Intellectual Output 3

Guidelines for Instrumentalists and Orchestra Conductors

Intellectual Output 3
Guidelines for Instrumentalists
and Orchestra Conductors

Names of Authors	*Scientific Coordinators* Federico Bardazzi, Paolo Lippi *Editors* Federico Bardazzi, Andrea Bareggi, Marco Di Manno, Rebecca Huber, Anna Litvinenko, Paolo Lippi, Carla Giovanna Zanin *Contributions by* Orlando Aguilar Velazquez, Edoardo Angelini, Federico Bardazzi, Andrea Bareggi, Pietro Battistoni, Giacomo Benedetti, Giordano Betti, Luca Bimbi, Evan Buttar, Nicola Cavina, Elodie Colombier, Leonardo De Lisi, Marco Di Manno, Jean Marie Gardette, Rebecca Huber, Cecilia Iannandrea, Takako Kunugi, Paolo Lippi, Anna Litvinenko, Carla Giovanna Zanin
Leading Organization	**Heliosfero (The Netherlands)**
Version	**Version 2**
Use (external / internal)	**External**
Intellectual Output	**IO3**
Date	**28/02/2023**

Disclaimer

This document contains the Intellectual Output 3 (Guidelines for Singers, Vocal Coaches / Continuo Players, Directors, Choir & Orchestra Conductors) of the Virtual Stage project. Certain parts of it might be under partner Intellectual Property Right (IPR) rules, so, prior to using its content please contact the consortium head for approval.

In case you believe that this document harms, in any way, IPR held by you as a person or as a representative of an entity, please do notify us immediately.

The authors of this document have taken any available measure for its content to be accurate, consistent and lawful. However, neither the project consortium as a whole nor the individual partners that implicitly or explicitly participated in the creation and publication of this document hold any sort of responsibility that might occur as a result of using its content.

This project has been funded with support from the European Commission. This publication [communication] reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein. (https://europa.eu/european-union)

Orlando Aguilar Velazquez, Edoardo Angelini, Federico Bardazzi, Andrea Bareggi, Pietro Battistoni, Giacomo Benedetti, Giordano Betti, Luca Bimbi, Evan Buttar, Nicola Cavina, Elodie Colombier, Leonardo De Lisi, Marco Di Manno, Jean Marie Gardette, Rebecca Huber, Cecilia Iannandrea, Takako Kunugi, Paolo Lippi, Anna Litvinenko, Carla Giovanna Zanin.

Page 3 of 77 – Virtual Stage - Reference No:2020-1-IT01-KA226-VET-008970 – Erasmus+ Key Action 2 – KA226.
This project has been funded with support from the European Commission.
This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Index

Page 4 of 77 – Virtual Stage - Reference No:2020-1-IT01-KA226-VET-008970 – Erasmus+ Key Action 2 – KA226.
This project has been funded with support from the European Commission.
This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

1. Introduction

These Guidelines provide a detailed overview of the state of the art in remote teaching and training in the field of opera, with particular focus on the teaching activities of instrumentalists and orchestra conductors. We have analyzed the different approaches at various stages: before, during and after the pandemic. In order to pursuit this objective, we have based not only on the direct experiences of the partners involved in the Virtual Stage project, but also on an accurate survey via questionnaire addressed to more than 300 representatives of the sector (academic institutions, theaters, festivals, music associations, music schools, opera and baroque singing teachers, instrumentalists etc.) operating throughout the European territory.

The evidence shows a series of problems and needs, arisen during the pandemic, that can concretely open up to new opportunities beyond the specific emergency period. In other words, the search of alternative solutions represents a new digital paradigm with immense application potential for the whole sector, as well as a significant enhancement of good practices deriving from the contribution of technologies applied to musical activities (teaching, professional training, performance, recording etc.).

1.1 Lockdown experience

Before the lockdown restrictions, teaching and training in the field of opera were held almost always in presence, with little support by technologies.

What kind of technologies are we talking about?

Certainly not the technologies applied to the recording and transmission of musical activities and events that are usually present, starting from the last century, in the panorama and in the culture of the musician; the past months, which have prompted many people to search for new solutions, have revealed how technologies related to (social) networking and the self-processing / output of musical products were not part of the heritage of the classical teacher / musician.

We emphasize the term "classical musician" because the support of audio-video technologies is normally used in the context of pop music, jazz, etc.

Until the breakout of the COVID-19 pandemic, all the preparatory stages of the opera (learning, rehearse, practice, stage presence, costume and scene setting etc…) were undertaken in presence and people were used to meeting in large groups, working together for several hours, in long sessions that involved a considerable organizational and economic effort.

So, when we all found ourselves suddenly thrown into the pandemic era and the consequent restrictive measures, it became immediately clear that the learning and training activities in opera, as we had practiced them up to that time, were over.

Here a summary of the main problems we had to face:

- no access to live performance venues
- very often there was a suspension of orchestral and choir rehearsals, etc…
- very often the hiring of workers in the sector has been severely reduced: directors, set designers, technicians etc…
- in most cases it was not possible to attend music lessons in presence
- the approach to the NMP (Networked Music Performance) – due to synchronization problems – has   been mainly theoretical
- extreme difficulty in carrying out face-to-face auditions, tests and assessments.

1.2 The first response to the emergency

The musical world reacted to the crisis through a series of immediate technological solutions such as online meetings, NMP, streaming concerts and sometimes even a sort of synchronous activities, trying to test new possibilities for "playing together", also thanks to the experimentation of new apps and audio tools.

It is undeniable that financial resources reserved for culture are fewer and fewer, while costs for supporting the realization of the activities are increasingly higher. In order to invert this trend, new cultural policies are needed as well as considerable investments on the artistic and cultural sector. Besides that, it is possible to have strong support from technologies applied to teaching and professional training and, if possible, also to the performance in the opera sector.

This will have a positive impact in containing costs and above all in their optimization, with a clear improvement in the cost / performance ratio.

The goal of this project is to create a generation of new classical musicians who know how to use most of the great opportunities offered by new technologies. At the same time, the project aims to stimulate teachers to use technologies in a functional way, so as to increase all teaching activities and sharing of procedures and best practices.

1.3 Why are we talking about opportunities?

Starting from national and international experiences on how to deal with this new and unprecedented reality, in which face-to-face meetings were not possible or at least strongly limited, the challenge is to design and propose some effective procedures that teachers of musical institutions can apply to enhance and expand their teaching activities. It might seem too optimistic, but we think that several problems can be turned into opportunities.

The Virtual Stage work group has included into this project the various experiences gained during the months of lockdown, aiming to transfer what was initially an emergency need into a stimulus to increase digital skills not only in teaching and training, but also in the performance.

This analysis finally led us to consider how much these technologies could bring benefits to final users: students on one hand and audience on the other.

1.4 List of needs encountered during the stop of the activities in presence

We believe that all teachers of conservatories, music schools, operatic institutions and festivals etc. have got the need to continue to:

- give indications on the performance criteria
- give indications on the interpretation criteria
- assess students' performance and learning progress
- rehearse in groups
- work together, with regard to different roles and matches: singers and vocal coaches, singers and choir & orchestra conductor, singers and director

But how to deal with these new needs?

1.5 The experience we built on

Two main elements were taken into consideration and analyzed as follows.

1.5.1 The Survey

Since it was necessary to broaden our view beyond the team of researchers involved in the VS project, a survey was carried out that allowed us to investigate some aspects related to the use

of digital tools in the world of classical music at European level, specifically in the opera. To do this, we created the multilingual questionnaire which is described in the Output 1 (IO1) report, and which served as a further stimulus and study for the creation of these Guidelines.

1.5.2 The first project phase

Finally, a third element is linked to the work and discussion group that took place during the first phase of the project, including the Joint Staff Event held in October 2021. The group of experimenters / researchers was in fact divided into smaller groups: Singers, Vocal Coaches / Continuo Players, Directors, Choir and Orchestra Conductors.

The division into small sectoral groups offered the possibility to plan an important remote interaction for the following months, in order to significantly develop and deepen the project's research areas.

The groups have identified, each for their own area, a list of needs, problems, criticalities encountered during the emergency period, but more generally they questioned about how their activity can take advantage from a more widespread use of technologies.

All these aspects will be discussed in the following chapters.

VIRTUAL STAGE

Co-funded by the
Erasmus+ Programme
of the European Union

2. Guidance for teachers

We propose a guidance for teachers on how to carry out online virtual exchanges, establishing criteria on how to select the best digital apps, as well as the best model that can be activated in one's own context (exploiting, among other possibilities, the functionalities of online platforms). With this type of activity it will be possible for teachers to share training paths with partners in other countries inside and outside the European area.

2.1 Finding applications

This section aims to introduce several resources for applications for session, lesson and learning in the online music scene, especially focused on the sound part.

In many fields online education has been taking place for decades. Though it may not be the preferred medium, it has made it feasible for people to receive an education that would have otherwise not been possible, be it for matters of money, distance, time, or more recently, even a pandemic. The exponential advancements in technology in recent years have made these virtual exchanges increasingly more accessible. Now, the world of classical music training is catching up, using a multitude of platforms and apps to make music making and learning more accessible.

Music, like many other arts, has traditionally been always taught in person. Today, online teaching has become a reality, but does raise many questions. On a theoretical level, there are many ways lessons, rehearsals and concerts can function. On a practical level (teaching an instrument for example) however, it does present difficulties that live lessons do now. Learning to play an instrument is like learning a craft, something that requires specialized and personalized attention. However, though the thought of online music education may come with some resistance, it seems inevitable for it to head in that direction and there are many useful tools available that make it possible and as worthwhile as the live lesson learning experience.

In this section, research from interviews with teachers across Europe sharing experiences with online teaching gives possible solutions and platforms for making online music learning possible. Below is collected information on giving private instruction, group instruction, making tutorials, the preparation for online teaching, and a list of recommended digital apps and platforms that can be used for this virtual exchange. The main contributors, Orlando Aguilar Velazquez, Jean

Page 10 of 77 – Virtual Stage - Reference No:2020-1-IT01-KA226-VET-008970 – Erasmus+ Key Action 2 – KA226.
This project has been funded with support from the European Commission.
This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Marie Gardette, Rebecca Huber, Anna Litvinenko and Takako Kunugi have together taken on the exciting challenge to explore the possibilities for the future of musical online learning.

Below, the most popular methods of online teaching are described, as well as the apps most frequently used for each method.

Lectures/Theoretical Lessons

In many cases, teachers are using apps like Microsoft Teams, Skype and Zoom to teach online classes in a lecture format. It's easy to share one's screen on these apps, speak to the students as a group or one on one and to form break out rooms where smaller groups can work together. In these kinds of lessons, it's also possible to play live, watch and listen to prerecorded videos and even manage master classes, though the connection speed can impact the work. It's also useful to record these sessions for future reference, which is a benefit that live lecture formats do not have.

Solo instrumental Lessons

Private lessons have proven to work well online, except for being able to always judge the quality of sound coming from students. For these lessons, the most frequent apps used were Skype, Zoom, and Microsoft Teams.

Rehearsals and group performing lessons

There are more difficulties which arise with multiple students playing at the same time, but as technology continues to improve, more methods of teaching are becoming possible. Some of the most popular methods used today are Jamulus and Zoom.

Tutorials

Because of variances in connection speed and playback in online live lessons, tutorials are instrumental for online music learning. Not only do they allow students access to quality material by the teacher, but they also help solve some of the issues that can arise with online encounters due to lack of visual definition, sound quality, or a poor connection. Though they are not meant to be used in lieu of the lessons, they can be used as complementary tool to the lessons that helps reinforce what is taught in the lesson. These tutorials can be personalized to a specific student or can be catered to a larger community of students with general questions and problems.

Depending on the purpose of the tutorial, different processes can be used:

- Demonstration of certain techniques or specific concepts
- Demonstration to help learn a piece/passage
- Help putting together a work with another instrument

Some of the apps which work best for tutorials are iPhone and computer recording video and audio recording apps, YouTube, and software such as iMovie and other video editing apps.

APPS AND TOOLS

There are many platforms that can be used for the above exchanges which continue to grow. In this section, many of the most popular apps are described, including FaceTime, Google Meet, Skype, WhatsApp, and Zoom. The apps described are the ones which currently appear to be most popular with online music learning, according to the teachers interviewed for this research output.

Zoom

Features: Ability to use "original sound," which facilitates teaches and students to listen with a more realistic sound

Sharing screen - this not only facilitates the exchange of documents, but it also allows both the teacher and students to write and make notes on the documents. This feature also allows both parties to share audio and video clips. This is an easy way to show musical examples as one gives a lecture.

White board - this feature enables teachers to write and draw things easily on the screen in order to give visual examples of what is being taught.

Google Drive

This platform is an excellent tool for teachers and students to share documents. One can easily organize all files (videos, photos, documents) into different folders, using as many subcategories as needed, in order to make the clear and simple to use.

Powerpoint

Musicians can organize musical conferences and lectures using PowerPoint software: it's possible to put musical videos on the slides, photos of instruments and artists, explanations, and exercises.

Turboscan

This app facilitates the scanning of documents. It is a very simple to use and simplifies the process of digitizing books, scores, etc.

Features:

- Easy to crop
- Easy to convert to a PDF file

- Easy to send as an attachment, either through airdrop, email, or messaging apps

Genius Scan App

This app is used for scanning documents from a phone or tablet camera

Dropbox

Useful service for storing and transferring files to other people or devices. Free up to 2GB storage and transfer size. This is also a helpful app for sharing materials like scores, recordings, and planning materials.

WeTransfer/Collect

Useful service for storing and transferring files to other people or devices. Free up to 2GB transfer size

Pages/Word

These basic word processors that allow teachers to create their own documents/ handouts and exercises for their students. This is especially useful in personalized classes, where each student has different learning processes. These word processors allow its users to insert figures and photos, create charts, highlight important information, etc. It is also simple to turn these files into PDFs, which allow for the format to remain the same for students using different kinds of computers.

Phone Camera

Phone cameras are useful in order to record didactic videos for students. It is not necessary to have expensive materials to create a functional video. It is more important to have adequate lighting, to maintain an adequate distance from the camera, and to use proper angles in order to capture the best shots for students to have a clear demonstration of the desired result. Leaving a moment of silence before and after the demonstration is done is useful when it comes to editing the video.

Photo/video editing apps (such as Photos or iMovie)

It is sufficient to use a photo-editing app to edit the phone-made videos and make them fit for students to use. These apps can help trim the videos to the desired length, to adjust the lighting and sound quality, etc.

Procreate

This is a graphic editor app that can be used on iPads. It is very useful when devising exercises. It is easy to export the document and share it with other devices.

Cleartune

This app is optimal to work on intonation. One can easily adjust the pitch and the temperament.

Logic

Logic is a program that facilitates the manipulation of sound. This can be used to create audio tracks for students. One can record directly into the program with microphones, or one can import audio files into the program. Logic enables users to adjust pitch and intonation, timbre, speed, length of the track, and to layers different recordings, create minus ones, to change the make cuts, etc.

Pro Metronome

This app is very convenient for teaching rhythm since it has many features.:

- Subdivisions
- Polyrhythms
- Tapping feature that allows to calculate the BPM

Pulse

Metronome app that allows users to bluetooth sync their metronome with other devices with the same app. It allows everyone in a rehearsal to hear and have their own metronome.

