Towards a Telematic Dimension Space

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ABSTRACT
Telematic performances connect two or more locations so that participants are able to interact in real time. Such practices blend a variety of dimensions, insofar as the representation of remote performers on a local stage intrinsically occurs on auditory, as well as visual and scenic, levels. Due to their multimodal nature, the analysis or creation of such performances can quickly descend into a house of mirrors wherein certain intensely interdependent dimensions come to the fore, while others are multiplied, seem hidden or are made invisible. In order to have a better understanding of such performances, Dimension Space Analysis, with its capacity to review multifaceted components of a system, can be applied to telematic performances, understood here as (a bundle of) NIMEs. In the second part of the paper, some telematic works from the practices of the authors are described with the toolset developed.

Author Keywords
Telematic performance, networked performance, distributed choreography, dimension space analysis

CCS Concepts
• **Applied computing** → **Sound and music computing**; *Performing arts; Fine Arts*;

1. INTRODUCTION
Today, the practice of telematic performance can refer to a broad – and increasingly growing – range of works and tools. These bring to light the multifaceted dimensions at play when connecting performers at two or more physical locations by technological means so that they are able to interact in (more or less) real time. The terminologies used for such practices (dating back to early explorations in the 1950s, becoming topical in the 1990s and popular in the early 2000s, with the rise of Internet2) vary distinctly. And yet, they share in a tendency to focus on specific aspects of interplaying dimensions: network (musical) performance [21]; networked music [27]; networked performance, telematic performance [1]; distributed choreography [25]; cyberformance [14]; cybertheatre [10]; and telepresence art [16], to name just a few.

While some of these terms also refer to practices that go beyond being strictly telematic, the neologisms and the vocabulary at play indicate a complex imbrication of dimensions, blending human and non-human agents, and oppositional concepts: live and mediatised ("tele-", "cyber-"), presence and absence ("distributed", "-presence"), real and virtual ("cyber-", "[infor-]matic"), closeness and distance ("tele-", "network").

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1.1 Telematic Performances as NIMEs
This paper proposes a classifying framework for organising the variety of dimensions at play in telematic performance practices. It also details recent compositional and choreographic experiments made by the research unit at the Institute for Computer Music and Sound Technology (Zurich University of the Arts). The technical constellation in telematic performances can be understood as a 'NIME': a 'New Interface for Musical Expression', or more accurately in the case of our work, a 'Novel Interface for Multimedial Exploration', to play on the variety of NIME-acronyms [15, p. vii]. That "Interface" is the only constant in our modified version is much less owing to any accuracy the acronym demands, than to the open-ended indeterminacy it allows. Observing how telematic interfaces are discussed in seminal secondary literature, or conceptualised in artistic works themselves, it becomes clear that a wide variety of metaphors are applied. This suggests the multifaceted options and perspectives that can be taken to the exploration of (this bundle of) telematic NIMEs. The term "interface" can therefore be treated as a variable which substantially changes the equation in service of the involved artistic concept as well as the medial traditions or disciplinary backgrounds involved. In the experience of our research unit, as well as in reviewing the existing literature and projects, it has been useful to differentiate four dimensions which are loosely linked to the above-mentioned oppositional concepts: The variable "X (Interface)" in the equation "Novel X (Interface) for Multimedial Exploration" can therefore stay for: Instrument, Media, Network, Space.

1.2 Use of metaphors
The list of terms is more than just ornamental wordplay or rhetorical flourish. Rather, understood as metaphors that are well established and that migrate through discourses and practices, they play a significant role in structuring and guiding our "conceptual system" which can be understood as "fundamentally metaphorical in nature" [19, p. 3]. Artistic practices, research questions or aesthetic conceptualisations will be guided in different directions if we consider the telematic NIME as instrumental or spatial, as a network or a medium. With the risk of improper contraction, the focal points engendered by the use of these metaphors can be summarised as follows:

– Regarded as an *instrument*, the functionality of the different components and their interplay inside the telematic apparatus come to the fore, in that, it is less about playing an instrument than building one. The coordination and composition of the involved actors and media, as well as the handling of latency effects, are the focus of attention. This emphasis is encountered most often in telematic *music* performances.
– The interpretation of telematic practice as a complex interplay of *spaces* leads to the exploration of the virtual and the real, to query the precarious character of experiencing presence and absence, as well as the body as a wayward and vulnerable actor. This notion is most prominent in telematic performances in the field of *dance* and *theatre*.
– Practices highlighting their *media* aspects do not reconcile with the idea that the involved media withdraw by delivering their message but, on the contrary, participate in its very generation. The involved

media thematise themselves, the medium is apparent as a medium. This approach is most common in the *fine arts* field.

– Considered as a *network*, the de-hierarchization of the components and nodes of the telematic apparatus are subject of discussion and practice. This means to not play 'in' the network, but 'through' and 'with' it. The awareness of the fragmentation of local and global perspectives often leads to ethical considerations or to the observation of transcultural aspects.

