UNIVERSITÄT FÜR MUSIK UND DARSTELLENDE KUNST GRAZ

proto-type: Trials of unification of acoustic and electroacoustic environments

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Abstract

The text focuses on the composition proto-type for string quintets and live electronics, where the phenomenon of space, resonance and aspects of instrumental modularity are explored. The first section is dedicated to the conceptual foundations. It describes various ideas, observations and motives relevant to the piece's conception. The second section treats the purpose and use of the electronics in the piece. The devices, setup configuration, processing and spatialisation approaches are discussed. The third section focuses on compositional aspects, particularly how all the previous ideas were integrated into the piece and the reasons behind it. The proposed structure, the musical representation in the score, and the musical material are described.

Abstrakt

Der Text konzentriert sich auf die Komposition proto-type für Streichquintett und Live-Elektronik, in der das Phänomen des Raums, der Resonanz und Aspekte der instrumentalen Modularität erforscht werden. Der erste Abschnitt ist den konzeptionellen Grundlagen gewidmet. Er beschreibt verschiedene Ideen, Beobachtungen und Motive, die für die Konzeption des Stücks relevant sind.
Der zweite Abschnitt befasst sich mit dem Zweck und der Verwendung der Elektronik im Stück. Es werden die Geräte, die Aufbaukonfiguration, die Verarbeitung und die Verräumlichung besprochen. Der dritte Abschnitt befasst sich mit kompositorischen Aspekten, insbesondere damit, wie all die vorangegangenen Ideen in das Stück integriert wurden und welche Gründe dahinter stehen. Die vorgeschlagene Struktur, die musikalische Darstellung in der Partitur und das musikalische Material werden beschrieben.

1. Foundations

1.1 General description and objectives

The goal was to compose a modular piece for a string quintet with live electronics. I define modular as the possibility of rearranging and adjusting the piece according to the available players so that the work can be performed with different combinations. For example, as a solo piece if only one of the parts is performed or as an ensemble piece with a combination of the parts. The setup is also scalable to different multi-channel system configurations for the electronics output.

The phenomenon of resonance was integral to the composition of the piece. The argument for using resonance as the main guideline is that many of the agents, such as the players and the instruments, that are involved in the performance of a piece are engaged to some degree with this phenomenon of resonance.

1.2 Observations and factors of resonance

Assuming that “Resonance is the tendency of a system to steal energy from, and vibrate sympathetically at, a particular frequency in response to the energy supplied at that frequency” (Loy, Gareth 2006), we can observe that many physical devices involved in reproducing the piece consist of various resonant systems, such as musical instruments, speakers, and the room. All have differing characteristics, where we can roughly differentiate degrees of resonance according to the range of frequencies that can be excited.

Musical instruments

The design and shape of the construction, materials and particular vibration system determine their natural vibration frequency and which harmonics are more prompt to resonate with the vibration source, as musical instruments are built and designed with the resonator in mind. The resonant frequencies on each design are limited according to the specific build. These frequencies of the instruments are located in a narrow band of the sound spectrum compared to the space where the sound unfolds.

Speakers

The speaker construction consists of a coil that alternates its position, pushing a membrane that transfers the energy to the air amplified through resonation by the speaker. Ideally, the speaker should be capable of reproducing the sound without colouration. Still, the physical limitations of the construction will inevitably exaggerate the frequencies near its natural vibration frequency. Nevertheless, it is less resonant than the instruments.

Space

Dimensions, materials, positioning of receivers and emitters, and vibrating frequency contribute to stimulating the natural resonant frequencies of a space. Ideally, the design of the space intended for music performance will avoid the particular accentuation of a sound frequency. Nevertheless, the sonic imprint of the space in the reproduced sound is unavoidable.

1.3 Exchange of information between agents

Naturally, all these systems communicate and exchange information. It is essential to observe how and where this happens, where the limits lie, and what advantages and disadvantages are brought to the reproduction of the piece. It is an influential factor that can further solidify the coherence of the idea of using resonance as a primary future. The observations cater to the particular setup used for the reproduction of this work.

Instrumentalist

Instrumentalists apply energy to the vibrating system of the instrument and, depending on their choices of interference (e.g. bow use or string pull), the sound output will contain different colour, pitch and loudness characteristics.
The cognitive capabilities of the human players allow them to reflect on the sonic result of the input that unfolds in the Room, and they are trained to continuously adjust their actions in response to the sound's interaction in the Room.