Teoria - https://www.teoria.com

This is a website that helps musicians practice the recognition of interval, chords, chord progressions, melodic and rhythmic dictations, among other things. It's a great tool for students to practice the skills that are taught in solfège and ear training classes. This platform automatically calculates the score, which is a useful way to analyze the progress of the student.

YouTube

This is a platform for sharing audio and video recordings. Is an excellent tool since it stores all sorts of material ranging from instructional/educational videos to historical recordings, and live performances of the great masters. It is also a great platform for teachers to upload their own material to share with their students. This platform is also easy to share since it does not require a subscription in order to see the material. With the videos, one can also see the technical aspects used by the musicians during their performances, especially bowings and fingerings. There are

also many documentaries about music or musicians, tracks of online masterclasses and online lessons available.

ForScore

This is a versatile app for storing and editing scores. It includes various options for preparing scores, including jumps between pages. It is easy to transfer libraries between devices. Requires purchase, however free alternatives include IMSLP and Piascore

Google

Google is a great source to find broad information about music concerning composers, musicians, instruments (Wikipedia for example), specific online music and history of music websites.

Jamulus

This is one of the most innovative new platforms enabling performers to play together at the same time, with almost no delay. This makes it possible for musicians around the world to work together, regardless of distance.

Grove Music Online and JSTOR

They are excellent and reliable sources for teachers and students to find research-based information on any given subject.

IMSLP

Enormous free library of music scores that allows users to download scores and edit them in a basic way and perform

Enote: Intelligent Sheet Music

Brand-new app that just came out of beta testing. Has a growing library of scores that are possible to edit fully, including transposition and arrangement.

Henle Library

This App is offered by the music publishers Henle. It is free, but scores require purchase. It also allows users to purchase, edit, print, and share scores published by Henle.

MuseScore

Free app that allows users to create, download, and share their own scores.

PageFlip Firefly

Reliable dual control pedal with a variety of settings and options. It is equipped with lights for easier use during performances. It is a silent instrument with Bluetooth and USB connections. It is battery-powered.

Deezer/Spotify

These platforms give many recording versions of a same musical piece which musicians can use for reference. It's possible to easily compare the musical ideas of the different artists for the same piece (tempi, styles, instrumentation, etc.). It's also the opportunity to discover some composers and musicians.

Doodle

An app which is used to organize timetables of rehearsal

2.2 Which applications are available as open sources?

There are several open sources available such as Jamulus, Jamkazam, FarPlay, and Jamstud.io.

	Jamulus	JamKazam	FarPlay	Jamstud.io
Connecting system	Client Server	P2P ClientServer	P2P	P2P
Requirements and Recommended conditions	Windows macOS 10.12 or lower Linux, Recently released for Android Ethernet Wired headphones A reasonable audio device, sound card and/or microphone	Mac OS X 10.8 or higher, Windows 10 or higher. Ethernet, Broadband Internet service with 1Mbps uplink bandwidth for real-time online sessions	MacOS 10.13 or higher, Windows 10 or higher. Ethernet Wired headphones	MacOS 10.13+, Windows 10, Linux A stable and reliable internet connection audio interface supporting

		External audio interface		44.1KHz or 48KHz

2.3 How is the trend of apps for online music sessions?

Google Trends shows, after the pandemic online music activities became very trendy, and transition of each application's popularity.
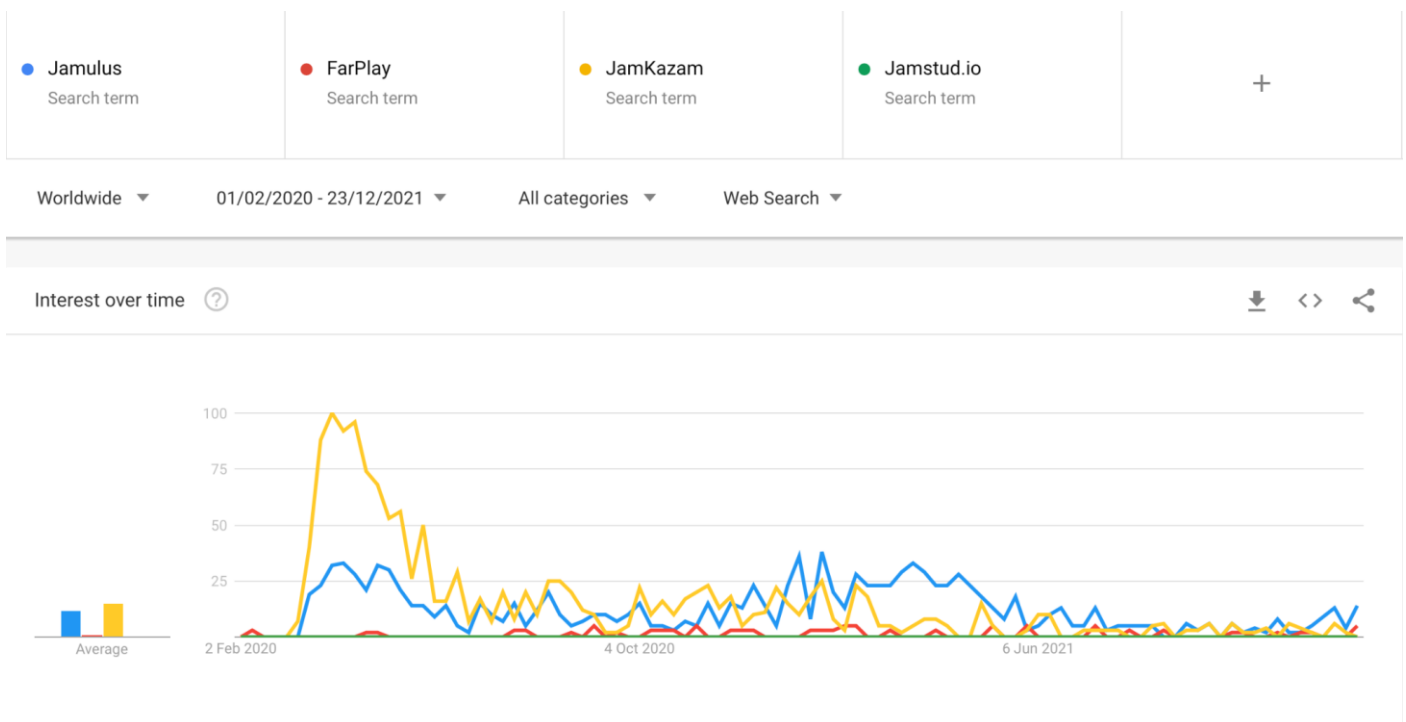
2.4 What type of communication system are there?

There are two major methods of communication. The first one is P2P and the second one is called Client Server system. Below I would like to explain their features and characters.

2.4.1 Client Service

In the Client server model, the server functions as a data manager, and all the information is managed at the centralized server, although there is a disadvantage of a downtime server, however as advantages are clear address of information, consequently less risk of data loss, and keeps high security.

2.4.2 P2P

P2P is the abbreviation for Peer-to-Peer, a communication technology and software that allows many clients (such as smartphones, computers) to share data directly with each other without the need for a server.

("Peer" means terminals that share information on an equal footing. And a terminal which is connected to a network is sometimes referred to as a node. The network in which nodes are connected to each other using P2P technology is called a P2P network.)

Pure P2P connection is the original P2P system. Let each device be connected directly to each other and share information.

HybridP2P system is the server added to the P2P network. Yet clients are connected directly to each other, and data of clients is stored at the server.

Some nodes are selected by their excellent processing capacity and stable connection lines as Supernodes. In the case of HybridP2P system, data is managed by indexserver, on the contrary, the Supernode P2P system the supernodes are responsible for managing the data information which are distributed on each node.

2.4.3 The present situation of P2P networks

Squeezing the bandwidth of other users and their security reasons, a lot of university, educational institutes and companies ban using the P2P networks on the network at their building. Also some internet provider companies change transfer restrictions and speed limits when a user is using a P2P system application.

2.4.4 Advantage of the client server system

Centralized management and backup on the server. The server controls access, resources, and data integrity to prevent disruption by unauthorized programs or clients on the network. The

server is able to control all the accessibility, also the server can control the right of access by each node.

2.4.5 Advantage of P2P system

P2P systems allow all the devices to connect to each other without through a server, data and load distributed on each device, therefore the P2P system saves time to share the data.

2.4.6 Conclusions

We hope that the above text will give you some insight into the technology behind the application we are using, and that knowing the characteristics of these systems will give us more options, ideas and further possibilities for our online music activity. You can use a centralised and secure In client-server system, or a system that prioritises speed on an equal footing, such as the P2P system. It is very important, both for teachers and students, to know how the information we handle is managed, provided and restricted.

3. How to use distance learning

In this section, we will look at how to use distance learning in the opera's training programmes. Here, didactic methodologies based on the use of digital technologies are linked to the exploration of innovative and interdisciplinary content to be integrated into training programmes, including significant examples and case studies, chosen to exemplify the different aspects and implementations of the didactic model developed in the project.

3.1 The "Orfeo" case study: distance/blended rehearsals and technological performance

Multitrack Recording

This recording methodology is inspired by over half a century of experience in the pop music industry. Unfortunately, in Classical Music there is often mistrust of innovation and this precludes the possibility of experimenting with innovative techniques and methodologies for the sector even if already experimented in contiguous repertoires. For this reason, Orfeo's experience was a milestone in the proposal of the Virtual Stage method also in the specific aspect of recording.

Multitrack recording allows you to simultaneously use sample sounds of historical instruments performed on midi keyboards or EWI and an instrument / voice with microphone. This allows you to have eg. 3/4 separate tracks which can however be played and recorded simultaneously.

It is necessary to have the click for the mensural passages before the beginning of the piece and also during the entire performance.

It is advisable to record harmonic and grave instruments first and then melodic and acute instruments.

This also allows you to select the instrumental arrangement in some cases in the post-production phase.

If intonation problems occur, it is possible to use tools such as Melodine, while for the synchronous it is possible to align the different voices / instruments during the editing phase.

Multitrack recording is crucial for the realization of tutorials and partial playbacks with the flexibility of being able to add / exclude the desired voices from time to time.

Partial Playbacks

This mode is inspired by pop music concerts and involves the interaction between pre-recorded sections and live musicians. For *L'Orfeo* partial playbacks were used for choir, cornets, trombones, percussion. The result is extremely immersive from the sound point of view and allows the public, especially in open air venues, to perceive and enjoy the impact of the choral and orchestral masses.

For the interaction of live musicians, 2 modes were tested:

1. Director, Singers and Instrumentalists all with headphones and clicks only at the beginning
2. Only the conductor with headphones and clicks throughout the song.

L'Orfeo, a Virtual Stage milestone

In the previous section we have discussed a specific experience, the staging of *L'Orfeo* by Claudio Monteverdi, in order to illustrate the use of a technological approach in the training process finalized to the recording of an opera. In this context, the recording must be understood as a multimedia product (both audio and video) which serves multiple purposes: the release of a cd, the publication on Youtube, and the preparation for the performance itself. To achieve this goal, two main tools were adopted, i.e. tutorials and multi-track recording.

This part is strictly connected to the above, as it refers to the same case study, but this time the focus is on the rehearsals and the performance of the opera, which took place in Florence in June 2021. Our report aims to highlight the differences between a traditional staging of this great masterpiece and a "virtual stage" version, which required a considerable effort from "classical" musicians who are certainly not accustomed to technological devices in their everyday practice. Besides singers and instrumentalists, the show included also a dance company, an artistic video projected on a big screen and functioning as backdrop, and an actor playing Dante Alighieri: the presence of the latter was motivated by the affinity of the great poet with Orpheus, as many explicit and implicit references to this mythological figure can be traced in the *Divine Comedy*.

Despite its experimental character, the performance was highly satisfactory: however, some flaws emerged, and it is important to consider alternative solutions in order to make future live experiences increasingly more enjoyable, both for the performers and the audience. The difficulties encountered during the concert will be briefly discussed at the end of this chapter.

L'Orfeo is universally renowned as a milestone in the history of musical drama, as it combines the traditional elements of the Renaissance era with the newly established vocal style, the so-called *recitar cantando*. Unlike the two other surviving titles by Monteverdi, *Il ritorno di Ulisse in patria* and *L'incoronazione di Poppea*, which were composed much later, *L'Orfeo* envisages an

extraordinary variety of instruments of all sorts, whose distinctive sound is masterfully employed by the author to portray the different worlds represented in the story. For the purposes of this analysis, it is worth reminding the instrumentation and the characters of the opera; in fact, the first concept underpinning our arrangement is **the use of a smaller orchestra for the live performance, as many of the instruments had been pre-recorded and their presence is only virtual**. Below the list according to Monteverdi's 1609 score:

Table 1

ROLES	INSTRUMENTS
La Musica (Prologo) Orfeo Euridice Coro di Ninfe e Pastori Speranza Caronte Coro di Spiriti infernali Proserpina Plutone Apollo Coro di Pastori per la moresca	2 harpsichords 2 double-basses 2 five-part string ensembles (*viole da brazzo*), each comprising two violins, two violas and cello 1 double harp 2 chitarroni 2 organs 1 regal 3 bass viola da gamba 4 trombones (sackbuts) 2 cornettos 3 trumpets 1 recorder

As already stated, the orchestra used for the concert was far smaller than the one displayed in the table above. So, how were the missing instruments replaced? The answer is: through the use of **sample sounds**. During the recording sessions, each musician involved in the project was asked to play the whole range of his/her instruments, note by note. Also this process is consistent with the philosophy of the "virtual stage" approach, because the sounds were not taken from random libraries on the web, but from real musicians who virtually interacted with their colleagues playing live. The sounds obtained - once proven to be reliable and acceptable in terms of quality - were recorded, transferred to a specific software and adjusted according to the meantone tuning at 440 Hz. The samples could now be played by using following equipment:

- a MIDI instrument. Besides the keyboard, another device was chosen, the EWI (Electronic Wind Instrument), a device capable of reproducing the sound of other instruments through a simple USB interface;

- a laptop with multiple USB ports;

- a software enabling performers to run sampled instruments. For this purpose, all the musicians who were supposed to play in presence were required to download KONTAKT, the most widely used host platform developed by NATIVE INSTRUMENTS;

- an audio interface connected both to the computer and to the keyboard;

- a pair of earphones connected to the central mixer and the speakers.

The table shows the distribution of the instruments in the live performance. As can be noticed, only ten musicians were physically present at the concert (the recorderist played also one of the two EWIs), while the other ten could be virtually heard through the MIDI instruments. For the remaining strings, which are excluded from this list, the partial playback was used.

Table 2

ACOUSTIC INSTRUMENTS	MIDI INSTRUMENTS	SAMPLED INSTRUMENTS PLAYED BY MIDI INSTRUMENTS
recorder 2 violins 2 chitarroni	2 EWI 4 keyboards	trumpet recorder cornetto sackbut cello double bass harpsichord organ harp regal

After this necessary clarification about the composition of the orchestra, the use of sampled instruments and the interaction between physical and virtual players, we are now going to provide a thorough account of the rehearsals and the performance.