These dimensions do not usually occur in their pure form. Nevertheless, one of them is most often foregrounded and act as a guiding principle. A recent and highly original contribution by Chris Chafe on Internet reverberation [9] demonstrates this on a purely musical plain. Here, the Internet is regarded as an "acoustical *medium* just like air or water", and the mere physics of propagation in real-time streaming is exploited: an acoustic loop between internet endpoints in a *network* is used to create *room*-like resonances. The title of Chafe's paper – a charming reference to Alvin Lucier's most well-known work – is telling: "I am Streaming in a Room". The punchline of Lucier's piece is not that he is playing *in* the room or *with* the room, but that he is *playing* the room – like playing an instrument [31]. The terms network, medium and space – the physical room in Lucier's case, the virtual one in Chafe's – only describe the components of an instrument that Lucier and Chafe, respectively, have built: "Composing means to build an instrument." [18]

2. ANALISING DIMENSIONS

2.1 Dimension Space Analysis

The listed terminologies and dimensions for the NIME analysis concerning this paper may still be too general and tentative for a more comprehensive and thorough evaluation of existing telematic interfaces. More so when it comes to further developing such interfaces or framing specific questions for acute research. Therefore, Dimension Space Analysis is called in as a tool to "better understand the properties of and relationships between entities" composing a system [11]. This approach allows one to visually plot each component of a system as a separate dimension on a separate axis and analyse its multiple layers from different perspectives. By placing points on an axis corresponding to a specific dimension, values ranging from low to high, in a continuum from one extreme to another, or discrete values in a logical progression represent the characteristics of the specific dimension. Connecting the points from each axis, a dimension plot is generated in the style of a radar chart.

Dimension Space Analysis was brought into the context of NIMEs in the 2005 paper *Towards a dimension space for musical devices* by Birnbaum et al. [3]. For the purpose of this paper, that research proposal is modified in one fundamental manner: telematic performances must deal with how remote performers are represented on the local stage. That representation might simply take place on an acoustic level, but as soon as an audience is involved, visual displays, e.g. transmission by video or by avatars, inevitably become factors of consideration. In light of this, a scenographic dimension is fitted into the model. Here, scenography is understood as the visual, experiential and spatial composition of a performance (for an application of the dimension space approach to the scenography of NIMEs see Berthaut et al. [2]). To avoid an unwanted multiplication of axes in the dimension space plots, it was decided that scenographic aspects would not be summatively added as independent axes, but that scenographic and acoustic dimensions and their respective axes would be defined so that they could be superimposed. The decision to blend dimensions that require a common denominator for each axis might seem as a knotty compromise at first, but on the contrary, the two-layered dimension space not only allows one to analyse the telematic NIMEs on acoustic-musical *and* visual-scenographic levels separately, it is also allows one to study the interconnectedness of such levels. As such, telematic performances and their involved technologies should not be understood as NIM(usical)Es, but as NIM(ultimedial)Es. For the construction of this dimension space, some of the axes (compared to [3]) are modified some are omitted and others introduced in order to meet the analytic needs of NIMEs with telematic characteristics.

2.2 Telematic Dimension Space

The following description of the different axes in the dimension space (Figure 1) refers on the one hand to the model developed by Birnbaum et al. [3], and on the other hand to the metaphoric terminologies listed in the introduction to this paper. It is important to note that the following dimensions do not exclusively describe what is happening at a location in a telematic performance but rather the dynamic and constant relationships *between* locations.

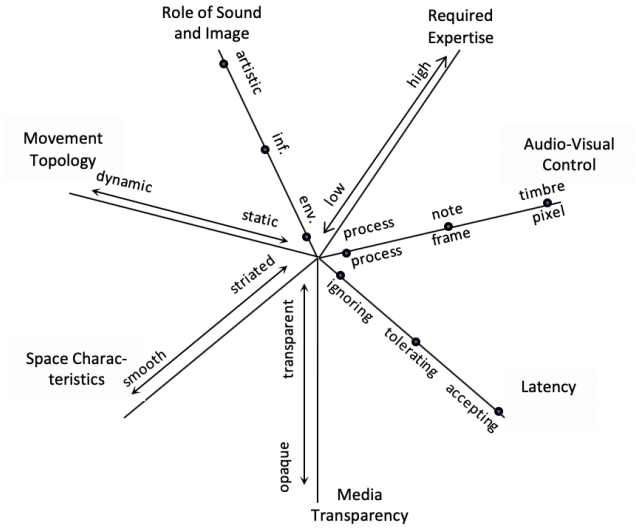


Figure 1. Telematic Dimension Space

2.2.1 Space Characteristics

"Distribution in space" is one of the axes in the dimension space model proposed by Birnbaum et al. and is a central aspect to telematic performance analysis. Nevertheless, the distance between distributed locations should not be a meaningful criterion as, on an aesthetic level, there is not much difference if, for example, two interconnected concert halls are located in two neighbouring cities or on two continents – concert halls usually look and sound very similar at very different places on earth. Thus, it is not relevant where the performative action is taking place but rather how these spaces are characterised and how they are conceptually connected to each other. The characteristics of the locations might be generic, as with concert halls, or they may be deliberately differentiated. On an acoustic or (in the stricter sense) musical level, this might happen if intercultural aspects between locations are carved out by the use of local instruments [23] or by different musical styles, as was the case in one of the very first, albeit overlooked telematic performances from 1971, Dieter Schnebel's *Drei-Klang*. Here, three ensembles – one in classical tailoring, another with archaic and exotic instruments, another in the style of popular music – at three different locations, interlinked autonomous works with different sound characteristics, effectively shaping individual musical spaces [24]. On a scenic level stages may be highly differentiated, as was the case for the site-specific walk *Call Cutta* by the German theatre collective Rimini Protokoll. Here, locations in public space in Berlin were linked to a call centre in India [22].