Musical Instrument

The sound generation depends on the player's external stimulation of the vibrating system. The natural resonant frequencies depend on the instrument's characteristics, enabling a particular mode of colouration and amplification of the vibrations. It also captures some of the room acoustics, which can be highly influenced by where the instrument is placed in the space.

Microphone

It is a device that translates sound waves in the air into electrical signals and, with the aid of an analogue-to-digital converter, enables the transmission of the instrument output to the process node. The proposed communication model assumes a contact microphone to focus only on capturing the sound emission of the instrument's body, as the use of other types of microphones will also involve the capture of the room acoustics. In practice, the setup is open to any microphone as it depends on the players´ willingness to attach a contact microphone to their instrument's body.

Signal Processing

It is the stage where the sound is manipulated before its reproduction via the speakers; the signal can be transformed in various ways. Several characteristics can be manipulated similarly to the player, as described above, such as the pitch and intensity of the sound output.

Speakers

After the signal processing stage, speakers reproduce the signal. Their placement exerts a high degree of influence on their interaction with the room acoustics.

Room ("Acoustics")

The sound of all outputs combines and unfolds in the room. It is the primary medium of communication between the emitters and the receivers.

Communication

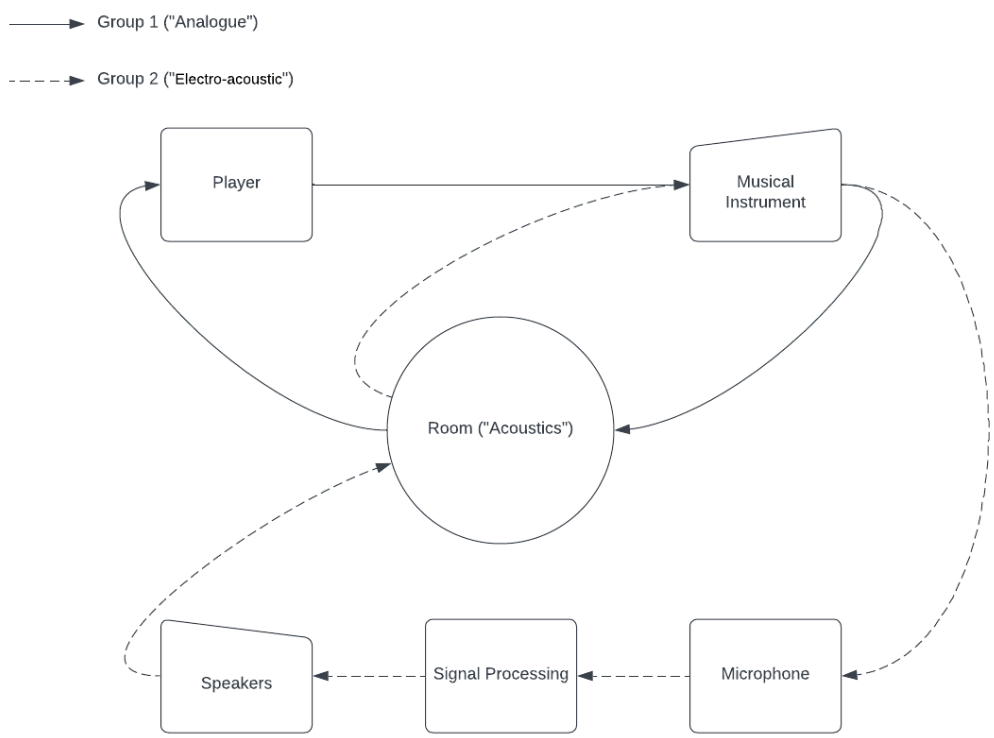

Figure 1

In this case, the flow of information between the agents can be best described by dividing them into two groups: Analogue and Electro-acoustic (Figure 1), which are discussed below.

Typically, systems using a circular energy exchange are described using feedback loops. However, I found the descriptions and terminology found in recursive communication theory (Krippendorff, K 1994) more helpful in clarifying my interests and conceptual aspects concerning these models. Recursive loops are allowed to be continuously adjusted by the external stimulus, which accounts for the agents' capability of reflexivity and cognition, in this case, the player or the players.