Rehearsals

The rehearsals, which lasted one week, were held in a large indoor space, and involved all the artists in presence: instrumentalists, singers, dancers and one actor. Besides them, a technological project like this required a staff of skilled professional technicians - mostly sound and video engineers - in charge of various tasks. More precisely, they had to: 1) check that all the softwares were correctly installed on each laptop 2) make sure that all the MIDI instruments were properly connected; 3) regulate the volume of all microphones and individual earphones; 4) start and stop the playbacks; 5) run the video on the screen.

In this kind of performance, the hardest challenge is to play and sing along with the base. To achieve this goal, the most obvious expedient is the introduction of a click sound to mark the beginning of the piece and to ensure synchronicity. The musicians had already become familiar with this method during the individual recording sessions, since each of them was supposed to play his own part after someone else. The fundamental difference is that, while the recording makes it possible to stop and repeat many times, until the result is perfectly acceptable, the rehearsals force the performers to link one piece to the following, without any interruption. For this reason, a member of the technical staff capable of reading the musical score is assigned a very delicate task, i.e. to indicate to the sound engineers the exact moment where the click should start: not too early, otherwise the echo of the final note drowns out the click, nor too late, which would result in an unnecessary break between two sections. Any minimum inaccuracy may be dangerous and alter the natural flowing of music.

In addition to synchronicity, the second main difficulty for musicians who have never experienced playing with earphones and microphones is the regulation of volumes. One one side, it is essential to hear the click and the playback throughout the whole section; on the other hand, the base must not be too loud, as this might negatively affect the production of his own sound. This might be really frustrating for singers, for whom the perception of their voice is the first and foremost condition to the act of singing and consequently to a good interpretation.

The third difficulty related to such an innovative model regards the MIDI instruments and the use of KONTAKT. Before and during each session, although the players are constantly supported by the technical staff, they are responsible for a set of crucial operations:

- check the audio and MIDI settings of KONTAKT. The selected MIDI channel must be the same for all the instruments loaded. In the audio options, the proper device (audio interface or built-in microphone) must be selected;

- the platform enables the simultaneous upload of two or more libraries of sample sounds: when switching from one instrument to another, it is necessary to mute the instruments that are not being played!;

- apart from the general volume regulated by the sound engineer through the central mixer, each musician should set his/her own volume on KONTAKT.

In light of this account, it should be clear how a musical production based on technology and a virtual - or semi-virtual - approach poses new challenges to all the artists involved. However, in respect to singers, the MIDI instruments are charged with various additional tasks which require not only concentration, but also readiness and flexibility.

Performance

In a virtual stage performance, a limited number of musicians covers all the instruments in the score. As for the present case study, the structure of the orchestra is shown in table 2.

While the rehearsals took place indoors, the performance was held in a beautiful location outdoors. Obviously, the different acoustics must be taken into consideration by the sound engineers when placing the microphones and regulating the volumes.

Unlike the instruments, **all the singers playing individual roles were present at the performance**, but only two of them appeared on the stage, wearing a headband microphone: La Musica in the prologue and the protagonist, Orfeo. The others were standing all around the circular stage, dressed in black and unseen to the audience, except when they had to sing. The choruses were sung by all singers with the support of a pre-recorded base.

The orchestra was also positioned around the stage, and each musician was provided with all the necessary equipment: microphone, headphones (for everyone); laptop and audio interface (only for MIDI instruments). In the backstage, there was the workstation from which the technical staff could control all the operations described in the previous paragraph.

Although it might seem superfluous, something must be noticed regarding the playbacks. First, during the playback section the live instruments are not inactive - it would be terrible to see an orchestra or ensemble standing still while recorded music is being played! On the contrary, the live music has to overlap with the base in order to create an extremely powerful effect of "tutti" as well as to preserve one of the main characteristics of early music, i.e. spontaneity of expression and improvisation. Consequently, this method can be applied only to some parts of the opera, where the rhythmic stability allows for a reasonably safe interaction without going the risk of asynchrony. Which are these sections? With reference to *Orfeo*, these are: the initial *toccata*, all the choruses and sinfonias and the final *moresca*. For all the other parts, namely recitatives, duets and trios, the playback is not applicable, as it would be totally unnatural for singers to be tied to an unchangeable version, while they need an accompaniment that respects breathing and rhythmic freedom.

4. The distance assessment of students' performance and learning progress

All researchers' contributors were divided in families of instruments: strings, winds, keyboards, percussions.For the past 2 years, music students around the world have had to drastically change their learning process in the wake of the covid pandemic. During this time, many new platforms have been utilized by teachers and students, with varying results. This section will show an overview of several of the most popular apps and platforms being used as a summary of the outcomes of various methodologies which were used by teachers and students across Europe and the world.
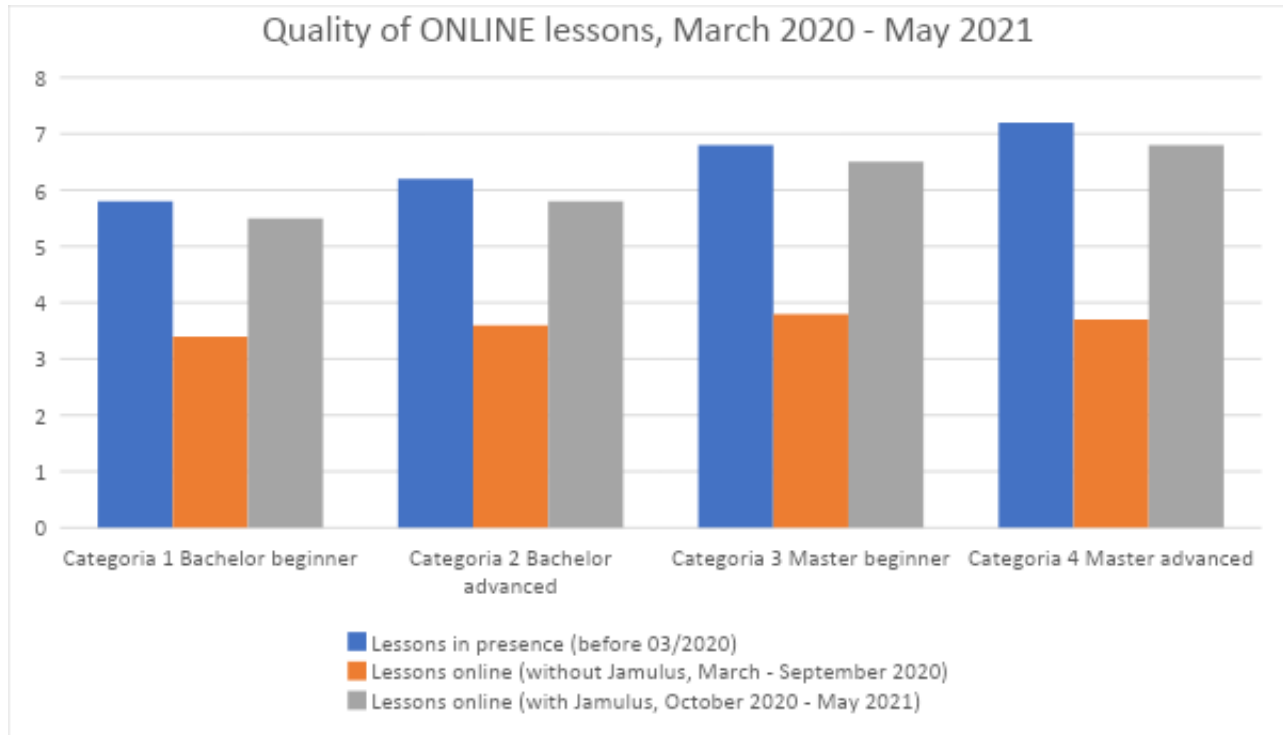
The main applications that were used by the majority of teachers and students who were interviews used Microsoft Teams, Zoom, Moodle, Skype, Whatsapp, Jamulus, imslp, PowerPoint, YouTube, and iPhone video recording tool.

4.1 Experimentation

The experimental part in Networked Music Performance, contextualized in Virtual Stage project, was carried out in two different music environments: the pre-professional higher education environment (License and Master Art Song Interpretation) and professional training (constituted music ensemble training).

4.2 Pre-professional training in Art Song Interpretation

The experimental part, from the pedagogical point of view, was carried out by Leonardo De Lisi, professor of Art Song Interpretation at Conservatory Luigi Cherubini of Firenze (Italy) during pandemic lockdown in Italy (March 2020 - May 2021). The amount of the collected data is not sufficient for supporting a full statistical analysis; however the experimentation provides guidelines and trends in the use of Networked Music Performance in the context of Virtual Stage project. This guideline includes a holistic scale of evaluation (for teachers and students) of the quality of the online lessons compared to the presence lessons.

Quality of ONLINE lessons, March 2020 - May 2021

Legend:
- Lessons in presence (before 03/2020)
- Lessons online (without Jamulus, March - September 2020)
- Lessons online (with Jamulus, October 2020 - May 2021)

Survey on a group of 24 singers from the Art Song Interpretation "Musica Vocale da Camera" during pandemic lockdown (March 2020-May 2021).

Data: evaluation of academic results (teacher) and appreciation feedback (students) in three precise periods

1. Before lockdown (before March 2020): lessons 100% in presence
2. During the national lockdown (March to September 2020) without the use of Jamulus: evaluation of the online lessons (100 % of the remaining scheduled lessons for academic year 2019-20)
3. After the national lockdown (from September 2020 on) with the use of Jamulus: evaluation of the online lessons (50-60 % of the scheduled lessons for academic year 2020-21)

Period of Survey: Dec. 27, 2021 – Jan. 22, 2022

Definition of the survey group:

24 singers of 4 different academic level

1. Bachelor, beginners (1st/2nd year): 7 students

2. Bachelor, advanced (3rd year): 5 students
3. Master, beginners (1st year): 6 students
4. Master, advanced (2nd year): 6 students

Scale of evaluation of academic results (teacher)

0 – 1   totally negative (no results, sometimes even sort of a regression to a less advanced level of performing skills: NO pass)

1 – 2   very poor (only a minimum progression, lack of organization and many delays in bringing to conclusion the preparation of the assigned work, many mistakes in the evaluation tests, incapable to advance to next level: NO pass)

2 – 3   poor (even with some progression the students show evident lack of the required skills in their advancement to next level: NO pass)

3 – 4   sufficient (the students meet the basic requirements in their advancement to next level, yet showing some difficulty and some mistakes: PASSED 18/30)

4 – 5   good (successful performance of the evaluation tests with good results and only some mistakes: 24/30)

5 – 6   very good (very successful performance of the evaluation tests, with almost no mistakes: 27 /30)

6 – 7   excellent (almost perfect performance of the evaluation tests, no mistakes and exact execution of all required tasks: 30/30)

7 – 8   exceeding expectations (absolutely perfect performance of the evaluation tests, bringing up some very personal and interesting contribution from the students: 30/30 cum laude)

Scale of evaluation of appreciation feedback (students)

0 – 1   totally negative (I don't feel I could learn anything during the lessons, even I have the feeling I got more confused about my performing skills, I am stressed and preoccupied that I will not pass the evaluation tests)

1 – 2   very poor (I did only very small progresses during the lessons, and I still have many doubts about my performing skills and how to get better in my singing, I am a bit preoccupied I will not pass the evaluation tests)

2 – 3   poor (I did learn what I was expected to, but I don't feel I can really reproduce those same results on my own, I need to repeat this same lesson in order to fully understand

what the teacher asks me to do, I am sure that need much more lessons in order to pass the evaluation tests, I feel rather preoccupied)

3 – 4   **sufficient** (I feel I have learned something and that I can reproduce the same results on my own, yet I doubt about some details that I couldn't catch at the lesson, and I don't remember well some other parts: yet I feel quite secure about being able to pass the evaluation tests because I can count on my basic skills)

4 – 5   **good** (I feel secure and positive about what I learned today, I can reproduce the same results on my own and my performing skills are much better than last week: I get some good feeling about being able to pass my tests and I look forward to my next lessons to feel more and more secure in all my next performing events)

5 – 6   **very good** (during the lesson I was able to do something that I wouldn't have been able to do on my own, I feel full of positive energy and willing to progress: I am sure I will pass my tests with a high mark; I am really looking forward to my next lessons and performing events)

6 – 7   **excellent** (I am euphoric about the lesson I have just had; I did everything my teacher asked me to do and I got enthusiastic feedback from him/her: therefore, I feel that my performing skills have advanced so much in the last few months that I can expect the highest marks during the evaluations tests)

7 – 8   **exceeding expectations** (this was the best lesson in my life! My teacher told me that I have reached all the planned goals and advanced even further!)

The students were asked to evaluate the "quality" of their lessons during the three precise periods of this study, mostly concentrating on their feeling of study "fulfillment" or "frustration" about the actual results. The teacher collected his personal notes after the lessons and the marks of the various evaluation tests done before and during the pandemic lockdown and blended them with the students' survey.

As a general result, it clearly strikes that before the extensive use of Jamulus the online lessons were often unsatisfactory or just sufficient compared to the previous good or very good achievements. The most important problem being the latency that caused a reduction of performing skills in both the teacher and the student. As soon as Jamulus became a substantial tool in the online teaching methods (together with the enhancement of other digital skills, such as a better Wi-Fi or internet connection, the extensive use of both plugged-in microphone and speakers) we noticed a dramatic change in the quality of the lesson and much better results in the evaluation tests. We can point out that the more advanced students' reaction to the new tools reflects the better situation of the pre-pandemic period, therefore confirming that the quality of the online lessons went back to an almost normal situation, on a trend similar to those

in presence. On the other hand, the degradation of both quality and results during the pandemic lockdown in the online lessons (without the enhancement of the digital tools and the discovery of the Jamulus application) clearly shows some almost equal results among all four groups. When before the pandemic the general level would settle between 5-6 (good) and 7-8 (exceeding expectations), those 6 months under strict national lockdown (100% lessons online) caused the general results to a dramatic drop in the 3-4 (sufficient) level: lessons and evaluation tests showed to be "just" sufficient, somehow canceling the possibility of excellence even in the most advanced students. As soon as Jamulus came in, the general use and when we were allowed to blend online lessons with others in presence (40-50%), the quality of the academic work jumped back to a pre-pandemic situation.

4.3 Non-performing classes

When teaching lecture format classes, Zoom and Microsoft Teams were used the most often of all of the various applications available. Some teachers used PowerPoint and gave traditional lectures with slides, while usually also incorporating some links to sound examples from sources like Spotify or YouTube. There were also some teachers who used multiple mediums within a lecture, for example combining a PowerPoint lecture with mini masterclasses, made with pre-recorded videos. In the lecture format, there is still room for online interaction and teachers can make breakout rooms for smaller groups of students to work together.

In both Zoom and Microsoft Teams it's possible for educators to share sound and video slides of the "main" computer with people who follow from their own computers. It's also possible for students to share their screens so that their work can be seen by the whole class as well.

Another useful aspect of both Microsoft Teams and Google Classroom is that one can share assignments, extra information, recordings, scores, and even chat when there are questions from students. Students also have the ability to upload their assignments and keep track of their work and assessments.

