Choir@Home

Tools for a Stay-at-Home-Choir

Software solutions for collaborative music-making

Collaborative music-making and singing over the internet were among the few remaining possibilities to unite a choir, band, or even an orchestra during the pandemic. Even after the restrictive period of distance, these forms of collaborative music-making continue to be utilized, as they have not only become established but also remain a simple way to overcome distances without much effort and time investment. The advancement of technology and the establishment of broadband internet also made it possible to transmit high data rates. In the following, different tools with their advantages and disadvantages are introduced.

Tools and apps for audiovisual communication have gained immense acceptance in recent years. Well-known platforms such as Skype, Zoom, Microsoft Teams, Webex, and similar ones enable real-time communication and coordination across any distance. These platforms were originally developed for conference exchanges, and a wide market of video conferencing systems primarily serves the exchange of spoken words, with latency being of secondary importance as it is less noticeable in conversations. They are also used for collaborative music-making and singing, allowing people to make music together regardless of location, without the need for significant technical setup or additional equipment. Furthermore, these tools are widely established, easy to use, and readily accessible. Dedicated online solutions for singing and music have evolved rapidly in terms of quality, stability, and user-friendliness.

Software solutions such as video conferencing systems, as well as specifically developed sound software, will be introduced below, which have been designed for low-latency collaborative music-making.

Zoom

The most established and widespread video conferencing solution is Zoom, making it the market leader in this field. Due to its user-friendly interface, Zoom has extended beyond professional contexts and is widely used in private settings as well. Both video and audio transmission meet high standards and are available for free up to a time limit. Meetings can accommodate up to 1,000 participants. Additionally, the inclusion of extra interactive features, such as *Breakout Rooms*, has proven advantageous, allowing for easy and controlled session divisions. Moreover, Zoom offers a *High-Fidelity Music Mode*, optimizing music transmission for musicians.

Advantages
• high functionality
• many interactive features, such as Breakout Rooms
• available on multiple platforms
• accommodates a large number of participants
• high stability
• user-friendly interface
• high-Fidelity Music Mode

Disadvantages
• time limit in the free version
• incurring costs for phone dial-ins
• data-intensive with numerous participants
• limited features in the free basic version

Microsoft Teams

In the corporate sector, Microsoft Teams is a widely used tool for video conferencing. Users can access a variety of additional features, such as Breakout Rooms or data sharing, through both a free version and paid Pro versions. The paid versions allow for a participant capacity of up to 300. Microsoft Teams has integrated a Music Mode, intended to simplify and smooth music and multimedia playback. However, for collaborative music-making, it is still only partially suitable as it does not adequately reduce bidirectional latency.

Advantages
• integration with Office 365
• high security and support system
• 10 GB cloud storage for data transfer
• optimized music transmission for musicians

Disadvantages
• no meeting recording in the free version
• complex user interface with various setting options
• limits of the free basic version reached relatively quickly
• microsoft Teams Essentials will become paid according to the announcement.

Skype

Skype has been dominating the conference software market since 2003. Users can make free video calls via computer using the app, web browser, or mobile device, and enhance the experience with interactive features such as raising hands, subtitles, and translations. Up to 100 participants can join a meeting, but there may be costs associated with certain extensions. Further options for call recording and data sharing allow for post-session follow-up and rehearsals, making it suitable for collaborative music-making and singing. Skype has been a part of Microsoft since 2011, making it closely integrated with their services

Advantages
• established and widely-used software
• cross-platform compatibility
• extensive additional features such as recording and data sharing
• free to use for up to 50 participants (afterwards, paid options available)
• mobile app version available for portable devices

Disadvantages
• stability
• user interface may be cumbersome
• sound quality not geared towards music and vocals
• no open source

Webex

The Video conferencing software Webex by Cisco is a cloud-based solution that promises exceptional data privacy and security.
Its high compatibility and extensive planning options make it particularly attractive for business use.
Features such as data sharing, host takeovers, and recording options ensure high interactivity. The Music Mode is optimized for transmitting musical content and aims for more authentic playback of voice and instruments.
In addition to the free version with limited options for up to 100 participants, Cisco offers an extension for up to 200 participants based on the premium variant.

Advantages
- simple and intuitive user interface
- easy interactivity
- calendar integration
- recording function
- music mode for optimized sound transmission for instrumentalists and singers

Disadvantages
- limited time interval of 50 minutes in the free version
- registration only possible via email
- comparatively high prices for the premium version.