Group 1 ("Analogue"): describes the most standard exchange of information in a concert situation where the player excites the vibrating system of the musical instrument that resonates with the body of the instrument, amplifying the sound that is unfolding in the Room ("Acoustics"). The player receives the acoustic information almost instantly, adjusting how he inputs energy to the system to match it to the desired output. The most prominent communication characteristics of this group are:
Circularity: The result of the action is heard by the player after unfolding in the space.
Reflexivity or Self-Adjustment: The player can adjust how to input energy to get the desired output.
Recursiveness: It enables an ongoing sound production adjustment.

Group 2 ("Electro-Acoustic"): is superimposed and flows parallel to Group 1. In Group 2, circularity, Reflexivity (self-adjustment), and Recursiveness are not inherited traits as in Group 1. An adjustment must be made to approximately recreate its functioning to that of Group 1. To enable a circular exchange, the introduction of a feedback loop is required between the speakers and the microphone to re-introduce the signal that passes through the space into Group 2. As for reflexivity/self-adjustment, a means of re-adjusting the loudness of the output is required to facilitate a recursive capability similar to Group 1.

In my model, the exchange of information occurs between both groups as the instrumentalist acts as a receiver of the sound emissions of the instrument and the speakers that unfold in the room. The input and adjustments of the instrumentalist influence the output of both groups. Similarly to the instrumentalist, the instrument's body can capture the emitted signals unfolding in the room. Here the room acoustics are filtered (adjusted) by the body of the instrument's natural resonant frequencies and then re-captured by the microphone.

1.4 Points of Encounter and Deviations

Energy Supply.

The initial energy supply for both groups comes from the player. Once the feedback loop is engaged, the energy is re-supplied to the system via amplification. Nevertheless, any action the player executes will directly affect the whole system, while the energy supplied by the amplification will not necessarily affect the energy supplied by the player.

Vibrating System Manipulation

The agents capable of manipulating the vibrating system in these two groups are the player and the signal processing. In the case of the player, this occurs depending on the interference with the vibration system, such as shortening or extending the vibrating surface of a string and the amount of pressure applied to make the strings vibrate. Within signal processing, this can be achieved by manipulating the signal with mathematical operations that could increase or decrease the amplitude or modify the output pitch. In contrast, the player can naturally execute and adjust these actions simultaneously, while in signal processing, these adjustments occur at different moments and instances of the processing chain.

2. Integration of electronics

2.1 The purpose of electronics

The primary purpose of the use of electronics in work is to reinforce the initial idea of resonance at conceptual and practical levels. Observing the phenomenon in play and carefully selecting processing resources can permit the self-referencing of the material, allowing a recursive development of the piece. With this in mind, the question that comes to mind is how and where this reinforcement can be achieved organically. Looking from a global perspective, how to self-reference the natural characteristics of the analogue mode in the electronic model.

2.2 Circular Exchange

The first task for the electronics and the purpose of reflecting the communication qualities present in the acoustic model is enabling a circular exchange. The ideal solution for this configuration is the introduction of a feedback loop. The reasoning behind this is that the resulting frequencies on the sound that occurs with the acoustic feedback are also related to the resonant frequencies of the physical devices used through the chain, their emission position, capturing position and the room acoustics in the feedback loop. Furthermore, it is a compelling and robust solution for carrying the different agents' sonic information through the chain.

2.3 Dynamics

The introduction of the feedback loop brings some challenges to the table, as acoustic feedback is a positive feedback situation. There is an infinite and rapid increase in energy in the system as the frequencies reinforce themselves continuously, capable of eclipsing all other sounds present in the medium. To make a cohesive integration to the proposed model is essential to limit and adjust this energy continuously. For this piece, I opted to use a target gain adjustment operation device (Image 1). The purpose is to enable the capability to adjust each output, in this case, speakers, to a fixed target dynamic independently of the room acoustics situation. So if the level increases, the operation decreases the energy, and if the energy decreases, the operation increases the energy. On the one hand, this is an attempt to reflect the player's recursive capability of continuously adjusting the amount of energy supplied to the instrument. On the other, it also permits me to plan the speakers' dynamic output to treat the speakers' dynamics as any other instrument of the ensemble, in this case, a string quintet.