For these types of online lecture classes, the level of engagement from the students was high, though sometimes it's difficult to know what their reactions are, especially when presenting PowerPoint lectures and they many times will turn off their cameras. Finding a good use of timing so that one doesn't speak over the other also proved challenging. Groups varied in size dramatically from 2 to 50 and the size of classes impacted the overall assessments from students.

4.4 Individual lessons

Many of the teachers who were interviewed for this output were not accustomed to teaching individual lessons online until 2020. At the beginning of the pandemic, a variety of apps were used such as Zoom, Skype, FaceTime, and Google Meet. Some of the first issues that arose were camera and sound speed issues. There were moments when a student would play and it would sound as if they were rushing or slowing down, but it was the speed of the internet that affected the performance, not the player. Microphones also made a difference as many students were using phone or computer microphones and the quality depended on the equipment being utilized.

There were many people who used FaceTime or Skype for a while, but several issues arose. One problem was the sound quality of the lessons. Many times the volume would change in a lesson, and sometimes it became difficult for the student to hear when the teacher demonstrated something his or herself. When the lessons were live, there were also many issues with the recordings speeding up or slowing down suddenly and it was difficult to discern whether that was caused by the slow connection or the player.   It was also nearly impossible to practice tuning or dynamics because playing a drone or with a harpsichord was difficult. Most of the time, the video and sound don't have the same latency, so it is also difficult to follow the technical issues of students. Another interesting observation was that it was not as easy to focus for a long period of time so many teachers switched to more frequent shorter lessons of around 30 minutes. It was also common to work on smaller sections at a time since students couldn't hear well if the teacher interrupted them while they were playing.

Because of these, many teachers switched to asking for a combination of both prerecorded and live video material so there were two versions to judge by and most of the teachers interviewed switched to Zoom. There is also a setting which helped many which was the "Noise cancellation" setting which can be found under "Settings", "Audio & Video". On Zoom (and several other platforms as well), this can be adjusted in such a way in order to create the best and most efficient result.

The positioning of the camera when teaching or demonstrating examples in terms of touch quality on the keyboard, or bowing on a string instrument, dynamics, gesture and body movements continue to be a struggle, but each teacher has found various solutions using a combination of synchronous and asynchronous tools.

Students were also interviewed and many struggled with similar issues. Many students bought new microphones and worked out camera positions to best show their positions and also to see their teachers. For instance, one student in trying to keep a good sound quality result, used the front camera of the laptop – placed just in front of him, in order to be able to watch on the screen

the teacher as well – and connected to the pc an external microphone. Using the "Noise cancellation" setting the quality of the sound resulted pretty acceptable and clean.

It was not easy for students to get used to this new method for individual lessons, especially in the first months. The main problem is given by the impossibility of working on the sound quality and the dynamic levels. Moreover, the inability to get exposed to the body language of the teacher, which is an essential component of the learning process, for many felt like a missing inspiration source.

However, after several months the initial discouragement was left aside, as students realized that it was still possible to work on many different aspects of music making, such as: the interpretation and the general musical approach to the piece (characters and affects, tempi, articulations), technical choices (fingering, bowings), and body posture.

For both students and teachers, the use of headphones was also incorporated into many lessons. This helped in some ways, but many students found it difficult to play with them. It also strongly depended on the quality of technology that one used for lessons.

Another interesting point to mention is the freedom that online teaching gave to some students. In face-to-face lessons, students might tend to be shy and introverted and distance provides them with a shield. They feel less intimidated by peers and teachers with a barrier in front of them and it proved to give some of them more confidence to express and play with more liberty. This could be because they feel less threatened and given that the teacher and others will hear only as good a connection and sound equipment they have. Although this fact in itself might not appear important, it opens a door for the student to stop the fear of mistakes and move on to play.

4.5 Chamber music

Although there have been numerous technological advances for simultaneous playing online, it is still quite unusual to teach chamber music or orchestra online. In this section, several methodologies and approaches from interviews with music teachers are addressed.

The easiest way to teach chamber music was when the musicians are together in the same room and the teacher is remote. With very good microphones, it's possible to work style, tempi, phrasing, more difficult for dynamics and tuning and very difficult to practice details because of the low quality of sound. It is difficult to interrupt in the middle of a phrase, so it was useful to work on small sections at a time. This method works well because the students don't need to worry about that they won't hear each other.

Another way of application is to have people playing simultaneously in different locations on platforms like Jamulus (computer) for distance rehearsals. The technology does still need to be developed because of the latency and of the different levels of connection. For instance, it is much for difficult to:

- anticipate: the more the music goes on, the more the musicians slow down and play out of tune

- follow the conductor on the computer (also because of the too small window computer);

- to play in tune (also because the electric sounds of the computer are too poor of harmonics: not enough harmonics means it is impossible to build correct common chords in tune);

- follow musicians on computers and people in the same room at the same time.

- feel the style, the dynamics…

Musicians in this Virtual Stage project already have some experience working together online playing Monteverdi's masterpiece *L'Orfeo*. The project envisaged both the complete recording and the staging of the opera. The musicians rehearsed using a combination of the use of tutorials, partial playbacks and MIDI instruments capable of reproducing sample sounds.

During the past several months, this project also started to use Jamulus for online rehearsals, with musicians playing simultaneously along with other musicians based in France, the Netherlands and Czech Republic.

One final method which was addressed by teachers, was to incorporate the technique of 'Muted mics'. This technique works as follows:

All microphone players muted. The ensemble decides which musician will turn its mic on. The picked musician plays its own part for the rest to hear and rely on. Musicians with muted microphones cannot hear each other, but they can see each other while they play.

Every musician eventually becomes at some point picked on.

This procedure allows the 'picked musician' to be prepared to the maximum. Everybody else is listening and relying on him/her. This musician might even be more aware of his/her physical movements while performing.

The rest of the musicians find a way to play their own individual part relying sometimes on an unusual reference for them. This gives them a better aural and visual map of the whole music.

In conclusion, the advancement of online music learning has been incredible over the past two years and even without the corona pandemic, online lessons are here to stay. Though live lessons and rehearsals are preferable according to most teachers and students, great work can be

accomplished using online platforms and technology will surely continue to improve over the coming years.

5. Interaction with others in the sector, both in training and production, in online training paths for opera

With travel becoming more complicated, expensive, and a high contributor of climate change, finding ways to work online for an opera production could revolutionize the music world in the coming years. Creating an online methodology for opera preparation has several benefits, including cutting costs, enabling musicians to work together who live far away, a solution for moments like Covid where travel may be restricted, and it's better for the environment. New technology is making it possible to change the approach to online rehearsals and in this document, a hypothetical plan for producing an opera almost entirely online is proposed.

There are several possible types of productions that can be put together, including:

1. Completely online performance - each musician records their own part individually or in small groups
2. Partially virtual - some musicians perform live and some pre-recorded material is used
3. Completely live performance with preparation done online

This part will address solutions to each of these types of performances and will also lay out some difficulties or special considerations for each instrument.

5.1 Overview

The process of preparing an opera has many people involved and several finite steps which must be followed:

1. Conductor prepares score

2. Conductor works with singers (see Virtual Stage output 2)

3. Participation of continuo players in the rehearsals

   a. Continuo players meet with conductor online and go through the score

VIRTUAL STAGE

Co-funded by the
Erasmus+ Programme
of the European Union

b. Continuo players make recordings for the singers to be used for recits and arias

c. Continuo players work with singers individually along with the conductor

d. Jamulus rehearsals with singers in groups along with the conductor

e. Rehearse with choir (if needed)

4. Concertmaster

a. Meets conductor

b. Prepares the string parts

c. Coordinates with other string leaders and continuo

5. Winds/brass/percussion

a. Lower voices work with continuo team (using recordings)

b. Separate recordings of solo wind parts that other wind players can use (obligato parts)

c. Upper voices work with strings (oboe/violin arias, etc.)

d. Brass and percussion work with score, prerecorded continuo or string parts

The hours involved in opera preparation for each individual varies depending on responsibility and instrumentation. In this proposed outline, the hours average as follows:

Conductors: at least 100 hours, preparing the score and working with all singers and instrumentalists

- Concertmaster: 10-20 hours (preparing bowings, fingerings, meeting with the conductor, rehearsing in small groups, preparing the other principals)
- Continuo: (harpsichord to start - 40 hours with conductor, singers one on one)
- Adding cello, theorbo, finally bassoon for recits and arias - a minimum of 10 hours per person
- Tutti strings - Tutorials of principals, learnings parts, minimal online rehearsal - 5-10 hours per person
- Winds - Personal preparation, meeting in small groups, discussing tempo, tuning - 5 hours per person
- Brass - tempo, temperament - 2 hours per person
- Percussion - 2 hours per person

After this initial preparation, there are at least 3 days of 8 hours per day needed for rehearsals. This will be significantly more for the continuo players, depending on the repertoire.

5.2 Violin/Upper Strings

There are several roles within an orchestra for violinists and for a virtual opera. In this section, the researchers will outline the various positions and responsibilities of being a concertmaster, 2nd violin or viola principal or tutti string player.

At the beginning of opera preparation, it is helpful to work with the 4 or 5 section leaders of the strings as well as the principal winds, before adding in the rest of the tutti section for online rehearsals. The first step is usually a meeting with the conductor and the concertmaster to discuss planning and the musical direction of the opera. This can be online and is helpful to get a clear picture of the conductor's vision as well as the cuts and solos which might be added or changed throughout the score. If it's an early opera, this meeting might also be planned with the continuo team as well.

After an initial meeting, the conductor sends the concertmaster of the opera orchestra the string parts as well as a full score so that they can write in bowings and fingerings, if necessary. If there are musical gestures that need to be communicated, then the conductor should also prepare the score to show any unusual or surprising indications. It's normal to send scores via pdf and it's possible to edit scores and share notes with many ipad apps.

The concertmaster then sends the prepared parts to the principals and tutti players of the opera. Because rehearsing is complicated to do in large groups, the next step would be to record videos or have online musical rehearsals with the principal players or the concertmaster and continuo team. The continuo players may also wish to have some online meetings together at this time as well. If it's possible for the quartet or quintet of players to play together, then it would be useful to make a recording of the parts or of the full quartet and send it on to the rest of the tutti players.

It would depend on whether the performance is live or not as to whether a tutti rehearsal would be necessary or if it's best to meet on the concert day or the day before in person. If everyone is recording their parts for a fully virtual opera, then it would be important to have clear recordings of each of the principals and possibly a click track or recording of the conductor that can be used to sync the section together.   If the performance is live, with the amount of information that is being sent to the string players, it should be sufficient for everyone to be ready for a dress rehearsal.

Some issues that can arise for virtual preparation with the violin are that the sound quality can come across thin and sometimes with distortions. It's important to have good microphones and

recording equipment. The speed of sound can also speed up and slow down so if there are live rehearsals using software to play together, it's essential to have a fast internet connection.

The preparation of an opera, virtually assembled, needs to integrate those aspects of ensemble playing that are generally left to the live-rehearsal process: working on intonation (individual and for the whole ensemble); finding a common sound of the section/ensemble; individual awareness of the others' lines.

For what concerns the first issue, besides the personal preparation on the notes, the concertmaster and the principals of each sections should point out to the other string players all those spots that need special attention (parallel lines with singers, or wind instruments; unisono sections or at the distance of an octave) and in case of an opera from the early music repertoire: which temperament will be used, and which extra cares need to be taken in this regard; how to tune distinctive intervals according to the affects needed; the balance of the different voices in the construction of a chord.

Video tutorials or audio samples made by the principals and shared with the other players can provide a good training method (together with the continuo section, if it is the case of an Early opera).

Regarding the sound of the section/string group, the concertmaster and the principals will take care to specify to the colleagues which are the tools that need to be used in order to achieve the musical interpretation that has been proposed beforehand by the conductor. The different characters, affects and atmospheres in the text or in the music itself will be executed with specific articulations; timing of the notes; quantity of bow; type of sound (more/less attack or grip). Making clear for all the players how to phrase and bow in each section/aria of the opera can be done, again, by sharing video/audio tutorials.

The individual awareness of what is in the score for the other voices and which role is inherent to the personal line according to the different moments can be easily prepared, individually, by reading the full score, listening to recordings and eventually playing on top of them. In the case of a piece not so well-known, or a world premiere or a rediscovered work the preparation of audio tutorials will do the job.

5.3 Continuo

An important aspect of the continuo group is the instrumentation. In a live context, this is usually dealt with by starting with a general plan (certain characters have their own instrumentations, for instance) and by experimenting with different combinations upon the original basis. It is difficult to do this same form of experimentation at a distance since it involves playing many

different instruments together for single chords, as well as the difficulty of not hearing the space or combination of certain timbres in a space. That being said, there could be a very interesting way of experimenting with instrumentation at a distance. Building on the idea of the keyboard setting the basis with the singer, and then the other instruments recording on top of that, it would be very easy to hear different combinations of instruments by simply adding or removing tracks in an audio editing program. From here, the leader of the group or conductor could ask for differences from individual players and get close to a final result of instrumentation and style.

Keyboardists are key figures in opera because they are needed not only in the orchestra but also and mostly in the early stages of preparation. Accompanists are involved mainly in the first phase focusing on musical aspects of the Opera with singers and concertmasters, later, eventually, they may be involved in direction rehearsals.

The first approach to the score could take place at a distance and the vocal coach/accompanist could be of great help to the conductor in sharing the tasks with him/her, also helping the conductor to have a broader analysis of the score. In a second step, the score should be shared with all the necessary indications and the accompanist should clarify musical matters to the concertmaster and singers and - if present - to the choirmaster. Subsequently, the accompanist could record a basis of the entire work or only specific sections - especially for the singers. When the first rehearsals begin, the accompanist is indispensable if we are talking about early music; if we are talking about romantic or contemporary opera, he or she does not always have to be present. In the last scenario, it can be useful for the conductor to clarify the conductor's musical idea to each section of the orchestra and the singers. In baroque opera, he is not only an essential part of the orchestra, but is also the one who leads the recitatives and can be a mediator between singers and orchestra.

The first phase can take weeks and can be organised entirely online. The second phase starts on the day the score is shared with everyone and only ends on the last day of rehearsals: it can take place either remotely or in person, even 50/50. The organisation of the third phase depends on how much can be arranged for keyboard and how much has to be recorded to be used by the soloists. As an indication, 85% can be assumed to be pre-recorded backing tracks. The fourth phase can even be blended (if there is too much delay, soloist and accompanist can alternately turn microphones on and off), but in the last days of rehearsals, physical interaction is indispensable.

The role of the continuo cellist is constantly shifting - at one point being more accompanimental, at other points more soloistic, and many other times more as a chamber musician. Alongside the work that is normally needed to prepare one's part for an opera, being involved in a production that is mainly assembled virtually requires several extra steps. One of these main points is preparing the musical numbers in (virtual) communication with various (if not all) the members of the ensemble, both instrumental and vocal.

After receiving the orchestral/vocal scores and individual parts (when final decisions and arrangements have been made), one of the first steps would be to take note of the groups of musicians one needs to be in contact with for each musical number. For example, if there are various instrumental sections, it would be appropriate to have a meeting (via Zoom or another platform) with the concertmaster and principal leaders to discuss the different effects of each musical number, in order to agree on articulations and bowings.