Instead of measuring the overall characteristics of the telematic space with the binary distinction of homogeneity versus heterogeneity, we propose the more fluid concept of "striated" versus "smooth" space as the two extremes on the relevant axis in the spider chart. Striated space is understood as an organised space with distinct positions favouring the "optic" and "distant" vision, whereas smooth space is understood as an open space with no end or beginning, favouring the "haptic" and "close" vision (for an evaluation of the concept introduced by Pierre Boulez and developed by Gilles Deleuze and Félix Guattari in the context of virtual topographies see [26]). Although the concept allows one to describe two different perceptual spaces, the more interesting feature is that it allows one to observe the passages or

movements from one state to the other – how smooth space is transformed by markings and how a striated space is made fluid. A telematic space where the positioning of its components is clearly perceivable is regarded as striated; a telematic space where multidimensional transitions between the locations and between physical and virtual characteristics are possible and consciously configured, is regarded as *smooth*.

2.2.2 Latency

One of the intriguing paradoxes of telematic performances is their capacity for interactivity despite geographic distance. The dimension "Feedback Modalities" as proposed by Birnbaum et al. will always be similar if it indicates the "degree to which a system provides real-time feedback". The devil is in the detail, specifically in the term "real-time", as a feedback between the different locations will never take place in a world of synchronicity. Latency – the delay-time of signals on their journey between the sender and the receiver – always comes into play. It would be intriguing to organise the axis in the dimension space by the degree of latency itself – from low to high latency – but this is not the most relevant criteria in telematic performances. Much more pertinent is how the performers deal with lag. They may *ignore* it (because it is irrelevant for the musical or visual structures [laid back approach]) or because it is below the range of a disturbing effect [realistic interaction approach]); they may *tolerate* it (because the involved locations adopt different roles [master-slave approach] or the latency is artificially enlarged to match a musical logic [delayed feedback approach]); or they may *accept* it (by understanding latency as a resource for musical or visual composition [latency accepting approach and fake time approach]). Even if the terminology is derived from a musical perspective [8, 7] it appropriates seamlessly to video lag – and to the relation between auditory and visual feedback mechanisms.

2.2.3 Media Transparency

Telematic performances are highly mediated. Data has to be sent between the different locations and the representation of this data has to be designed. This requires cameras, projectors, screens, microphones, loudspeakers, spotlights, computers. Practitioners of such formats are all too aware of the fact that a whole apparatus has to be assembled in order to make their performances work. In more conventional telematic music performances which try to emulate classical concert situations, much is done so that this apparatus is made invisible in order to direct the attention to the music itself. Contrary to this effect of withdrawal, types of media can also expose themselves and reveal their generative aspects. For example, in Maurice Benayoun's and Jean-Baptiste Barrières' *Tunnel under the Atlantic* from 1995 [20], members of the public in Paris and in Montréal could interact with each other. To establish the connection and to be able to interact with partners on the other side, users had to virtually dig through a universe of images and sounds representing the history of the two linked cultures. While from a technological perspective only a small and negligible latency is in play in Benayoun's interface, the added lag and the time consumed in overcoming a physical, worldly distance, reveals the paradoxical nature of distant communication devices and enmeshes the user into it, making the medium itself perceivable and tangible. Thus, media are not regarded as neutral messengers but as actors which not only interfere with the message, but are an integral part of its generation.

In one case, the medium is invisible, *transparent*, in the other, it reveals its features, is *opaque*. The dichotomy between transparency (or immediacy) and opacity (or hypermediacy) is discussed in various media theories (e.g. [4]). It is used here to differentiate between approaches that operate in an immersive way and others that explore the meaning of the interface itself. The "Degrees of Freedom" axis in the model by Birnbaum et al. is therefore substituted by the dimension "Media Transparency", as it must be decided which modalities are fed into the telematic system and in which way they are addressed.