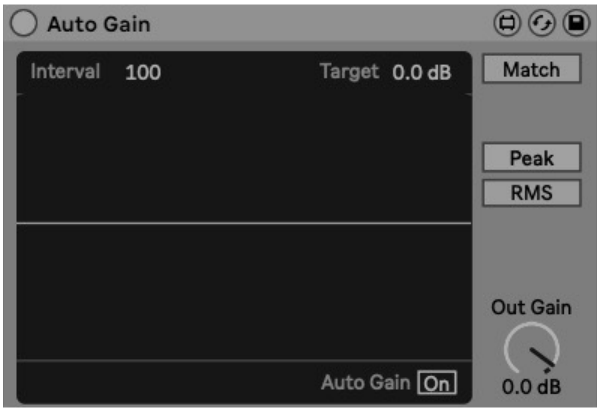

Image 1

2.4 Process

As electronics can bifurcate in many directions, I came to the task of observing the implications and possibilities that its use brings to the table. The first consideration was how to use the electronics; how can this help me explore the idea of resonance? Considering the previous observations, I used electronics sympathetically to relate sound processing to the resonance idea. Moreover, the work focuses on the natural process of the vibration systems and the flow of energy through the resonant bodies. Consequently, this implied discarding electronic means related to audio synthesis or pre-recorded material to avoid introducing any foreign material that could disrupt the observation of the phenomenon. So the choice came to process the signal with a procedure related to the resonance phenomenon and the characteristics previously observed; I find the use of the delay lines well suited for such a task. As this is the fundamental building block for various digital audio operations, and its principle resides in the disturbance caused to the audio signal through the delay of the same audio signal. The flexibility is another compelling factor, as depending on the magnitude of time used; the delay lines can have different sonic results. In the case of the piece, I am using the delay lines in a manner that results in comb filtering.

The purpose is to add more sympathetic entities to the chain, avoid adding other vibrating systems in the chain of communication, and enable the manipulation of the possible sympathetic frequencies in these new nodes.
The use of comb filtering is possible with the help of a feedback loop in a delay line, and the output and the electronics are meant for a multi-channel system, implying the use of several iterations of the same process. As a self-referencing manoeuvre for this aspect, I choose to enable the exchange of information between the iterations of delay lines with the help of a feedback delay network. As a bonus, this also extends the resulting possibilities of using several delay lines simultaneously.

Feedback Delay Network Proposal

The design of the feedback delay network (Figure 2) proposal departs mainly from the feedback delay network toolbox proposed by Sebastian Schlecht (Schlecht, Sebastian 2020).

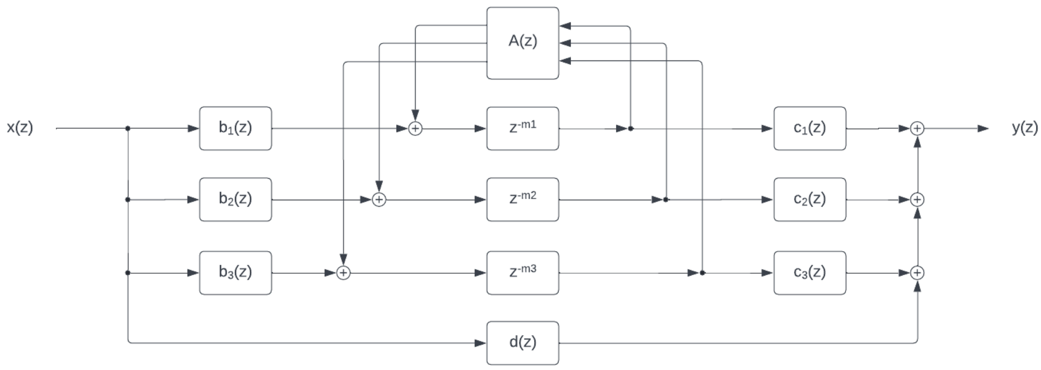

Figure 2

The model is intended for reverb designs, but I found the configuration practical and coherent. Furthermore, it brought the curiosity of transitioning between reverb and filtering.

The main difference in my model (Figure 3) lies in the addition of a mixing matrix for summing the signals at the end of the network and routing the outputs independently to different speakers. This enables the possibility of disjointing or joining the different iterations of the delay lines in a multichannel system.