For arias and recitativos that only involve the singer(s) and the continuo, it would also be helpful to set up a meeting (with the other members of the continuo, especially the keyboard players) to establish an understanding of the singer's vision and desired tempi and articulation of the arias. The singer could demonstrate his/her part while the continuist mutes the microphone and plays along with the voice and vice versa. Jamulus could also be a useful tool, if the latency between the locations is minimal. This kind of work could culminate in having an exchange of recordings between the singers and the instrumentalists - the singer first records a version, the keyboardists later record a track based on what they hear (possibly by following the singer's track with headphones), finally, the rest of the continuo team could practice and make recording using the keyboardist's and singer's track as the base. This would allow for most of the preparation to be done at distance, requiring only minimal rehearsal in presence to establish the right balance and feeling of ensemble between the musicians.

If the continuo team is made up of more than one cellist, it would be useful for the principal to prepare the parts for the rest of the group, outlining solo versus tutti parts, and of course, including basic bowing. It would also be important to establish how much time will be dedicated to each part of the opera once the ensemble rehearses in presence. This would also give an idea of how much time should be spent preparing the material virtually.

If the whole production would be carried out virtually, requiring all musicians to record separately, of course many other steps and tools would be involved. First of all, there would be the necessity to have proper microphones/recording devices and a quiet space to execute the recording. It would be useful to work with a click track and (depending on the number) a minimum of the keyboard's and singer(s)'s part as a base in order to record a reliable part for the rest of the ensemble. This would be done, of course, after the initial preparation that was discussed above.

5.4 Wind Instruments

Recorder and other wind instruments, such as transverse flute, oboe and trumpet, are frequently employed in the early music repertoire. While in most late Baroque operas there are specific parts for these instruments set by the composer, this rarely happens in 17th-century music,

where the absence of clear indications allows the performers a much greater freedom. In this case, it is generally the concertmaster or conductor who decides whether the wind instruments should double the strings, if they have some solos or if they should play along with the singers in an aria or in a chorus. This is the first stage of the preparation, which focuses on the score. Today it is common to share the score via pdf with all the players of the ensemble, so that they can choose if they prefer to keep the full score or extract their own parts through one of the softwares available.

In a traditional performance, the recorder player(s) have to consider several aspects when playing together with upper strings, in particular tuning and articulation. Since wind instruments tend to get higher after they warm up, while strings do the opposite, it is extremely important to find a balance otherwise the whole ensemble might sound out of tune. Also regarding articulation, the two types of instruments often have complementary approaches in the interpretation of the same passage, which is not at all wrong or avoidable, but certainly implies particular attention on both sides.

When switching to a networked music performance, these issues can be more challenging than in a live session. The sound quality, the latency and the physical distance are all factors that can impact the final result.

When musicians make music in a normal environment, they harmonize and play together by sensing each other's body language, body tension, and so on. For example, it is very important for someone to give a cue to begin playing. Depending on the angle of the camera, it may be difficult to detect the body movements of the player when holding the instrument so it may be necessary to consider the angle of the camera.

To break it down into more detailed techniques, for example, in the case of wind instruments playing in ensemble, you may time your notes together by watching the movement of your co-performer's neck muscles. You can't see the mouthpiece as it is placed in their mouth, however you can sense when a colleague is going to produce a sound by observing the muscles of their neck.

In order to accomplish this in an online session without compromising the quality of the ensemble performance, it would be helpful to ask fellow musicians to place their camera at an angle and distance where you are able to see these details for the timing.

If there are many wind instrumentalists, one useful option would be to decide in advance who will be the section leader in charge of cueing the others. Camera settings can then be prepared beforehand in order to save rehearsal time.

Latency issues due to the quality of the internet connection are to be expected. In this case, it is difficult to visually determine the timing of the performance. In fact, it may be more efficient to use aural cues for timing since sound signals are delivered reliably faster than visual signals to

each device. In the end, one can choose whichever option is more efficient. There are a few things to keep in mind when working in online sessions.

Online rehearsals also require one to be more involved than in traditional rehearsal environments. As a tutti wind player, one cannot rely on the leaders when rehearsing online and need to be more self-directed and motivated rather than passive. Behaving passively online can seriously damage the entire performance as with today's communication technology, it is impossible to be exempt from latency. An orchestra or ensemble will stall if each player follows other online performers as they will consistently be late with one another. Avoiding following other musicians might make you feel uncomfortable, as if you were ignoring your colleagues. Online ensemble playing requires more initiative and responsibility from each musician. Each performer is responsible for every musical sentence, phrase, and section, and of ensuring an agreed upon tempo is maintained. This will contribute greatly to the musical quality of the orchestra as a whole.

Another helpful addition to asynchronous rehearsing is to organize a system that allows musicians o communicate with each other even if they don't know each other (for instance an instrumentalist and a singer), such as a community website like https://stackoverflow.com/, These platforms allow musicians to share and deepen their knowledge with each other, as well as having the opportunity to experiment together.

By developing such a decentralised system, which is expected to become the mainstream of future society, we should also focus more on developing a structure for students to start creating and publishing content. Working in this way, students could specialise further and go on to create a professional business and eventually their own ecosystem based on their content.

5.5 Percussions

In the case of percussion instruments, almost all preparations are possible in distance, although in the specific case of performing opera, it will be almost impossible to be right in time with conductors and singers if this is not 'live' at the same acoustic space.

A very common preparation of percussionists is playing along with existing recordings. A variety of styles are recommended to try different ways of interpreting before having a personal approach. When recordings are not available, then one relies on the score. Recently PDF's are very handy.

Percussion instruments normally join the last phase of rehearsals. But if there is no recording and if the music has been scarcely played, these rehearsals won't be enough.

Digital instruments could be useful here, allowing the percussionist to have early access to rehearsals thanks to the remote connection or to rehearse separately, e.g. only with woodwinds.

To sum up, 90% of the preparation can be done in distance, although the most important part, might be the last 10% live at the same acoustic space, where the percussionist gets to feel the orchestra, conductor, singers and ultimately the music.

5.6 Orchestra Conductors

Registration of tutorials under the guidance of Orchestra Conductor

In the first phase, the teachers will make a video recording of the single part of the piece, even within their own pool.

Thanks to the collaboration of an audio technician, the recordings will be returned with a qualitatively suitable sound and superimposed on a multitrack file that will allow to exclude the part that the student will have to perform to practice. It will be possible to slow down the speed to allow a more effective initial study phase for students.

To facilitate the work, for example in the instrumental introductions of vocal pieces or in the case of long pauses, a low volume sound guide can be created.

Furthermore, further solutions can be developed, in order to facilitate the students' practice in the different situations experienced.

Deliver tutorials to students and use them

In the second stage, students will receive the recorded tracks. In this way they will be able to practice with greater awareness and deepen the study of the piece in a more chamber style.

The choice to make a video recording (instead of just the audio recording) will allow students to observe during their performance not only breaths, fingerings and arches, but also more easily follow the pauses, attacks and movements of the body, which "guide" them. performance of the piece.

It should be emphasized, in a preparatory phase, that the tutorials can also be used as a guide for one's part. Therefore, three phases could be identified:

1. Listening and studying the version of the tutorial with its single part to assimilate it correctly, even practicing at the same time
2. Listening to and studying the complete version of the tutorial with all the parts, to assimilate it in its entirety even by practicing at the same time

3. Performing your own part individually using the version of the tutorial that excludes it to make yourself autonomous
4. Realization by the students of their own recording and elaboration of the final product

In the third phase, students will be guided by the Orchestra Conductor, during the Academic Year, to produce their own recording, which will replace the track initially prepared as a tutorial by the Orchestra Conductor.

Also thanks to the collaboration of an audio technician, the tracks will be processed as described above.

If, as we all hope, it is possible to go back to carrying out teaching activities and face-to-face exams, the audio-video product created by the students can be considered to all intents and purposes a result of the training process that will integrate the musical skills acquired. This experience will bring greater skill in creation of audio-video supports, which are increasingly important in our sector today, especially for young people for auditions and placement.

If necessary, these products can also constitute elements for the final evaluations of the courses.

Equipment and costs

The nature of this experimentation is to facilitate the online training process with the equipment that both Orchestra Conductors and students normally have available, without having to acquire specific equipment and incur costs. Will be enough:

- audio headphones or earphones
- smartphone or another device to practice on the delivered multitrack file.
- smartphone and other device at the same time (tablet, PC, etc.) to be able to listen and see the basic track and simultaneously record video.

Repository and database

The material created can be made available free of charge on an interactive Repository such as IO4 on the type of IMSLP or a dedicated youtube channel, which can also be freely implemented by Orchestra Conductors / professionals of other conservatories in Italy and abroad.

Conclusions and perspectives

Interested Orchestra Conductor will be able to collaborate in the way they deem most appropriate: they will be able to make each other available for recording the tutorials of the vocal and instrumental parts and will also be able to use this methodology in whole or in part.

In the future, if the restrictive provisions allow it, it would be desirable to integrate the experimentation described above with recording in the presence of audio-video supports, in

order to also provide more real models of the performance of the piece, which are complementary to the multitrack.

The use of this system could also be applied, on an experimental basis, to some proposals of the Institute Project.

As happens in many other experiences of DaD, seminars and online conferences, this methodology can also be applied in both alternating and mixed blended modalities. In alternate mode, part of the lessons in presence and part online could be carried out, while in mixed mode, part of the students in presence and part online could be foreseen, especially in the case of extended staff.

This flexibility could therefore make it possible to integrate the lessons and tests in the presence, rather than replace them, providing further support even when the teaching can finally be carried out in the presence.

5.7 Special Considerations

Taking into account this methodology of online opera preparation, several special considerations must be made. In some cases, online work can be easier than live traditional practices. For instance, score preparation, conversations between principals, recordings for tutorials can all easily work online

When working exclusively online, it is important to create a database with recordings, tutorials, message board, that all musicians involved can use. When it's too exclusive and only for principals, many players might not become as involved. Another consideration one must take into account is the quality of internet connection, microphones and speakers/headphones are incredibly important. Finally, the organizer must coordinate which apps, score readers, edition, etc. that everyone must use.

6. Tech

6. 1 Best practices for simple and effective recording and sound sharing by internet connection

The methods of recording and sharing audio via an Internet connection require the introductory technical clarification of certain key concepts relating to the necessary tools.

A sure and necessary goal is to understand how a sound source can be technically captured, and the result recorded or otherwise shared.

To do this, we need to introduce the concept of a transducer.

A transducer is a device that converts one physical quantity into another. In our case, the transducer is the microphone. From this device, the signal travels in a cable to a device called preamplifier.

In fact, a microphone converts a sound pressure applied on a capsule into a voltage.

There are several categories of microphones, classified according to the method of operation. The main categories are dynamic microphones, condenser microphones and ribbon microphones.

Each of these categories has specific characteristics.

Dynamic microphones involve the movement of a moving coil in a permanent magnet, due to the effect of sound pressure. The movement of the coil causes a voltage change. Such microphones, often used in live applications, are very durable, but tend to have limited performance at high frequencies, and not necessarily excellent sensitivity.

Condenser microphones, on the other hand, generally much more sensitive and with a more natural frequency response in the highs, rely directly on the operation of the condenser. The sound pressure is converted into voltage due to the movement of one of the plates of the capacitor itself. Such microphones require a power supply in order to function. This needed power to charge the condenser is frequently supplied in the form of Phantom Power - that is, sending 48V through the use of the same XLR cable on which the audio is carried. The tube condenser microphones have their own power supply.

Ribbon microphones tend to be analogous to dynamic microphones. In fact, there is a very thin ribbon suspended in a permanent magnet. Such microphones have historically tended to require a high preamp and are extremely fragile. They do not require Phantom Power (unless otherwise

specified by the manufacturer). Indeed, sending 48V to the microphone itself is to be avoided, unless otherwise indicated, because it would compromise the microphone itself.

Microphones are also classified in relation to their directionality.

There are directional, bidirectional and omnidirectional microphones.

Directional microphones (cardioid, sub-cardioid, hypercardioid pattern, etc.) tend to mainly capture the signal directly and frontally introduced into the capsule, and reject the signal, in different ways and quantities, for positions other than the axis of the capsule itself.

Directional microphones tend to manifest an effect called proximity: approaching the sound source to the capsule, there will be an unnatural increase in the yield of low frequencies. This effect can be compensated for in equalization if necessary, but it can also be used to your advantage if the low frequencies need to be emphasized.

The bidirectional microphones, on the other hand, capture signals from the front and rear. The omnidirectional, 360 °.

The signal that comes out of the microphone must therefore reach a device called a preamplifier, which does nothing but increase the amplitude of the signal it receives, that is, its voltage. This is done by acting on a control called gain.

The preamplifier is part of another useful device for our purposes: the audio interface.

The signal which, then, captured with the microphone, is preamplified, is then subsequently processed by the audio interface itself. This processing is called conversion.

The signal is converted from continuous to discrete by means of an analog-to-digital converter.

This signal is measured a certain number of times per second (sampling frequency). The measurement is then approximated, in a fictitious grid, in the dynamic range, by means of the bit depth. In practice, the bit depth is needed to represent the loudness at a given moment. The greater the bit depth, the greater the dynamic range represented. A bit depth of 16 guarantees 65535 quantization levels (one bit is used for the sign), while a bit depth of 24 allows for more than 16 million quantization levels.

As for the sampling frequency, that is the number of signal measurements in a second, it is always the theoretical double of the maximum sampling frequency. The minimum value commonly found in audio devices today is 44100 Hz.

Once the signal has been converted, it can be processed in software.

In our case, the software used will be Digital Audio Workstations or Jamulus.

Digital audio workstations are software that have been developed since the mid 90's for the integrated management of MIDI and Audio data.

This management takes place in projects. Each project is made up of units called tracks.

A track is a container of audio or MIDI events. Within a track, we identify what is generally called a region, event or item.

A track can contain one or more regions. In some software, in addition to the properties of a track, you can also have specific properties for the individual items it contains.

There are generally three different types of tracks: audio tracks, MIDI tracks, and virtual instrument tracks.

Audio tracks are containers of audio regions that point to a file stored in mass memory; MIDI tracks are containers for MIDI events (messages); virtual instrument tracks are tracks with regions that contain MIDI events, but which output an audio signal through software that interprets these events.

In order for a track to be enabled for recording, it must be armed.

The possibility of obtaining a prompt response in listening to the input signal, while playing and recording, depends on a parameter available in the configuration of the audio interface, within the software, called buffer size.

The buffer size is a form of buffer memory, which the system uses to ensure a continuous stream, free of interruptions, clicks or pops, of data from the sound source to the software.

The buffer size, generally expressed in samples, necessarily determines a latency - that is, a form of delay.

To record, or in any case to send the signal to the software more promptly, you will have to try to keep the buffer size as small as possible, that the system can support.

In fact, how small the buffer is, depends on the overall performance of the computer.

However, the latency time is also a function of the sampling frequency. With the same buffer size, a higher sampling rate will result in a lower total latency.

As far as audio events are concerned, they are represented in a timeline by means of the use of pointers. It is in fact possible to resize a region to delimit the playback of the audio content available in digital format, in a non-destructive way.

If you are using files already available on the mass memory, just drag them into the project timeline.

Usually, unless specified by the user, deleting a region does not delete the file it points to.