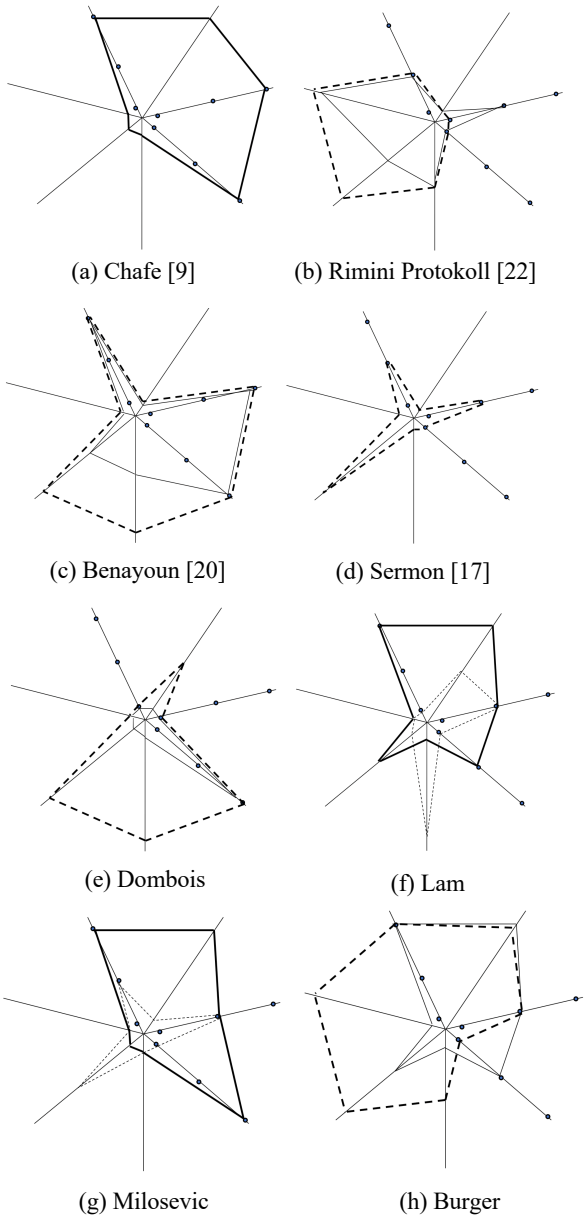


Figure 2. Dimension Space Plots
drawn through lines: acoustic layer; dotted lines: scenographic layer; bold line: leading layer

2.2.4 Role of Sound and Image

The "Role of Sound"-axis, by contrast, can be easily adopted from the existing model, even though a visual aspect has to be added. The discrete values on the axis are derived from an investigation on performed sound in virtual environments [28] and are named as *environmental sound*, as *information transfer* and as *artistic expression*. Nevertheless, the leap to similar structures in the visual field is not so far from what situations in telematic music performances evince. If interacting musicians are represented not only musically but also visually on screen, the usual hierarchy of signal transfer is inverted. Because the video lag is usually bigger than the latency of the sound, the latter arrives earlier than the former – contrary to a 'natural' situation where a fellow musician perceives the visual bodily gesture earlier than the sound. Therefore, gestural cues to coordinate the music do usually not make sense in telematic environments (an interaction between remote musicians considering latency can nevertheless be practiced to a certain extent). However, musicians often appreciate if the remote musician is represented on a screen and this can facilitate musical interaction substantially. For example, even if cues (information transfer) grasp at

nothing, bodily movements and the expression of the remote musician do contribute to an overall perception that enhances awareness and the feeling of presence. In sum, visual representation is perceived as environmental. In order to eliminate the modal characteristics of the term, we have named the three distinct values *environmental, informational,* and *artistic*.

2.2.5 Audio-Visual Control

Again, the axis "Musical Control" as proposed by Birnbaum et al. has to be extended to include visual information. Referring to Schloss [30], three discrete points, from the microlevel to the macrolevel, serve to describe the level of control over musical processes. On a *timbral level* the transmission of sound from one location to the next is modified in the way that the internal structure of the sound is itself manipulated. In an approach on *note level* the transmission leads to a 'normal' representation. From a macroscopic perspective, neither the timbral nor the note level is in focus, but the *process level* is; the sound in this case is the result of musical processes and it tends to take an environmental role. This terminology is, of course, strongly acoustic, but the principles are very similar if visual representation is regarded. On a *microscopic level*, the video image can be processed, either by software or by using the peculiarities of the telematic instrumentarium (e.g. exploiting the effects of jitter), whereas it is not additionally altered on a *middle level* or as the result of a specific process in a *macro-perspective*. The equivalents to the musically informed terms *process – note – timbral* can be renamed *process – frame – pixel* for a description on the visual plane.

2.2.6 Movement Typology

The interaction between the human actors and the technical interface is an important aspect in telematic performances, even when the number of people involved in such an action [3] might not be the most telling aspect to characterise the performance. But what and who exactly is interacting there? Obviously, the performers – local and remote – are interacting with each other, but they are also interacting with the visual and auditory representation and, moreover, with the material carriers of such representation: screens, loudspeakers, computers. Such interactions are partly covered by the components represented in the aforementioned axes of the dimension space, but one crucial aspect is missing: the *topological* arrangement of these components [29]. In telematic music performances, the musicians are clearly positioned on stage and do not usually change their position during the performance of a piece, so it is consistent that their visual and acoustic representation at the remote location is static as well. It is less obvious that movements of the performers in telematic theatre or dance pieces are most often projected on flat, static screens, as it is often the case. Alternatives for mapping movements of performers have been developed in the concept of "distant puppetry" in the early telematic performances of the Gertrude Stein Repertory Theatre (e.g. *The UBU Project* [11, p. 422ff.]), where performer's bodies function as projection screens. On an acoustic level, moving loudspeakers or 3D-sound systems like ambisonics could be applied as well. Compared to the dimension "Space Characteristics" described above, the aspect of "Movement Topology" introduces a strongly performative element, linked by movement characteristics to bodily presence and to phenomena of virtualisation. The points on the axis of the dimension space can therefore be arranged between the values *static* and *dynamic* and can inform how the different physical and representational elements are interacting and put in motion.

2.2.7 Required Expertise

This axis "represents the level of practice and familiarity with the system that a user or performer should possess in order to interact as intended with the system" [3]. This dimension does not have to be modified for the purposes of this paper. In the aforementioned "mobile phone theatre" *Call Cutta,* a user does not have to have much more agency other than to dial a phone number; in Paul Sermon's seminal *Telematic Dreaming*, 2003, the user has the option to join a remote performer who is projected on a bed. No technical display diverts from the immersive environment [17]. On the other side of the expertise axis, ranging in value from *low* to *high expertise*, instrumentalists, electro-acousticians or dancers have to acquire and perfect highly specialised competencies in order to play and actively make the specificities of their telematic apparatus productive.

