance, for the 2024 performance no specific video was developed for the concert, with the works focusing mainly on the immersive sound aspects, which included, in addition to the acoustic sound of the instruments, the sound processing of the live electronics. The visual elements were limited to the projection of the musicians during the performance, alternating between soloists and the full ensemble.



**Figure 9: View of Rossetti's Computer Screen During a Rehearsal in 2024, Containing the Group Meeting in Zoom, patch in Max, and Score of Rossetti's *Estudos Texturais 3* [12].**

As a result, we observe that within the context of undergraduate education at a Brazilian public university, the practice of telematic chamber music introduces students to the field of mixed electronic music. It also serves as a valuable tool for cultivating collective listening skills in a latent virtual environment and for promoting interaction with sound processing systems. Participation in the ensemble provides students with foundational training in the use of audio equipment and microphones, including techniques for instrument-

specific microphone placement.

## 4. Conclusions

Telematic art integrates art and telecommunications to create a space for innovative, collaborative expression. It facilitates collaboration among artists across different locations and cultures, enabling them to work together in real-time or asynchronously, regardless of geographic boundaries. By exploiting a global pool of creativity, techniques, and perspectives, telematic art fosters cross-cultural exchange and cooperation.

In telematic art, digital networks serve as both the medium and the space, allowing artists to collaborate from any location. By combining live streaming, interactive installations, virtual environments, and AI-driven experiences, artists can produce dynamic, responsive works. This interconnected framework enables the sharing, remixing, and reinterpretation of each other's work in new and exciting ways. Moreover, telematic art empowers audiences to participate in the creative process, blurring the traditional distinction between artist and viewer. In collaborative telematic projects, performers can actively contribute to shaping the artistic composition, fostering a more inclusive and participatory art-making process.

The creation of the Telematic Music Center at the University of São Paulo marked a pivotal advancement in research, artistic creation, and pedagogy within the field of networked music performance. Throughout this project, we achieved significant results that contributed not only to the artistic outcomes but also brought forth tangible innovations in both technical and educational domains.

Our initial collaboration with composer Paulo C. Chagas was fundamental in designing integrated telematic audio and video systems and in establishing the Telematic Ensemble LaFlauta. This collaboration also served as a critical catalyst for our creative research in both performance and audiovisual composition. This early phase was seminal to the development of all subsequent stages of the project.

One of the most crucial technical achievements was the resolution of persistent audio feedback. By implementing a six-channel configuration in JackTrip, Malt created a possibility of having an enabled clean, high-fidelity sound transmission – an essential requirement for meaningful telematic collaboration. Furthermore, the use of binaural diffusion and advanced spatialization technologies allowed us to construct immersive virtual soundscapes, reshaping the listening experience for performers and audiences alike.

From an artistic standpoint, the integration of sonic and visual elements—particularly through symbolic color schemes and curated imagery—contributed to the construction of a ritualistic and expressive virtual stage. These elements enhanced not only the aesthetic dimension of the performances but also supported the development of new forms of audiovisual narrative in the telematic domain.

Pedagogically, we began our work alongside

Chagas and Rossetti, continuously refining Max patches and ensemble interpretations in search of improved sonic outcomes. Rossetti, the ensemble's composer-in-residence, has contributed significantly to the pedagogical exploration of mixed electronic music through this collaboration. In 2024, composer Fernando Iazzetta joined the group, initiating a collaborative project with Rossetti and Carrascoza – together with active student participation – slated for the next years.

The Telematic Ensemble LaFlauta has proven to be a powerful educational platform, introducing students to the practice of live electronic music while fostering essential skills such as collective listening, technical adaptability, and fluency with audio technologies. Through their participation, students engaged in artistic research and creative experimentation, received hands-on training in microphone use and spatial positioning, and explored collaborative improvisation in real-time, networked environments.

The central objective of the project, to investigate telematic music as a medium for creative and performative exploration in virtual environments, was realized through collaborative processes involving composition, improvisation, real-time interaction, and sound processing. Our work with Mikhail Malt, along with the use of AI-driven systems like Somax2, enabled us to explore and develop new methodologies for artistic creation and telematic performance, merging technological innovation with expressive experimentation. Our next step will be to expand this work with a focus on the creation of hybrid environments and telematic deep listening experiences inspired by the work of Pauline Oliveros.

Ultimately, this experience underscores the importance of establishing dedicated spaces—both physical and virtual—for the development of telematic music. The Telematic Music Center served not only as a technical infrastructure but also as a creative and pedagogical hub, where research, education, and performance converged. It laid the groundwork for future interdisciplinary practices that integrate music, technology, and higher education.

Building on the outcomes of this project, we propose to continue our research by further developing hybrid performance environments that integrate telematic and in-person elements. This next phase will deepen both technical and artistic dimensions to support meaningful concert experiences with audiences present at both ends of the telematic connection.

Telematic art enables new forms of collaboration that enhance both the artistic process and its outcomes. As it continues to evolve, it holds the potential to make artistic collaboration more inclusive, participatory, and accessible.

## Acknowledgments

We appreciate the support given to this research by The São Paulo Research Foundation, FAPESP Proc. 2022/05986-0 and by ERC (European Research Council) project REACH (Raising Co-creativity in Cyber-Human

Musicianship) ERC- ADG-19-883313. PI Gérard Assayag, Music Representation Team, IRCAM STMS Lab (CNRS, Sorbonne University, Ministry of Culture).

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