In DAWs, time is represented horizontally, and event containers (tracks), vertically.

It is therefore also possible to move regions in space horizontally, to obtain a reproduction differential over time.

The most frequently used tools to manipulate regions are separation (scissors) and resizing.

Audio regions, in the case of joining together, require an operation called cross-fade. This causes the signal to fade out of the previous temporal region and into the next temporal region, to avoid clicks or pops in playback.

Furthermore, the signal can be further manipulated at the output by means of the mixer.

The mixer is a device, in our virtual case, which allows you to adjust the volume of each audio track or virtual instrument, the positioning in the stereo field (panning), manage the sum of the signals (master channel). The mixer also allows you to manage devices being inserted (for example: equalizers, compressors), or to create sends to auxiliary channels (often used for managing effects such as reverb or delay).

Among the devices, which from now on we will call plugins, which can be inserted in the mixer, there is also ListenTo - a software that, by means of a streaming subscription service, allows you to capture the sum of the signals from the master channel and send it through servers to remote clients, set up with a receiver, which can also be a web browser or a remote DAW channel, always in the form of a plugin.

In parallel, a different type of software that can be used for our purposes is Jamulus - in the case also in combination with DAWs such as Reaper.

Jamulus is an integrated solution for creating servers and clients to provide musicians with the ability to collaborate and play remotely.

You need to use a microphone, an audio interface, a pair of headphones, and preferably a good stable cable connection.

In the configuration parameters, it is possible to specify not only from which input the signal to be streamed to the server is received, but also the buffer size. As we have already seen, you will have to try to keep the buffer size as low as possible. It is necessary to make some attempts, in order to determine which are practically for the session the smallest tolerated buffer size values, for the management of the audio and for a correct streaming.

6.1.1 Equipment: Microphone, Sound board, Digital Audio Workstation (DAW)

We recommend using both a soundcard and a microphone, due to more flexibility and expandability during the learning process both of students and institution/trainer.

Also, the soundcard is mandatory for everyone who use a MIDI Keyboard with midi output (newer keyboard uses Usb for MIDI) or any other Midi instrument.

We can identify three levels:

- Institutional level
- Trainer level
- Student level

Audio Interfaces

Institutional Level:

- Arturia Audiofuse Studio
- Arturia Audiofuse
- Focusrite Scarlett 18i8 3rd gen

Trainer Level:

- Arturia Audiofuse
- Focusrite Scarlett 18i8 3rd gen
- Focusrite Scarlett 8i6 3rd gen

Student Level (with a PC):

- Focusrite Scarlett 4i4
- Zoom U24

Student Level (without a PC, requires a Tablet or a Cellphone, for IOs and Android):

- IK multimedia iRig Pro Duo I/O
- TC Helicon Go Twin
- IK multimedia iRig Pro
- TC Helicon Go Solo

Microphones

Istitutional Level:

- Aston Microphones Spirit (Pair)
- Lewitt LCT 440 Pure (Pair)

Trainer Level:

- Aston Microphones Origin (single)
- Lewitt LCT 440 Pure (single)
- Audio Technica At2035 (single)

Student Level:

- Audio Technica At2035
- Lewitt LCT240 PRO
- Audio Technica At2020

Setup without Soundcard

Trainer level:

- Audio Tehcnica At 2020 usb plus
- Rode NT-USB

Student Level:

- Rode NT-USB mini
- Samson Q2u Podcasting

Software:

Pc user (MacOs, Windows, Linux):

- Reaper
- Cubase Elements (or higher version)
- Kontakt (full version, for Virtual Instrument players, not available for Linux)

Tablet/Cellphone user (android, IOs, Chrome OS):

- Cubasis 3

Brands and relative models showed in this article are examples of many possibilities that the market offers at the time the article has been written, and they are all intended to be just samples. The product have been chosen with the purpose to maintain the highest possible price to performance ratio.

All the choices have been made thinking to the relative budget of the three identified levels; the institutional level (conservatories, schools, music schools) has the highest budget of the three, the teacher level has the medium budget, and the students the lowest.

With every level and setup, it's possible to work flawlessly, however for streaming lessons and playback, we strictly recommend to follow the institutional or teacher level.

6.2 The two methods used in Virtual Stage

The two methods used in Virtual Stage refer to the use of the aforementioned ListenTo and Jamulus.

ListenTo is a subscription service, where the software is provided free of charge. Basically, subscriber users have the ability, through the use of proprietary servers, to stream high-quality audio signals remotely. The receiver gets a link to connect to, and can consequently therefore receive this signal.

In Jamulus, on the other hand, anyone has the free possibility to set up servers, even private ones, or to use servers set up by others.

The Quality of Service is not necessarily guaranteed in the same way compared to ListenTo: it depends on the respect of the best conditions established by the software manufacturer by the users.

These best conditions are:

1. Connection quality: avoid using WI-FI (latency induction and potential instability) and prefer cable connections (for example, ethernet)
2. Appropriate network configuration: control of access to the network by the computer device used and control of the local network (for example: router / modem configuration)

On paper, therefore, Jamulus is a more "democratic" tool, since it theoretically allows anyone to set up streaming audio sharing services but has the disadvantage of requiring users to comply with specific technical requirements.

Audiomovers Listento is the solution chosen to stream, listen to and record high resolution multichannel remote audio in real time, with multiple collaborators, anywhere in the world. The solution includes a set of plugins, Listento and Listento Receiver, as well as mobile apps. It is also possible to receive the audio stream through a web browser. User-selectable latencies permit to match internet connections or sync to video chat. The Hi-Resolution Audio stream is with AUDIO AAC or PCM options. It is also possible to stream mono, stereo, quad, 5.1 or 7.1 surround audio. Compatibility covers all major DAWs.

Jamulus, on the other hand, is an open source (GPL) networked music performance software that enables live rehearsing, jamming and performing with musicians located anywhere on the internet. One key problem is of course, latency.

To reduce latency as much as possible, Jamulus makes use of compressed audio and the UDP protocol to transmit audio data.

The total latency is mainly composed of:

- Network latency – due to delays within the network
- Conversion latency – AD/DA conversion

As explained, Jamulus is client-server based. Each client transmits its own audio in a compressed format to a server. The server mixes the decompressed audio stream for each user separately and re-trasmits the individual compressed mix to each client. Each client is provided with a mixing console to control the balance of the various received signals. Servers can be either public or private.

6.2.1 Networked Music Performance with Jamulus

The evolution of technology and the consequent increasing speed of digital communication networks allows to improve the communication experiences with the dramatic reduction of the virtual distances.

The Virtual Stage project aims to develop and improve tools for distance learning of music

and to collect such tools in integrated remote environments for music interaction and education. Within the project, we have chosen two techniques for distance learning: Partial Playback and Networked Music Performance (NMP); this paper is mostly concerned with the latter technique.

Networked Music Performance is an area of ongoing research. The relationship between technology and contemporary popular or electronic music is a well-established field based on computer based communication. As networking is evolving from a communication medium to a shared space virtually inhabited and animated by bodily presences. Chamber music is a social musical practice characterised by peculiar spatial and temporal interactions. In NMP, these relationships are altered by the interposition of the network. NMP computer systems are categorized according to their temporal (synchronous/asynchronous) and spatial (co-located/remote) dimensions. NMP focuses on remote music performance systems supporting real-time synchronous musical interactions among geographically-displaced musicians of the above categories and aims at reproducing realistic environmental conditions for a wide range of applications from tele-auditions, remote music teaching and rehearsals, to distributed jam sessions and concerts. However, several aspects of musical interactions must be taken into account. Musicians practicing in the same room rely on several modalities in addition to the sounds generated by their instruments, including sound reverberation within the physical environment and visual feedback from movements and gestures of other players.

Here we focus on technological issues related to near-real-time performance between musicians in remote locations, with particular interest in professional training in the opera environment. As the Covid-19 pandemic has threatened the continuity of training activities in music education,

some solutions are emerging as viable possibilities in distance and blended learning in music education. Therefore, the NMP approach is of particular interest in the context of Virtual Stage. Using partial playback or NMP techniques, virtual exchanges in music, vocal and instrumental practice can be realised. Rottondi et al. presented a comprehensive review of NMP technologies, reproduced in the table below:

Authors	Name	Architecture	Network range	Network protocols	Data type	#Audio Channels	Multi-stream synchro	Codec
Saputra et al.	BeatME	Client-Server	LAN, WLAN	UDP or OSC	MIDI	16 (input), 1 (output).	none	uncompressed
Kurtisi, Gu et al.	-	Client-Server	LAN	RTP, UDP (stream) TCP (session data)	audio	n.a.	NTP	ADPCM, FLAC (real-time) or MP3, MPEG4 (on-demand)
Renwick et al.	Sourcenode	Client-Server	LAN	UDP	MIDI	n.a.	none	uncompressed
Stais et al.	-	Client-Server or P2P	WAN	n.a.	audio	2	NTP	uncompressed
Kapur et al.	Gigapopr	Client-Server	WAN	UDP	audio, video, MIDI	n.a.	n.a.	uncompressed
Wozniewski et al.	Audioscape	Client-Server	WLAN	n.a.	audio	1 (input), 2(output)	GPS	uncompressed
Sawchuk, Zimmermann, Chew	-	Client-Server	WAN	RTP/RTSP, UDP	audio, video, MIDI	16	GPS, CDMA	MPEGl-4

et al.							
Akoumia nakis et al.	Musinet	Client-Server or P2P	WAN	SIP (signaling), RTP (stream), HTTP (text)	audio, video	any	none	OPUS (audio), H.264 (video)
Carot et al.	Soundjac k	P2P	WAN	UDP	audio and video	8	external master clock	ULD, OPUS (audio), uncompr essed or JPEG video
Drioli et al.	LOLA	P2P	WAN	TCP (control) UDP (stream)	audio, video	8	n.a.	uncompr essed audio and video
Lazzaroe tal.	-	Client-Server (control) P2P (media)	WAN, WLAN	RTP/RTC P, UDP (stream), SIP (signalin g)	MIDI	16	RTP/RTC P synchron ization tool	MPEG4
El-Shimy e t al.	-	P2P	LAN		audio, video	n.a.	n.a.	
Fischer et al.	Jamulus	Client-Server	WAN	UDP	audio	2	none	OPUS
Caceres et al.	Jacktrip	Client-Server or P2P	WAN	UDP	audio	any	software-based audio resampli ng	uncompr essed
Akoumia nakis et	Diamous es	Client-Server	WAN	RTP, TCP/UDP	audio, video,	any	internal metrono	uncompr essed

		or P2P			MIDI		me stream	audio, MJPEG video
Gabrielli et al.	WeMust	P2P	LAN, WLAN	TCP or UDP	audio, MIDI	12	software-based audio resampling	uncompressed or CELT
Meier et al.	Jamberry	P2P	WAN	UDP	audio	2	external master clock	OPUS
Chafe et al.	StreamBD	P2P	WLAN	UDP, TCP	audio	any	none	uncompressed

6.2.2 Software used in previous NMP projects

Some of the softwares in the table was used for developing the InterMUSIC project. We cite some of them:

JackTrip was developed by the SoundWIRE research group at CCRMA in order to support bi-directional music performances. It is based on uncompressed audio transmission through high-speed links such as Internet2. In the current version, it does not support video transmission.

The LOLA project was developed by the Conservatory of Music G. Tartini in Trieste in collaboration with the Italian national computer network for universities and research (GARR). LOLA is based on low-latency audio/video acquisition hardware and on the optimization of all the steps needed to transmit audio/video contents through a dedicated network connection.

On the other side, UltraGrid is an open-source software that allows audio/video low latency transmission. While its performance is still far from those achieved by LOLA, it is more flexible for generic hardware and networks and it allows contributors to implement new functionalities.

6.2.3 The framework of Networked Music Performance

A music performance occurs when two or more subjects musically interact together through a medium. Subjects can be musicians during a rehearsal, as well as trainers and students. In order to consider a large number of probable scenarios, a performance can occur with all the subjects in the same room (local performance), with all the subjects geographically distant (networked

performance) or with part of the subjects in the same place and part of the subjects geographically distant (mixed performance). Subjects interact by means of a medium. In the case of local performances, the medium is a physical medium, such as simple air propagation. In the case of networked performances, the medium is a network and a communication interface, such as an Internet connection and the NMP software/hardware equipment used in order to connect the two subjects. In the case of mixed performance both physical medium and networked medium are involved.

6.2.4 Materials and Methods

The NMP method used in Virtual Stage is based on the Jamulus free and open-source software programmed by Volker Fischer et al. in C++. This NMP software enables live rehearsing, jamming and performing with musicians located anywhere on the internet. Jamulus is Open-Source software (GPL, GNU General Public License) hosted at SourceForge and runs under Linux, Windows and MacOS. It is based on the Qt framework and uses the OPUS audio codec. There is one server running the Jamulus server software which collects the audio data from each Jamulus client, mixes the audio data and sends the mix back to each client. The concept is explained by the following figure.

The simplified core structure of Jamulus starts with a callback-based audio interface which captures audio sample blocks. The audio interface can be a USB microphone, a MIDI interface or audio card output. These blocks are compressed with the OPUS low-latency audio codec and transmitted through the internet using the connectionless User Datagram Protocol (UDP). At the server a set of jitter buffers collect the asynchronous network packets from all connected clients. In the server processing loop, the data packets from each client are taken from the jitter buffer, decompressed and mixed together. This mix is again compressed with OPUS and transmitted to all connected clients with UDP packets. Back at the client, the received server packets are stored in a jitter buffer. On the next audio interface callback, a network packet is taken from the jitter buffer, decompressed and sent to the sound card for output.
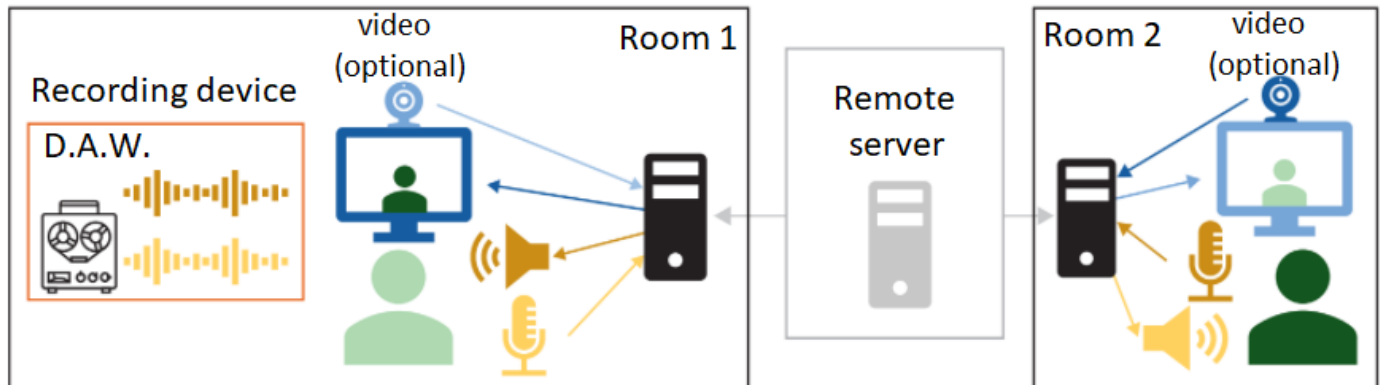
6.2.5 Installation of the experimental setup