Jitsi Meet

Jitsi is an open-source video conferencing platform that is freely accessible and available at no cost. It can be used without any time limitations and supports up to 75 participants, although it is recommended to limit the number of participants to 35 to avoid potential transmission issues.

Jitsi offers a viable alternative to Zoom and includes features such as screen sharing, personal chat, and the commonly implemented option to blur the participants' background. However, a weakness of the platform is the lack of end-to-end encryption.

Advantages
- open source and free to use online
- video recordings
- file sharing through chat
- easy joining process

Disadvantages
- more complex user interface
- not compatible with Internet Explorer

Google Meet

Since its introduction in 2020, Google Meet has established itself as one of the leading video conferencing platforms. Its integration with Google services allows for easy integration into calendar functions or Gmail, making team collaboration efficient with Google sign-ins. An AI-generated subtitles feature with automatic translation also enables collaboration across language barriers. The free version, available to users with a Google account, allows for video conferences with up to 100 participants for a duration of 60 minutes. Beyond that, the free version can be extended through subscription plans.

Advantages
- integration with Google Workspace
- cross-platform compatibility
- intuitive and user-friendly
- free to use for up to 100 participants without time limits (paid options available after)
- mobile app version available for portable devices

Disadvantages
- requires a Google account for sign-in
- data privacy concerns as Google collects user data for various purposes
- recording function is subject to a fee

Video conferen-cing system	User-friendliness	Music Mode	Video recordings possible	File transfer possible	Costs
Zoom	++	yes, with a paid pro subscription	yes, local storage	yes	basic version free of charge, pro version starting at 139€ per year
Microsoft Teams	++	yes	yes, cloud storage in the Microsoft 365-Version	yes	basic version free of charge, pro version starting at 3,70 € per month
Skype	+	no	yes	yes, up to 300 MB via Drag&Drop	no, except for calls and messages outside of Skype
Webex	+	yes	yes	yes, with a paid pro subscription	basic version is free, pro versions start at 13.50€ per month
Jitsi Meet	+	yes	yes	yes	none
Google Meet	++	no	yes, with a paid pro subscription	yes	free with a Google account, pro versions start at 5.75€ per month

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Real-time music-making

In addition to video conferencing systems, there are more suitable methods for real-time communication. While video conferencing platforms can enhance the team feeling in groups, they cannot truly allow a choir or band to musically collaborate harmoniously in a bi- or multidirectional manner.

Dedicated platforms tackle the issue of latency - the delay in data transmission - to enable real-time music-making. Besides the platform itself, the technical equip-ment also plays a significant role for latency and sound quality. External audio interfaces, for example, optimize internal processing and efficiently convert musical sounds while transmitting audio packets in a more stable manner. Both external microphones and headphones also have a considerable impact on sound quality. Additionally, the platforms offer additional settings to complement the technical requirements.

Apart from the five solutions mentioned here, there are others such as *Sonobus*, *Farplay*, or *Digital Stage*.

Jamulus

One of the most well-known platforms for music-making over the internet is the open-source platform Jamulus. This platform was specifically created for collaborative singing and playing music over the network and is available to users free of charge. Due to the GNU General Public License (GPL), the software can be freely extended, and its further development is driven by the users.

Jamulus hosts its own server, which gathers and sends back the data to the users. Therefore, users do not need to generate a complex server structure, which significantly reduces complexity. The user interface is also comparatively straightforward, and the technical barriers are lower compared to competitors. The latency is low, although not as low as in other softwares. However, it is usually sufficient for collaborative music-making.

Jamulus is compatible with common operating systems such as Windows, MacOS, Linux, and Android. If the number of musicians is larger, it is advisable to set up an individual server, as public server capacities may be limited.

Jamulus has a large community since the software was developed in 2006. This community supports each other with frequent questions and provides guides on various platforms, making the initial setup much easier. The community also collaborates for joint events.

Advantages
- Latency: Jamulus has low latency, allowing for synchronized music-making without experiencing delays.
- Audio Quality: Due to the use of high-quality technology and specific data compression, the audio quality is relatively high.
- Customization: Manual adjustments in the software allow individual participants to regulate their output. This can compensate for differences in technical equipment and harmonize the sound. Each participant can adjust the settings to achieve a sound a customized to their needs.
- Real-time MIDI transmission: Jamulus enables real-time MIDI transmission, providing digital music information such as notes and control commands to all participants synchronously.
- Large community providing help with technical setup and questions.