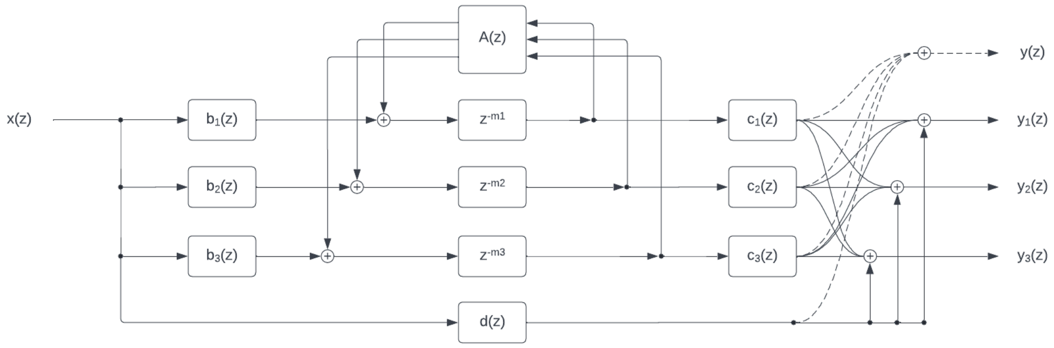

Figure 3

2.5 Spatialization

As space is an integral part of the idea, it was only natural to think about deploying electronics through a multichannel system. Nevertheless, with certain flexibility in mind, the possibility of performing is not tied to a particular system. This does not mean that I do not envision an ideal scenario for the reproduction of the piece (as I will describe), but I do not want to limit the interpretation of the piece to a specific site.

Ideally, I can output each delay line to one speaker. That would mean that each instrument uses a feedback delay matrix of 8 x 8. Each instrument would have eight speakers assigned to their respective matrix. A scenario where all instruments are present would mean having 40 speakers available for the piece's performance. As this is quite unrealistic, I thought of these delay line outputs as sound sources, and I treat them as speakers in a virtual space. The speakers in the space cannot move, so this result is coherent with the idea that not panning aside for the initial placements in the virtual space is used. Each source is static, as is a performer in a usual concert scenario.

As the delay lines could be more sympathetic to specific spectral configurations, depending on the delay time and sound input, some of the audio sources are more stimulated than others, thus having deviations in the way these sources are exited through the space at any given point. The static placement of the sound sources in the space is also thought to give a spatial reaction to the sound captured by the microphones and the gestures played by the instruments.

3. Composition of the work

3.1 Motivations and purpose

My primary purpose in composing a work for instruments and live electronics and going through the process of describing and observing the factors in play is mainly the possibility of bringing myself to understand ways that could facilitate and enrich my artistic practice. It also allowed me to filter results and therefore know which approaches to use and which not to. In short, it is a way to gain more clarity in my practice and further develop unity and coherence in my work. I always found it quite challenging to compose instrumental music with live electronics where the result feels manageable and the content completely subordinated to one another. Ultimately this is an aspect that I currently pursue in my artistic practice, most reflected in the attempt to self-contain the ideas and justify the materials' existence. This was a stimulating challenge to develop this aspect that interests me in my practice even further.

On the other hand, I also propose a modular composition, as mentioned at the beginning of the text. This may sound counterintuitive and against the purpose of self-containment of the ideas, as this characteristic dislocates and isolates the parts of the work. I have some reasons for this: first, it allows me to focus and observe individual parts of the work. Therefore, I can better understand their role in the totality of the piece and how they interact, their weight and meaning.

Second, it forces me to produce parts capable of sustaining themselves. No part exists without reason; it gives meaning to their exclusion or inclusion in the interpretation of the work.

Third, it references the scalability of the multi-channel system, as the electronics can also adapt the instrumental parts to have that capability. Moreover, it helps to equalise the relevance of the electronics and the instrumental parts.

Fourth, it gives even more weight to the re-interpretability and the emergent behaviour of the piece; what I mean by this is the unpredictable behaviours that could arise from any change in the system. This could be the change of space,

the number of speakers, the number of players or deviations in the physical states or qualities of the devices. This aspect is intrinsic to the reproduction of any piece of music. It is of great interest to me as this is the main reason for avoiding site specificity and providing solutions for adapting the piece to different setups. I found a similar interest in the phenomenon in Agostino Di Scipio's music. My work is less focused on this, but it is worth mentioning, as learning about his work has been of great use in making a more conscious treatment of material for this purpose.
Last, and for a more practical reason, it gives me more flexibility and chances to perform the piece.