The installation process of Jamulus for multiple platforms is relatively straightforward, according to the website of the software. Depending on the hardware the user would like to use, input and output should be selected in the ASIO settings.
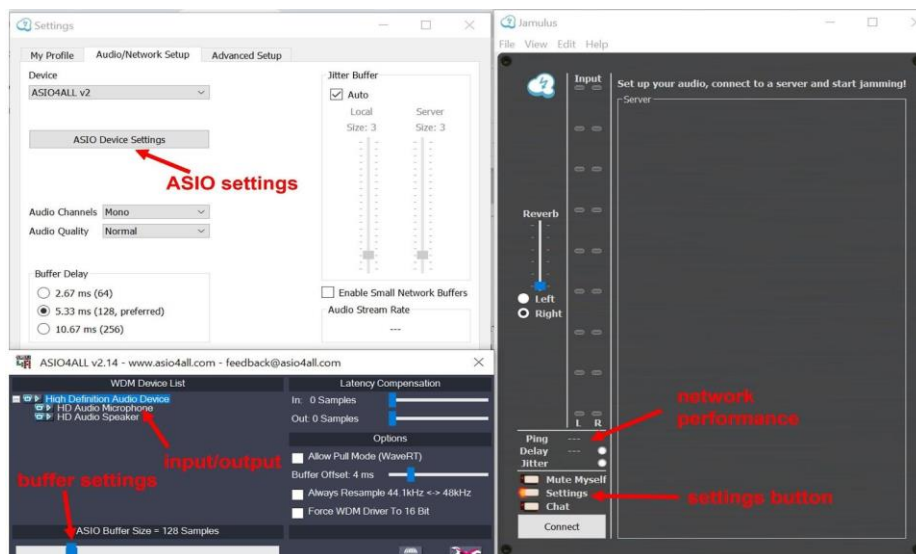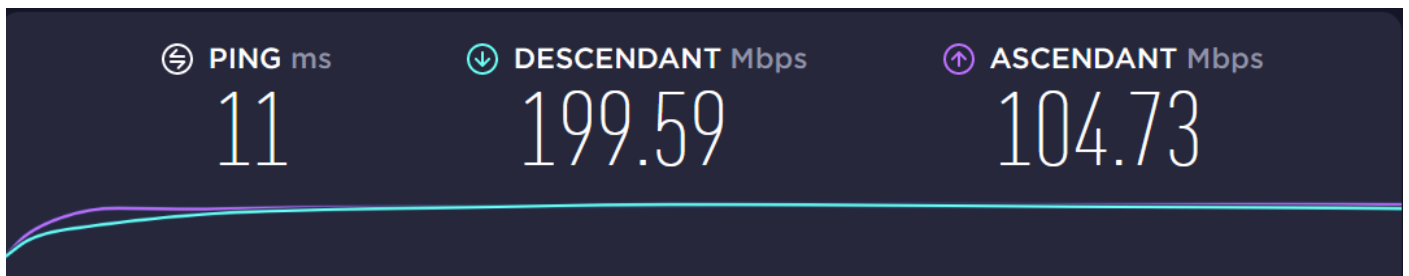

- Basic setup: PC or laptop with budget headphones (with wired) and microphone integrated (or wired). PC configs: Windows / Linux / Mac OS.
- Medium setup: PC or laptop with quality headphones, fast wireless internet connection, USB external microphone.

- Advanced setup: PC or laptop with quality headphones, fast internet cable connection, external audio board, USB external microphone.

PING ms	DOWNLOAD Mbps	UPLOAD Mbps
12	133.17	245.03
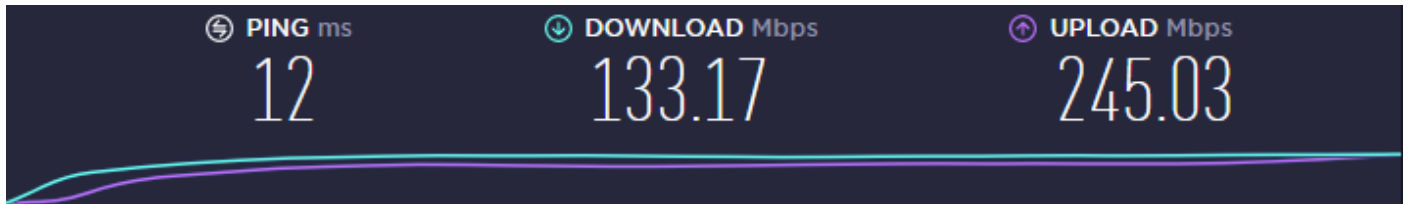
Set values for the speed of the connection

PING ms	DESCENDANT Mbps	ASCENDANT Mbps
11	199.59	104.73

PN: wifi (optical fiber)
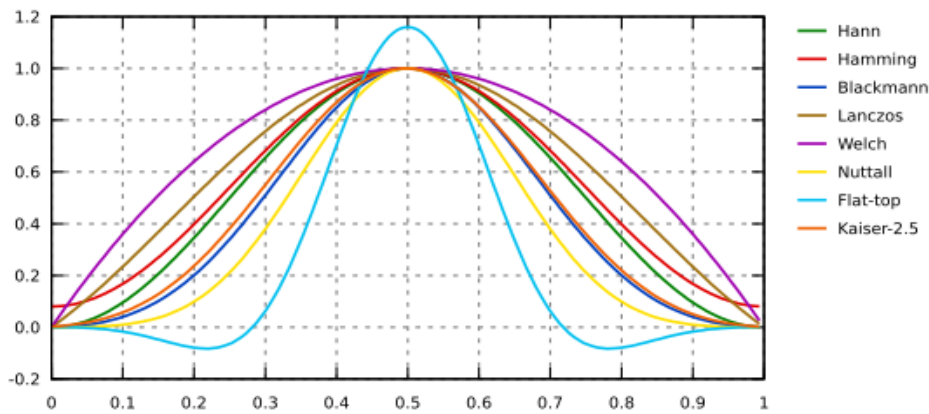
Windowing: Transformée de Fourier (gwyddion.net)

Blackman and Hamming windowing are interesting to avoid or minimize rebounds.

VIRTUAL STAGE

Co-funded by the
Erasmus+ Programme
of the European Union

6.2.6 Professional training: case study of ensemble Lira Transalpina

The first use of Networked Music Performance techniques with Jamulus for the Virtual Stage project was carried out by the ensemble Lira Transalpina during early stage of project designing process. The experimentation was carried out by all the members of the ensemble.

The ensemble Lira Transalpina participated in the NMP experiments composed of 4 musicians located at different distances between Italy, Switzerland and France. The ensemble was interested in this technology during the lockdown in order to continue the musical interactions for a chamber music work. The ensemble was interested in a varied and eclectic repertoire ranging from historically informed music to popular songs.

Choosing an NMP tool:

Solutions based on Networked Music Performance techniques were sought during the pandemic period. The knowledge of the LoLa system (cons. Tartini of Trieste) inspired the use of a web tool allowing remote rehearsal. The main constraint to the use of LoLa is the particularly high cost for a private user, while several higher education institutions use LoLa efficiently. The open source solution offered by Jamulus seems to be a good compromise between quality and digital divide. Lira Transalpina has chosen to carry out its first tests with Jamulus.

Inherent problems encountered in NMP

During the NMP session, several problems were encountered.

One of the problems with music played in real time over the Internet is latency, i.e. the time lag that occurs when (compressed) audio streams are sent and received by each musician. The effects of delay can be partially compensated for using ASIO4ALL in Windows (ASIO4ALL is already installed on mac and works easily, on Linux the installation and use is more complicated). Note that Jamulus can only work if ASIO4ALL is pre-installed.

Although the small delays (up to about 40 ms) can be perceived as synchronous, longer delays make it almost impossible to play together live. Another problem is jitter effect, a type of packet delay (information that travels over the internet) due to changes in latency over time, which

Page 60 of 77 – Virtual Stage - Reference No:2020-1-IT01-KA226-VET-008970 – Erasmus+ Key Action 2 – KA226.
This project has been funded with support from the European Commission.
This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

results in choppy or distorted sound. Significant delays can even result in packet loss (perceived as a "blackout"). These problems can be mitigated by delay buffers or jitter buffers (both present in Jamulus), but they then add to the overall round-trip delay and must therefore be balanced.

Preliminary tests of Jamulus (Installation, different possible configurations)

To use Jamulus, a phase of handling is necessary. It is important to know the basic settings in order to limit the problems of echoes, breaks...

Then, to limit the problems of delay or time lag, in addition of using ASIO4ALL, it is necessary that all the members find a server the closest to all the participants of the NMP session. To quantify the time lag, each participant must have a ping as low as possible (25ms or less). Remember that the ping is the duration of a round trip between the point of connection from Jamulus (host) and the server where the participants connect. Jamulus Ping is expressed in milliseconds (ms) and measured by the host server. Thus, the lower the ping, the faster and better the connection.

6.2.7 Distant learning setup: recording a NMP session with video

In this part, we present procedures allowing to realize a NMP session either with video or without video. The choice depends on the quality of the network. Also, sampled instruments can be used with Jamulus. The section shows the procedure as well.

Procedure for opening a session with virtual instruments and NMP

1) open Jamulus
2) open Reaper with ReaRoute template
3) connect to a server
4) additional step for video connection: open Zoom and connect to partners (sound devices will not work with Zoom, since ASIO is used by Reaper and Jamulus)

Procedure for opening a NMP session with sampled instruments:

1) open MIDI sampler software (Kontakt in our case) connected to a MIDI keyboard
2) load the MIDI instrument in Kontakt (for example the harpsichord Blanchet 1720)
3) configure ASIO output on speaker
4) open Jamulus
5) open the Digital Audio Workstation (DAW), in our case Reaper with ReaRoute template
6) connect to a server

Musician	Location	Network	Download	Upload	Jamulus	Overall	Network

		Ping	speed	speed	Ping	delay	quality
Evan Buttar	Den Haag (NL)	9 ms	71 Mbps	28 Mbps	15 ms	33 ms	Medium
Elodie Colombier	Lyon (FR)	5 ms	398 Mbps	274 Mbps	15 ms	46 ms	Excellent
Andrea Bareggi	Neuville sur Saone (FR)	10 ms	42 Mbps	61 Mbps	15 ms	50 ms	Medium

Table - Network data for the rehearsal of instrumental parts of Aquilon et Orithie by Rameau

6.3 Partial Playback with ListenTo

ListenTo is a software developed to stream hi-fidelity audio and record, even non-compressed audio (depending on the internet connection quality of the user.

ListenTo can be used as a stand alone plugin or inside a Daw, both on Windows or MacOs (for further information, please visit the site of the developer down below: https://audiomovers.com/storage/pdfs/LISTENTO%20Quick%20Start%20User%20Guide.pdf)

Also, ListenTo enable us to listen the broadcast simply by Browser on Windows, MacOs, Ios and Android: this feature is very useful because many students can listen to the same lesson in different places, or even participate to the rehearsal of an opera.

The procedure we tested involve the use of ListenTo by the Daw of the institute or the teacher, and the students follow the lesson via browser.

This method makes possible to send the audio to all the attendees, which can also play together and listen to each other, however it is not possible for the streamer to receive the audio from the attendees.

This works very well in case the institution or the teacher has a good internet connection while the attendees not.

6.4 Best practices for simple and effective recording and video sharing by internet connection

To make a video recording or streaming there are many aspects to consider, from the equipment to the positioning, composition and light to obtain a result that meets our needs.

With the passage of time, obtaining a good visual result is easier and easier thanks to new technologies. Every year new phones come out with more and more performing cameras that are sometimes unrecognizable compared to a film camera for the inexperienced eye.

Getting a perfect image is very difficult, and a professional has to deal with many settings on their camera depending on the location, type of light and content of the video. But it will not be a problem for us because we will rely on the automatic settings of the camera or webcam but with some precautions.

Most important of all composition and framing, and this rule applies whether you are using your phone's camera or if you are using a dedicated video camera.

There are many types of shooting and each one has its name, none are wrong but they must be used depending on the type of video we want to make.

- Close-up
- Medium Shot
- Long Shot

For our use we would need a medium shot as shown in the image:

In this way we can see the whole figure including the instrument and we can understand any movement well. It is important to fill the whole frame from bottom to top with our subject, if it remains in a small part of the screen we will struggle to see well.

It may happen that in front of the instrument we have a microphone, starting from this shot we can move slightly to find a compromise in which the microphone is able to pick up the audio well but in the meantime the subject is not covered too much by it.

The background is very important, there must be no objects or people who can distract attention and gaze from our subject.

We can create a themed environment, or else we can keep the background clean and take advantage of an empty wall.

Positioning is also important, for a better result it is better to have some space between us and the background behind at least 3 meters, this is because when the camera focuses on the subject automatically the background will be out of focus and this will give more importance to who is playing and will keep the audience more focused.

We make the most of the ambient light when we do not have the possibility to use dedicated lights. Let's not position ourselves with a window in the background but use it to illuminate ourselves. It would be good to have the window facing us or to the side.

6.4.1. Equipment: Camera, Lights, Computer, Software

Starting from the video camera, there are several possibilities depending on the financial availability.

For an institution it is recommended:

- Canon RP with kit lens

This camera returns a professional level quality.

The advantage of this camera is that it can be used as a video recorder, but can be connected via

USB to the computer and can be used as a webcam for live streaming.

A less expensive alternative can be the Canon M50.

VIRTUAL STAGE

Co-funded by the
Erasmus+ Programme
of the European Union

If the camera does not have the possibility of being used as a webcam we would need a cam link that will allow the computer to receive the signal from the camera and be able to use it on streaming platforms (Zoom, OBS, Youtube).

Using such a video camera also means equipping yourself with some other accessory to make it usable, such as a memory card, a tripod and a spare battery.

The recommended kit for the camera (Institutional level):

- Canon RP + kit lens 24-105mm
- Sandisk SD 128GB
- Spare Battery for Canon RP
- Tripod Neewer or Manfrotto for camera

For students and low budget professional players it is recommended to make the most of available resources such as the computer webcam, or the phone camera.

If we still want to increase the quality, we can invest some money in a USB webcam which will help us to increase the quality considerably.

Starting from the phone, it is recommended to use a tripod for smartphones to keep the shot stable and to facilitate its positioning and choice of shot.

It is important to use the rear video camera of the smartphone if we want to get the highest quality, but if we need to see each other in real time then we can use the front camera but giving up some quality.

On many computers the built-in webcam doesn't have enough quality, so an upgrade is the Logitech G920.

Once connected via USB it will be automatically recognized by the computer and ready for use.

6.4.2 Lights

Having the ability to light the scene to our liking is one of the biggest advantages to drastically increasing the quality of our videos. Sometimes the environment allows us to obtain optimal lighting without too many thoughts, but unfortunately this is not always the case so we would need to study the location and make the most of it, or better still equip ourselves with dedicated lights.

There are rules to be respected for the positioning of the lights, but with a little experience we can try to create different compositions to convey emotions depending on the type of video we want to create.

Let's start with the use of ambient light, it is important to try to have as much light as possible if we want to record a video as a tutorial in which it is important to see each step well.