The seven-axis dimension space shown in Fig. 1 is a summary of the entities and dimensions described above. It allows for the analysis and comparison of a wide variety of telematic performance practices, as can be seen in Fig. 2a-2h, where their characteristics have been plotted on the dimension space charts. To demonstrate its variability, only the acoustic layer has been mapped (drawn through lines) in some of the plots; in others, only the scenographic layer (dotted lines); in certain others, both layers are represented. The examples used here refer to both the telematic "classics" that have been brought up in the course of this paper and to telematic performances from our own artistic practices, which are introduced, after some technical considerations, in the second part of this paper.

3. DIMENSION OF PRODUCTION

3.1 Technical considerations of audio and video transmission

The most versatile tools for our research on telematic performances with bi-directional, low-latency, multi-channel audio and video transmissions between two or more geographically distant locations have been the JackTrip (audio) [6] and UltraGrid (video) [32] utilities. These have been used successfully in many of our distributed performances and, as they are multi-platform and open-source and integrate well with existing professional audio and video software, they have become tjhe tools of our choice. Nevertheless, two recurring obstacles hinder our effort to shift the focus in our work away from technical organisation to artistic experimentation.

On the one hand, the JackTrip and UltraGrid utilities operate in two modes: client mode and server mode. This works well so long as the client "sees" the IP address of the server. However, with today's Internet, public IP addresses are usually only assigned to headless servers and NAT routers, not to devices touched by humans. Therefore, running the utilities in server mode at a concert venue often requires a computer that has either a public IP assigned or the proper port forwarding already configured on the local network router. To configure the system in this way often requires huge administrative overheads and time-consuming liaisons with IT staff at venues where the performers are not the owners of the local network.

Another complexity is the planning and set up of connections when not two, but three or more venues are participating in an event. Two endpoints require one link. Three endpoints require three links, while four endpoints require six links. The number of links increases quickly with the number of endpoints. Events with more than two nodes require meticulous and careful planning.

As a result, we have developed a tool set to facilitate the audio connection, consisting of a client part (tpf-client) and a server part (tpf-server). The latter is permanently available so that any node and/or any performance venue of the telematic network can connect to it in client mode, bypassing most types of firewalls easily because the clients initiate the connection. The added latency of this setup is negligible (2-3 ms) as long as the server is located near one of the performance venues (otherwise the additional path of the data transfer leads to additional latency). Both tpf-client [33] and tpf-server [34] are open source, therefore, the latter can also be installed at other places and by other users if pathways have to be optimised. The same architecture is also used to facilitate the video streaming of the UltraGrid utility, and it was also used for other types of data, such as the tracking information of a performer represented as an avatar at the remote location.

The tpf-server additionally facilitates the handling of many concurrent audio transmissions in setups with more than two endpoints. In the user interface of the tpf-client, the user can see the clients that have a connection to the server already and connect to them easily – the handling is done by the server itself. For the purpose of user-friendly configuration of the tpf-client and smooth communication and with professional audio software (e.g. Ardour) and with the tpf-server, JackTrip was rewritten in Pure Data (for a detailed description see [13]).

3.2 Telematic performances

The tpf-tools have been developed alongside a series of performances between Zurich and, among others, San Diego, Stanford, New York, Belfast, Berne and Hong Kong. In recent concerts, they have enabled flawless performances. In recent concerts, these tools enabled the flawless performance of improvisations and pieces from existing repertoires that had been adjusted to the telematic environment. Additionally, a series of commissions by composers, media artists and choreographers – more or less familiar with the telematic setup – has proven beneficial for further exploring the aesthetic potential of distributed performances. Some of these works are introduced in the following chapter and mapped in the dimension space (fig. 2e-h).

3.2.1 Florian Dombois: Telematic Intermezzi

This composition by media artist Florian Dombois (Fig. 2e) reacted to the concrete set-up chosen for a concert between Zurich and Hong Kong. A number of pieces, with up to five musicians at each location were played and, as the title suggests, these little telematic exercises were executed as intermezzi between the other pieces, each one performed by the musicians who played in the preceding work. Besides a multi-channel audio connection, the visual setup was quite classical (Figure 3). A large screen at the back of the stage showed the remote stage, two smaller screens placed in v-shape below the big screen were used to facilitate the communication between the musicians. These screens were also visible for the audience. In front of each of the lower screens, a camera was placed so that the sightlines between the local and the remote musicians could be attuned intuitively: a performer looking at a remote musician projected on the screen would simultaneously look into the camera and therefore looks out from the screen at the remote location in the right direction. Two additional cameras were used for the video transmission on the large screen from one stage to the other. The setup of one location was similarly mirrored at the other – literally mirrored, as the lines of gaze only work intuitively if the stage setup is inverted.