As for the final output and delivery of the piece, I want to focus objectively on how the piece would be perceived independently of the theoretical intentions and conceptual motivations. The goal, in this case, was to make a composition where the electronics and the instrumental part could coexist and blend seamlessly. No clear hierarchy is meant to be heard, even if it exists between the instrumental parts or the electronics. I want both outputs to feel equally crucial for the functioning of the piece but not necessarily incapable of working without the other. As the main idea of the piece is resonance, I composed the music in a way that develops this further. In this regard, the purpose would be to strengthen further the focus on the resonant aspects of the music pragmatically and abstractly.

In the following sections, I will clarify the decisions and approaches I chose during the music composition to integrate the ideas and fulfil the objectives I had in mind.

3.2 Score and Notation

In the case of the creation phase, the use of the score has been of great importance. The score is meant to be accessible and explicit enough to observe all the parameters throughout the piece's duration. It is intended to be used not only to instruct the player how to perform the piece but as a guideline for building the electronics independently of the devices I made. I needed to keep the ideas across the different parts that constitute the work coherent and out of perpetual isolation. By the parts that constitute the work, I mean the programming of the devices, the music's writing and the sound's processing. It also pushed me to think about the parameters used in the score and, as a result, design the user interface (Image 2) that gives me meaningful information for different contexts and thought processes of the compositional planning. With this in mind, I pursued ways to facilitate the visualisation of the totality of the material and its relations in all layers.

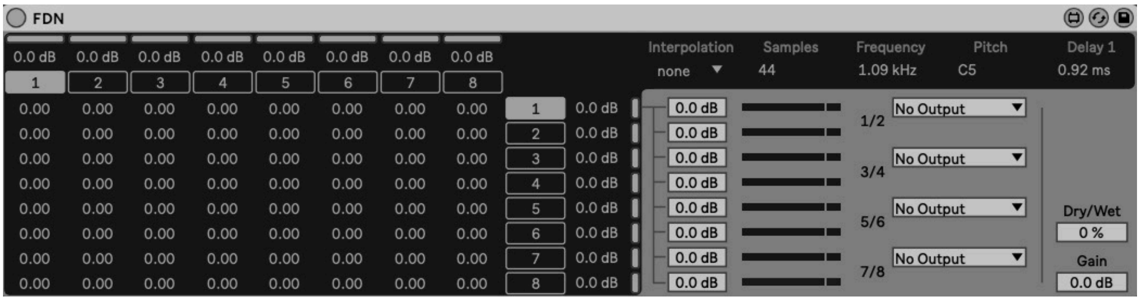

Image 2

For the representation of the electronics on the score, I chose to emphasise the audio processing parameters that are related to the attributes usually indicated in an instrumental piece's score: pitch, dynamics and duration. These are the pitch and dynamic. Generally, each parameter value is indicated in the measure bar where it needs to be set, and lines with arrows indicate a transition to a different value. If no line is present, the value is held until a new indication is written. In the case of the feedback delay network, the delay time parameter of each delay line present on the network is indicated in milliseconds, as it is the most ubiquitous way of working with delay lines. The device also reflects the equivalent values in samples, frequency and the approximate midi value in case that magnitude is more convenient for the work. The feedback parameter value is indicated in the usual amplitude magnitude in a range of -1 to 1 for the use of either positive or negative feedback in a specific position of the matrix. The matrix position feedback value to set is indicated in the name with the coordinate position x and y (Image 3).

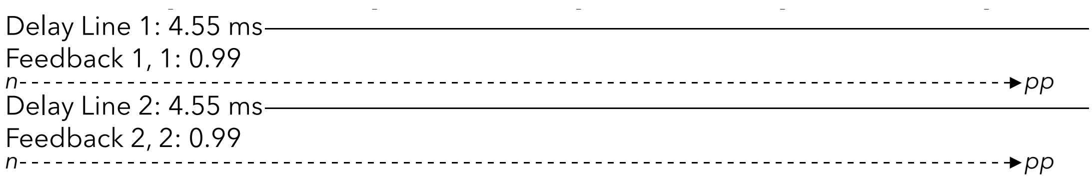

Image 3

For the dynamics (Image 3), I chose a slightly different approach; in this case, the values in decibels are not indicated in the score. I used the standard musical notation for dynamics and suggested mapping the values linked to the auto-gain device output. My reasoning for this came from the experience of setting up the piece in different spaces, as the loudness balancing is significantly related to the space, equipment, position, instrument and player performance. This needs to be adjusted according to the space where the piece should be performed, with the player's instrument performance as a reference. The standard musical notation for dynamics is better suited than the dB measurements for this perceptual indication.