Page 66 of 77 – Virtual Stage - Reference No:2020-1-IT01-KA226-VET-008970 – Erasmus+ Key Action 2 – KA226.
This project has been funded with support from the European Commission.
This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

VIRTUAL STAGE

Co-funded by the
Erasmus+ Programme
of the European Union

We turn on the lights of the room we are in or position ourselves near a window so that it lights up our face.

To get the most out we would need to use dedicated lights.

For institutional level:

- Godox SL60W / Amaran 100d / Aputure 120d (one of them, they are very similar)
- Godox / Aputure / Neewer → Softbox Bowens Mount

The lights listed are very similar to each other. Once turned on they produce a very strong light coming from a very powerful led, so it will be necessary to diffuse the light through a softbox that will attach itself in front of the light through its attack called "Bowens mount".


The larger the softbox and the more the light will be diffused, a softbox with about 80 cm in diameter is recommended at least if the subject is a person who is playing.

Page 67 of 77 – Virtual Stage - Reference No:2020-1-IT01-KA226-VET-008970 – Erasmus+ Key Action 2 – KA226.
This project has been funded with support from the European Commission.
This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

A cheaper lighting kit is recommended for students, but it allows to obtain a good result:

- Neewer / Godox Softbox lights kit

The light should be positioned slightly offset to one side of the subject but always remaining in front of the subject as in the illustration:
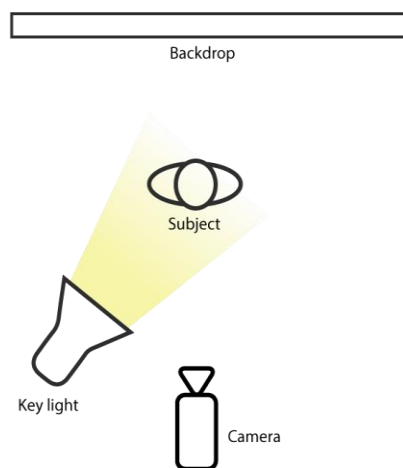
It is recommended to have additional lights of different types such as led panels to complete the lighting of the scene and make everything brighter. We can use the softbox to illuminate the subject, a led panel to illuminate the background, another light to illuminate the other side of the

person. It is important, however, that the main light is the first light we talked about that illuminates the subject.

An even simpler and cheaper solution remains the ring light, easily available and not very expensive, but it is the solution with the least quality of all.

6.4.3 Computer

The recommended computer depends on the type of work we have to do: if it is streaming on zoom via webcam or camera, we can use a mid-range computer such as the Huawei Matebook D14, D15, D16.

In that price range we find computers that can also edit videos recorded with a webcam or smartphone.

To edit videos recorded with a high-end camera like the Canon RP, you need a much more powerful computer like an Asus Rog or a Macbook with an M1 chip.

The recommended computer (Institutional level):

- Asus Rog / Macbook M1

Page 69 of 77 – Virtual Stage - Reference No:2020-1-IT01-KA226-VET-008970 – Erasmus+ Key Action 2 – KA226.
This project has been funded with support from the European Commission.
This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

6.4.4 Software

For streaming the best program is OBS studio, available for Windows, Mac and Linux. It gives the possibility to have complete control in the audio and video settings for streaming, you can connect through this program to other applications for online connection such as zoom, youtube, skype and many others.
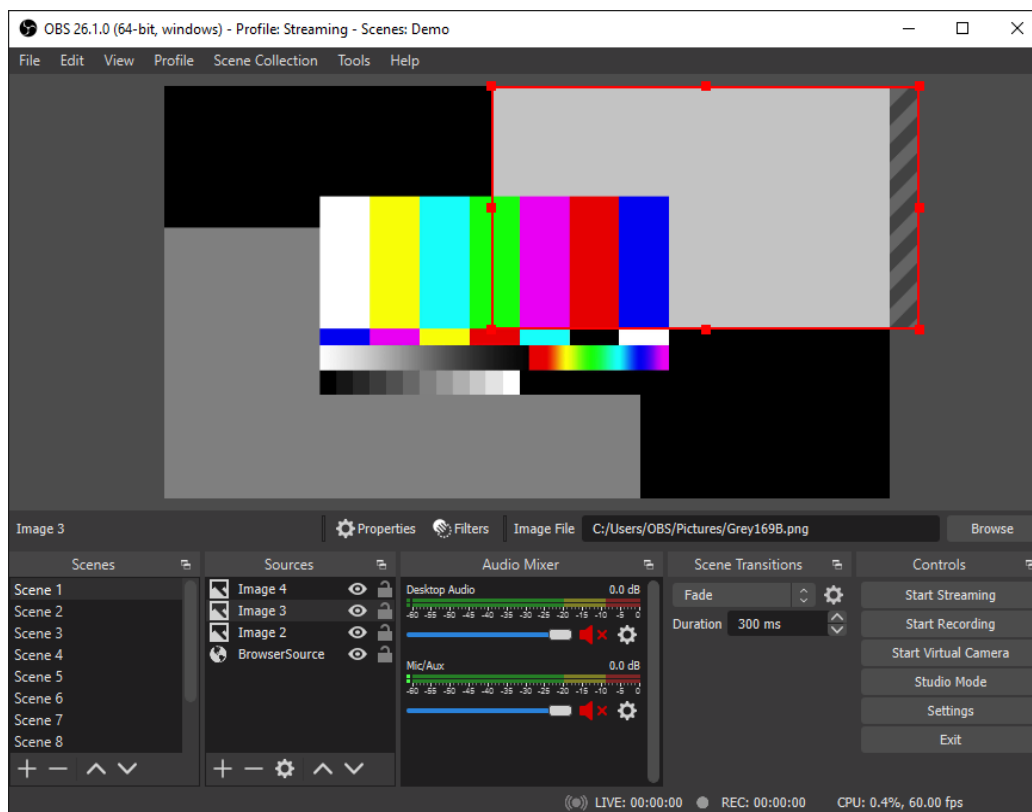
You have the ability to manage scenes, share your screen and be shot simultaneously from multiple angles if you connect multiple cameras. it is recommended for everyone.

For editing there are different programs, some are paid and some are free, but I will list the best 3:

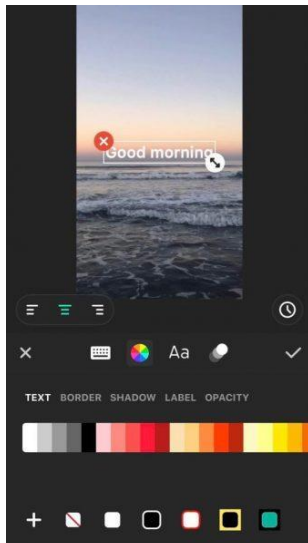- Adobe Premiere Pro (Windows and Mac)
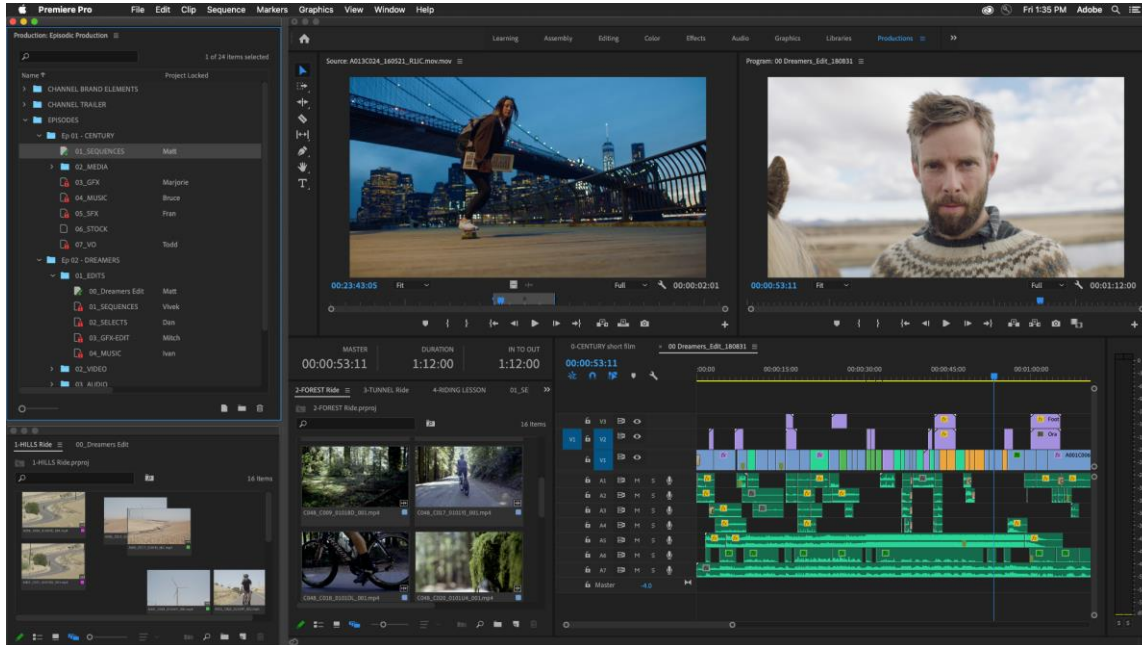
- Final Cut (Mac only)

- DaVinci Resolve (Windows and Mac) (FREE)

In case you have a fairly powerful smartphone such as an iPhone 11/12/13 or an Android High-range or a tablet / iPad, then through some free downloadable applications it is possible to edit recorded videos with your phone:
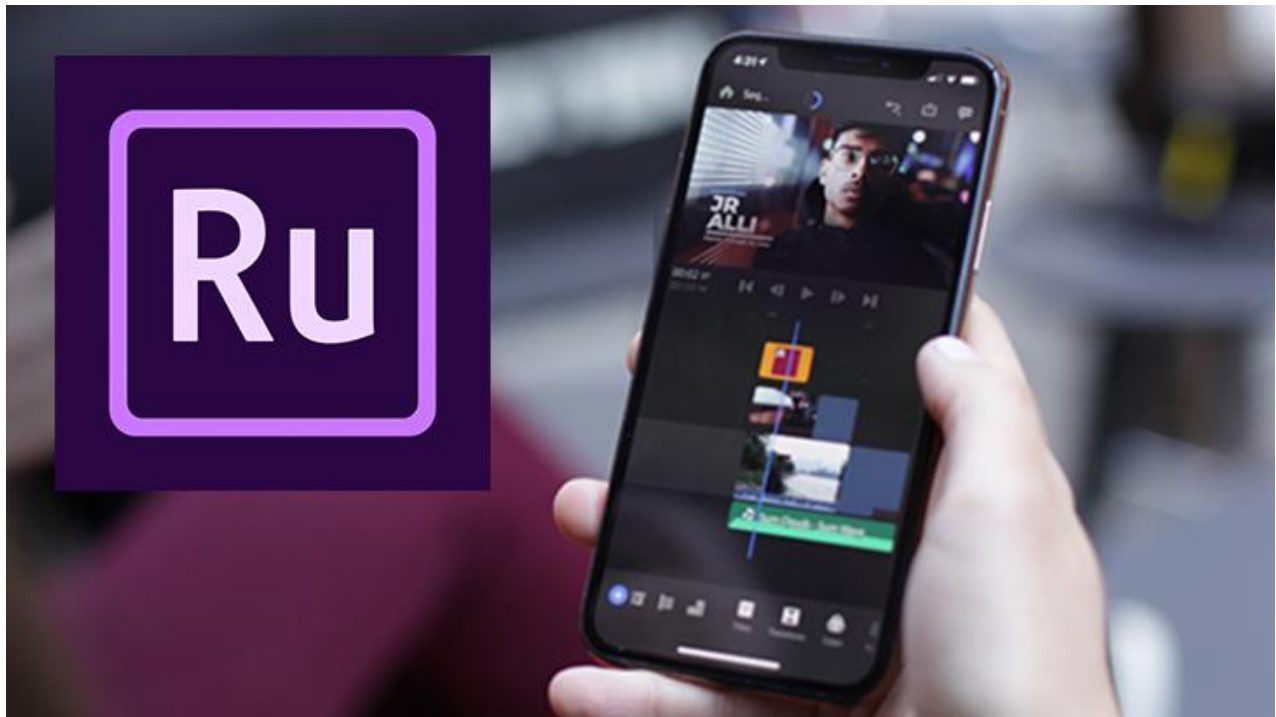
- inshot (Android and iOS)

- iMovie (iOS only)

- Adobe Premiere Rush (Android and iOS)

In Virtual Stage the project was carried out through the use of:

- Camera Panasonic GH5
- Leica 12-60mm f2.8

- Neewer LED panels
- Black Background

Editing and post-production was developed through DaVinci Resolve and Adobe After Effect.

In this case we have decided to use a green background to then be able to replace the background in the editing phase.

The paper background gets dirty and slowly deteriorates until the moment when it is necessary to replace it, but it does not create wrinkles and it is easier to illuminate it evenly.

It is important to brighten the background trying not to cast shadows on the green. Good light will make the work much more accurate.

Bibliography

A. Hogarth (july, 7, 2021). When two become one: Top tips for piano accompaniment. Pianist Magazine, Warners Group Publications, Bourne.

C. Ph. E. Bach (1762). Vom Vortrage. Der Versuch über die wahre Art das Clavier zu spielen, Part I, George Ludewig Winter ed., Berlin, Chapter 3.

E. Shanaphy, S. Isacoff, J. Jordan (1987). Speed-reading at the keyboard. 3 Volumes. Ekay Music ed.

W. Woszczyk, J. Cooperstock, J. Roston, and W. Martens, ''Shake, rattle, and roll: Getting immersed in multisensory, interactive music via broadband networks,'' J. Audio Eng. Soc., vol. 53, no. 4, pp. 336–344, 2005. [Online]. Available: http://www.aes.org/e-lib/browse.cfm?elib=13416

C. Rottondi, C. Chafe, C. Allocchio, A. Sarti. "An Overview on Networked Music Performance Technologies", 2017, IEEE Access.

J.-P. Càceres, C. Chafe, "JackTrip: Under the Hood of an Engine for Network Audio", Proceedings of International Computer Music Conference, Montreal, 2009.

C. Drioli, C. Allocchio, and N. Buso, "Networked performances and natural interaction via LOLA: Low latency high quality A/V streaming system", Information Technologies for Performing Arts, Media Access, and Entertainment, Springer, 2013 pp.240–250.

P. Holub, L. Matyska, M. Liˇ ska, L. Hejtmˊanek, J. Denemark, T. and Rebok, A. Hutanu, R. Paruchuri, J. Radil, and E. Hladkˊa "High-definition multimedia for multiparty low-latency interactive communication", Future Generation Computer Systems, 22(8), pp.856–861, 2006, Elsevier

V. Fischer, "Case Study: Performing Band Rehearsals on the Internet With Jamulus".

J.-M. Valin, G. Maxwell, T. B. Terriberry, K. Vos, High-Quality, Low-Delay Music Coding in the Opus Codec, Accepted for the 135th AES Convention, 2013.

K. Vos, K. V. Sorensen, S. S. Jensen, J.-M. Valin, Voice Coding with Opus, Accepted for the 135th AES Convention, 2013.

K. Vos, A Fast Implementation of Burg's Method, 2013.