Figure 3. Telematic Intermezzi: Stage Setup

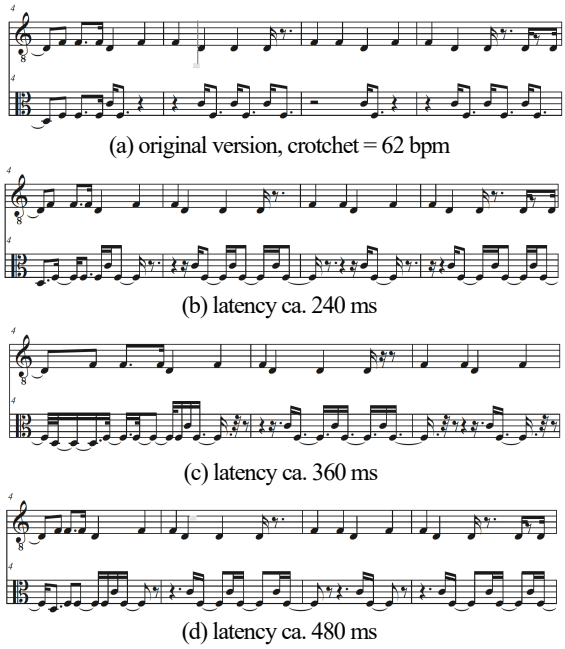
As in the tradition of visual music, a rhythmic score was used to guide the performers through the following four movements, interspersed between other works:

1 Three musicians on each side hold sheets, numbered with "Screen 1" to "Screen 6", for the cameras such that the six screens (three screens on each side) are numbered and therefore transmogrify into signs.
2 Four musicians on each side hold sheets, numbered with "Camera 1" to "Camera 8", in front of each of the eight cameras (four cameras on each side). Unlike the numbering of the screens, the camera sheets are contingent to the audience, who do not know how the eight cameras are rooted to the screens. Additionally, and in a defined rhythmic layer, the performers hold mirrors in front of their camera, showing, by reflection, the camera – usually invisible – as an actor of its own.
3 A clapping exercise adds an acoustic layer. Ten performers clap in a round which not only consists of the local, but also the remote musicians. The clapping information is given through the "wormholes" of screens and loudspeakers, producing a variety of disturbances on visual and acoustic planes because the different latencies hinder the establishment of a consistent pulse. In contrast to usual approaches that obscure latency-effects, its ambiguous power is made visible and audible to the public as a disturbing factor.
4 The concert hall lighting is dimmed as low as possible and six performers (three on each side) shine flashlights into the cameras. The six screens therefore mutate from 'windows' that give insight to a remote location, to mere 'light sources' that are remotely controlled.

Unlike more classical approaches to telematic performances, the components of the setup are not disguised in order to create a situation having immersive characteristics. Rather, the constituents of the medial situation are radically exposed and, with all their inherent perturbations and contradictions, the simulation destroys itself. As such, the telematic medium – with its components – makes itself visible *as* a medium.

3.2.2 Lam Lai: Raindrops

Lam Lai's composition for contrabass flute and viola distributed at two locations (Fig. 2f) includes theatrical elements which thematise the medial configuration on a scenographic level (not described here in detail). Additionally, it plays, in an intimate way, with the phenomena of audio lag. According to a master-slave approach [7] the respective roles are accorded to the performers alternately, in six short movements. The degree to which the composition calculates the audio delay can be demonstrated in the first bars of the composition: the flute is in the master position, so the viola is allowed to follow and can realise the score on its side, as stipulated. On the master side, the situation nevertheless sounds different: the viola reacts to the flute only after its signal has arrived at the remote location and, as there is a delay in the transfer of the viola signal back to the flautist, the viola will be delayed on the master's side, in the amount of a round-trip between the two locations. For the master, in this case the flute, this well-known situation in telematic music performance is highly uncomfortable because coordination breaks down as soon as the performer tries to improve their rhythmic accuracy. Under such conditions only technical – no musical – interaction is possible between the musicians.



(a) original version, crotchet = 62 bpm

(b) latency ca. 240 ms

(c) latency ca. 360 ms

(d) latency ca. 480 ms

Figure 4. Raindrops, bar 4ff.
sound result at slave (a) and master (b-d) position

The composition outwits these difficulties with a simple but effective subterfuge: the rhythmic structure is designed so that a variety of displacements between the two instruments does not destroy musical significance, but rather, leaves it intact or even enhances it in an aesthetically appealing way. Fig. 4 shows some of the first bars of the composition in original form and then in a series of shifts resulting at the master position. The offsets are of course dependent on the tempo and the latency between the two locations. A test with different latencies has shown that the musicians intuitively choose a tempo in which the music latches on a meaningful rhythmical structure. By alternately changing the roles of master and slave between the two musicians, this process can also be made audible to an audience. Therefore, this composition is not so much an example of a lag-tolerating master-slave approach, but rather an example of latency acceptance, wherein latency itself is treated as a compositional material.

3.2.3 Bojan Milosevic: Teoda

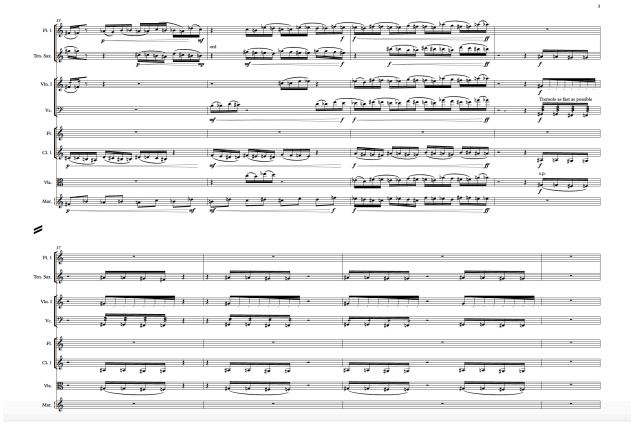
Whereas latency effects are taken into consideration in a musical way in Lam Lai's *Raindrops*, Bojan Milosevic's *Teoda* (Fig. 2g) literally calculates with them. The distributed performance consists of two ensembles, one comprising flute, saxophone, violin, violoncello; the other comprising flute, clarinet, viola, marimba. They play at two locations with a round-trip latency of 444 ms between them. As a result. When played in the stipulated tempo of 135 bpm on crotchet level, a shift of exactly one crotchet results between the two ensembles.