On the other hand, for the current setup is not possible to adjust each dynamic value to a given value, so the instrumentalist also needs to adjust the performance according to the system's output. This is one of many approaches. Furthermore, I am still determining and developing either more precise or imprecise solutions to implement.

3.3 Modularity conditions, form, and musical material

Different approaches could be taken to create a modular work; the first could be composing the piece a whole and then separating the parts, or composing the parts separately and recombining them either by stacking the parts or concatenating them. In both cases, to truly be able to call the work modular and avoid the infinite stacking and concatenation of parts (an approach that I consider acceptable), the parts must be conceived with awareness of the relation they will have to the other parts and with the capability of working independently.

In the case of this work, I took the path of composing the ensemble piece with the consideration that all the parts would be recombined. For this, I set clear conditions for the initial conception of the piece, first to find and maintain relations on the parts and second to limit the number of combinations I could get from the recombination of the parts. The first conditions I considered are related to the tuning of the strings on each instrument of the quintet. Depending on the tuning of the open strings, the instruments are grouped. As the first 2 Violins are set in a standard tuning G, D, A, and E, these are considered a group (Group A). In the case of the Viola and the Cello, they share the same pitches, C, G, D, and A, but in a different register, the condition only considers the pitches, so this is established as another group (Group B). The Double Bass has a unique tuning in the ensemble, so it is part of a new group (Group C).
The functions of the groups (Figure 4) are the next: Instruments of the same group are synchronised in time, which means that their starting points are the same in any situation. The musical material on the two instruments present in the group is a mirror of each other.

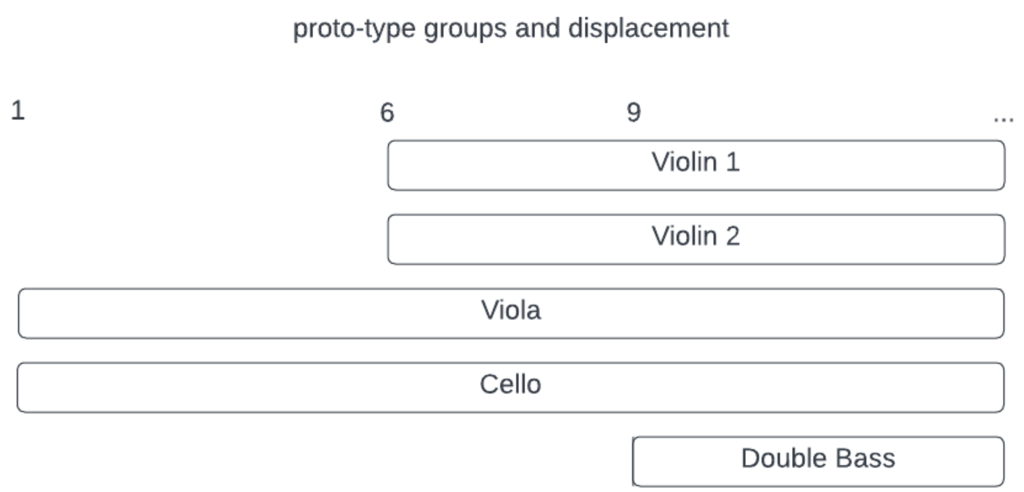

Figure 4

The choice of which group is the first to begin is determined by the combination of the sounds between the two instruments and the range they cover. They start first if the range they cover is less than the other group. In the case of group C, there is no combination of instruments, so this is not considered, and it determines this is the last to start. The displacement of the groups I related to the durations and proportions used for the construction of the music is precisely the beginning of any of the parts, so the first displacement is 5 bars, and the second is 3 bars. The displacement also affects the bow placement indication and vibrato transitions in the piece's first half; the starting bow position should be the same as where the bow position is in the already started group. Following the same logic, the senza vibrato to vibrato transitions should start roughly in the same sections of the piece for all the groups. The purpose of this is to maintain a relation of the sound production quality related to the structure of the piece at the beginning, as the positioning of the bow is meant to produce and promote instability in the spectral colouration of the sound and consequence, facilitate the stimulation of resonant points produced by the feedback on the delay lines.