The spontaneous latency between two locations is only partly controllable and strongly dependent on geographic distance. In the case of the *Teoda*'s first performance in a concert between Zürich and Hong Kong (and in the setup described in 3.2.1), a roundtrip latency of roughly 340 ms was measured. Therefore, additional lag had to be added in the audio transmission, a feature which is an integral component of the aforementioned tpf-tool. As a result, two different versions of the piece emerged at the two locations, shifted by a quarter note. The two ensembles played from two different scores (Fig. 5) and although musicians played asynchronously to the music their colleagues played one crotchet prior, the correct visual representation of the sonic result considerably aided the musical interaction. One of the ensembles took a leading role, the other followed, but in rehearsals, the vision of a 'real' musical interaction became conceivable. An additional hindrance was audio feedback, as an ensemble's own signal fed back from the remote location. This was reduced in an alternative setting with headphone monitoring, minimizing crosstalk effects.

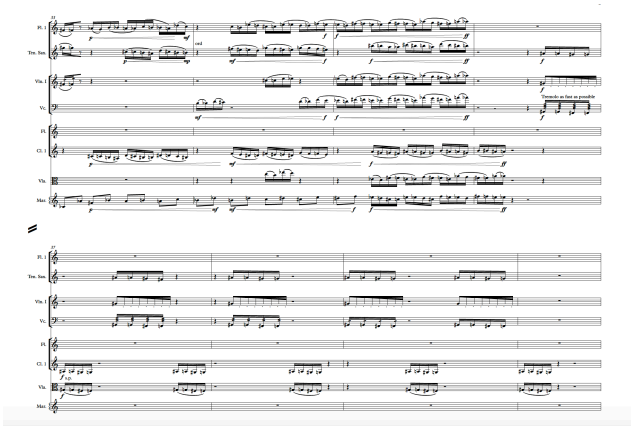
Understood compositionally, such "fake time" approaches to latency [7], also called "user controlled delays" [6], allow for experimentations with creating two simultaneously played works that are notably distinct, but equally meaningful – an approach not possible outside of telematic environments.

Figure 6. Teoda: Stage Setup

The careful staging of local and remote musicians not only facilitates the interplay between venues but can have significant bearing on the audience's experience. In a subsequent performance of *Teoda*, the remote musicians were projected lifesize on a number of transparent screens distributed between the local performers (Fig. 6). The transparency of the projection surface has the advantage of allowing the projected image to be seen on both sides of the screen. This enabled performers to be situated so that their communicative gestures (remote and local) could be executed and read intuitively – and by the audience. This not only considerably raised the illusiory character of the scenography but demonstrated that telematic space can be organized in complex ways; ones that go beyond simple combinations of present bodies and absent ones projected on a flat surface at the back of the stage.



(a) score location A



(b) score location B

Figure 7. Teoda, bar 33ff.

3.2.4 Benjamin Burger: Moving Screens, Sounds and Bodies

Musicians are highly trained to interact on auditory levels. While visual gestures can be of some importance, these can often be blended out. At the same time, musicians are commonly placed statically on stage when performing. As soon as dancers or actors come into play, the topological situation radically changes. A question that telematic performances then pose concerns the possible alternatives to the representation of moving bodies on a static screen at the remote location. Moreover, actors and dancers tend to interact on the level of physical gestures and bodily presence. In *Moving Screens, Sounds and Bodies* (Fig. 2h), these perspectives were tackled.

In a performance at two distinct (identical but mirrored) locations within the campus of the Zurich University of the Arts, audio and video transmission of the two musicians (one on each stage) and of the four dancers (a male-female couple on each stage) was organised as follows:

– Three static cameras – front of stage, stage left, stage right – film the performance;
– a screen measuring approximately 1.0 by 2.0 meters serves as a moveable projection surface by the performers;
– a motion tracking system tracks the stage position of the screen as well as its vertical and horizontal rotation;
– using two projectors, a video mapping system (Sparck [35]) places the video from one of the remote cameras on the local screen; it

therefore chooses the cutout of the video image exactly representing its (virtual) location at the remote space; additionally, depending on the vertical rotation of the screen, it chooses one of the three camera perspectives, thereby minimising distortion effects;
– the musicians are represented at the remote location by point source speakers at their (virtual) location on stage.

The moving screens do not show the whole remote location. On the contrary, they only give an insight into fragments of it – the fragment of the part of the remote location that could be seen in the frame of the screen if it were there. This experimental arrangement has proven fruitful as it allows one to explore and reflect the multilayered interplay of real and virtual spaces as well as human and technical agents. Different functions of the screen in the performance can be described as such:

– One of the performers moves the screen following the movements of the remote performer so that his image appears on the screen; if this is the case at both locations, two performers can directly interact on a gestural level. The screen is then *representative* of the (body of the) remote performer. At the same time, absent and present body parts can merge to virtual bodies (Fig. 7).
– The screen can also be used to literally "scan" the remote location by slowly moving over the stage; it then shows what is at the respective place, be it an object, a musician, a dancer or otherwise. The screen in this case mutates to a *window* giving information about the remote space.
– In the following situation, the screen gets a sort of (imaginary) *door*: Performer 1 is behind the screen and thus invisible to the audience; Performer 2 joins Performer 1; Performer 1 moves out and becomes visible to the audience. The surprising effect of transformation from Performer 2 to Performer 1 questions the overall construction of the complex spatial arrangement.
– As soon as the performers start to play with the screen as an entity in itself, it transmogrifies into an object or a *body*. Even if the screen serves as a representative of the remote performer, the local performer can choose between interacting with the dancer projected on the screen, with the screen itself as an object or with the fellow performer located behind the screen in order to move it.
– Finally, if both screens are placed at the same position at the two locations, they show themselves, not only subjoined in a reflective dimension but also serving as a mere *light source*.