Using displacements between the groups has implications for the form (Figure 5) and texture of the musical material. It implies the use of polyphony and contrapuntal treatment. It was only natural to reflect it on the state of the electronics where the settings of the delay lines transition in a manner of proportional canons through the duration of the piece. Similarly to the instrument grouping method, I opted to group the eight delay lines of each feedback delay network device (one per instrument) in pairs that reflect each other. As a result, is four groups of 2 delay lines each; each group makes a dilated canon of a section of the piece, starting at different points and running at different speeds. The first group of delay lines replicate the first section of the piece starting from the first section up to and through the last section of the piece. The second group does the same, starting from the piece's second section used for the canon. The following groups follow the same logic with their respective proportions. Between the first two sections and the last two sections, there is a section where all the gestures are re-synchronized in the case of the delay lines transitions. This is suspended till the third section's starting point. The third section's starting point resumes the process of the beginning to go to

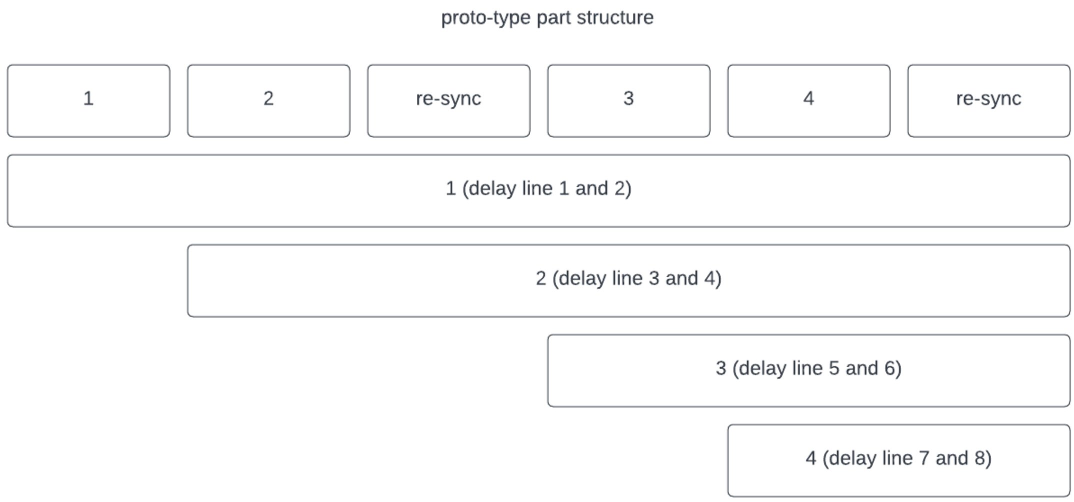

Figure 5

the end of the piece, where a new re-synchronization comes with an open-ended time to finish the piece.

For the most reduced musical material, the goal was to treat it in relation to the previous conditions mentioned; as previously explained, the piece results and is thought for the making of different combinations. I thought about using string instruments for this reason as I could explore the possible ways to simultaneously excite and interact with the different combinations of open strings against the closed strings and, consequently, the double stops. For example, in the part of the first violin, the process starts with a unison of the second string against the first open string that slowly transitions to a point where both open strings are played; the following motives are a consequence of the starting point and the direction of the intended movement. For the second violin part, the idea is the same but starting from the opposite strings (third and fourth) with the consequences of the impossibilities of achieving the same result in the mirrored process. I found the use of this idea appealing as the principle could be translated from the structural thought of a string instrument and subsequently to all the string instruments present. In conjunction with homogenous timber and similar instrumental characteristics, the transfer of ideas between the parts became a very intuitive process.

Conclusion

The practical result of observing, relating, and finding different places where self-referencing of the material is pertinent provided coherence. Having more awareness of the factors that I deemed necessary for the conception of the work resulted in a more consistent amalgamation of the ideas in different layers of the work. As mentioned, I have observed the unassociated tasks of composing a piece of this nature. Programming, sound treatment, and the elaboration of the score could easily cause the work to lose scope and deviate from the initial objective. Still, deviating happens, and it is a way to find new and unthought things, but it is undoubtedly less frustrating to have an anchor that helps to keep track of the things you are looking for in the process. In the end, what I wanted to investigate is how to achieve this and how to treat the layers within the same scope, as I find the use of electronics in instrumental music tends to feel like an afterthought in most cases, giving results that make the parts of the work unassociated. I do not criticise this as it may be the wanted esthetic result; I wanted to develop an initial framework that enables me to work in this respect. That I could easily apply to other pieces, expand and eventually become part of a core compositional criteria.

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