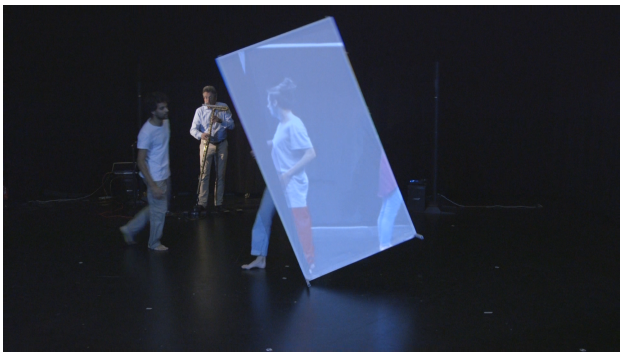


Figure 7. Virtual Bodies

These possibilities are multiplied if the actions at the two locations are deliberately differentiated; more so if the interactions among the musicians – and between them and the dancers – are taken into consideration. In any case, the setup does not simply frame two independent spaces that are somehow connected by video and audio transmission, to a much greater degree it enables a smooth transition between the different spaces – real and virtual – whose characters can be created or abruptly interrupted. The agents – performers, screens, sounds, spaces, carriers, objects, etc. – are not fixed in a well-tailored space-time construction, they are in constant transformation and constitute a multi-dimensional smooth space.

4. CONCLUSIONS

We have demonstrated that a dimension space paradigm allows for changing analytical focuses on a variety of acoustic and scenographic components; components that are essential for telematic performances and constitute the specificities of these NIMEs. Analysing the plots of some selected compositions and installations from a repertoire of historic works and from our own practices (Fig. 2a-2h), certain trends in the design of telematic settings become more apparent thanks to the visual representation of the dimensions at play. Often, the scenographic (dotted lines) or the acoustic layers (straight lines) are predominant for the overall structure; this is expressed with thicker connecting lines in the dimension space charts. Taking this into account, the charts demonstrate trends which resemble the metaphors assembled in the introduction part of this paper:

– Telematic performances that show a shift to the *(top) right* (Fig. 2a, 2f, 2g) mostly work within the framework of the *instrument* metaphor. As the performers or users deal with a complex instrument, their expertise is usually high. Also, it is not by chance that the refined play on internet reverberations – proposed by Chafe and discussed above – fits in well into this approach, which is the most common in telematic *music* performances.
– Telematic performances which show a shift to the *bottom* (Fig. 2c, 2e) focus on their *mediality*. It is consistent that the dimensions neighbouring "media transparency" – i.e. "latency" and "space dimensions" – are intensely exploited in such practices as they are their most obvious features and are therefore most apt to deliver a target for deconstruction. These approaches are most common in *media arts*.
– Telematic performances which show a shift to the *left* (Fig. 2b, 2h) are sensitive to performativity and exploit the multidimensionality of *spatial* aspects. These approaches are most common in telematic *dance* or *theatre* performances.
– The *network* aspect, on the contrary, does not have a clear representation in the dimension space, it seems to touch a different plane. That is, that networks are most visible and amenable to artistic exploration if they consist of nodes which are strongly differentiated and by this, allow one to transcend the limits of usually well delineated (cultural, political, economic) fields. The proposed dimension space model describes telematic performances from a rather technical perspective, in contrast, the transversal character of network approaches hints at a more symbolic level. This does not mean that such approaches are less vital, on the contrary, it means that they might affect most of the dimensions depicted in the axes of the model, but irregularly, making them less easily identifiable.

Besides the trends that are shown in the dimension space plots and that invite comparisons between different practices in an analytic perspective, the plots also allow for spotting the interconnections between the scenographic and the acoustic levels. It is quickly visible, for example, that the media opacity in Dombois' *Intermezzi* (Fig. 2e) only touches the scenographic axis but is not explored musically – a finding that is very similar in Lam Lai's *Raindrops* (Fig. 2f). Therefore, it appears that a reflection on mediality is more easily (and more commonly) expressed by visual or performative means than by auditory ones. To think about an inversion of these tendencies would open up a wide field of exploration. In a similar way, topographic movement is exploited on a scenographic level in *Moving Screens, Bodies and Sounds*, but not on an acoustical level (Fig. 2h). It is not our intent to synchronise scenographic and acoustic levels and subsequently flatten their potentialities, but to make such relations visible as an incentive to more consciously control the functions of the components at play, to mediate their interplay and to decide on their (de)hierarchisation.

Our model need not only be used for analytic purposes. It also serves as a powerful tool for the further development of a refined telematic performance practice. The complex layering of components and levels, the multifaceted dimensions of this bundle of NIMEs, is a strong motivation to explore the almost infinite stratifications offered by this "Novel Interface for Multimedial Exploration".

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