Disadvantages
- Server: Jamulus requires the setup of a server for larger numbers of participants to transmit audio data. Technical knowledge and hardware are necessary for the setup.
- Technical Equipment: Participants depend on powerful equipment for good audio quality. Microphones, headphones, and audio interfaces, along with a strong and stable internet connection, are crucial. Both the equipment and the setup can be challenging for technically inexperienced participants.
- Limited User-Friendliness: Jamulus is an open-source software primarily focused on functionality for musicians. Its usage is relatively complex and not necessarily intuitive.

Soundjack

Soundjack is a specialized platform for low-latency data transmission, designed for collaborative music-making over an internet connection. Due to its specific data modulation, the latency of data transmission can be significantly reduced, resulting in synchronization without perceivable delays. Soundjack is a closed-source software (source code not visible), but it is available to users free of charge and offers platform-independent access via Linux, Windows, and macOS.

In the peer-to-peer method, no external server is required, and the software utilizes the buffer memory of the sound card. However, in some cases, a port extension may be necessary, which is explained through videos and FAQs.

The sound quality heavily depends on the settings of both the sound card and the software, which can be quite complex for non-experts. The user interface is described as user-friendly, offering a range of customization options for audio parameters within the collaboration.

Advantages
- Low Latency: Soundjack provides a particularly small latency time, assuming powerful hardware. Perceivable delays are almost non-existent compared to playing music in the same room.
- Audio Quality: Clear and detailed audio quality can be transmitted through the platform, enhancing the collaboration by capturing fine nuances of voices and instruments.
- User-Friendliness: Soundjack offers a user-friendly interface with several possibilities for individual adjustments of audio parameters during collaboration.
- Cross-Platform Compatibility: In addition to Windows operating systems, Linux and macOS can also utilize the platform and collaborate independently of a uniform operating system.
- Low-Latency Video Transmission: Video transmission is also possible with lowest delays, especially used in directed music scenarios.

Disadvantages
- Hardware Requirements: The very low latency depends on suitable and high-quality hardware, including the need for a seperate audio interface and adequate internet bandwidth. Good microphones and headphones also positively affect the audio quality.
- Complexity: The specialized software requires a certain learning curve. Depending on the user's experience, this may require more intensive time investment.

JamKazam

JamKazam is another cooperative music platform, like Soundjack and Jamulus, designed for live music-making over the internet, focusing on low latency and user-friendliness to enable synchronized and coordinated music collaboration. JamKazam allows both audio and video streaming, and it provides users with a library of many titles. Unlike other platforms, JamKazam offers staggered paid subscriptions, varying depending on the number of users and usage duration. JamKazam runs on both Windows and macOS.

Musicians can collaborate either in a peer-to-peer manner or through their own server, and the settings can be relatively complex.

Advantages
- Low Latency: JamKazam can achieve low, though somewhat noticeable, latency. It enables synchronous music-making, even if not quite reaching real-time performance.
- User-Friendliness: JamKazam prioritizes a high level of user-friendliness, making settings and configurations easily accessible, even for beginners.
- Server: The use of central servers, not hosted by users, allows for a quick and straightforward setup.

Disadvantages
- Audio Quality: The software compresses audio data during transmission, which may result in some loss of quality. Depending on the load of centrally hosted servers, there might be limitations in usage.
- Hardware Requirements: Good audio quality requires powerful hardware, including a strong PC, sound card, and audio interface.
- Premium Version: To access all settings, minimize latency, or allow a larger number of participants, a paid premium version is required.

ELK Live

ELK Live is an online platform for collaborative music-making based on MacOS. ELK Live works with both the computer's integrated hardware and external professional equipment via audio interface and microphone. As a relatively young software solution for low-latency music-making in the market, it offers free usage during the beta phase. It is foreseeable that the software will become paid with a fixed or subscription-based fee in the future.

Peer-to-peer usage is possible but not recommended. ELK Live recommends an external audio interface and LAN connection. ELK offers its own audio interface for purchase, which comes with relatively high costs, but it also supports any other audio interface. For other operating systems than MacOS, audio bridges are required, which ELK also provides for a fee. A version for Windows is currently in development. ELK prioritizes a high level user-friendliness of its software.

Advantages
- ELK Live was developed as an on-demand solution, enabling stable and low-latency music collaboration.
- The computer's integrated hardware can be used for music-making, although it is recommended to use an external audio interface.
- The online platform allows for parallel video conferencing, facilitating collaborative coordination.

Disadvantages
- For the most latency-free connection, an external audio interface is recommended, such as the „Elk Bridge," which comes with relatively high costs.
- As a relatively new software, the community is still small.
- The software is still in the beta testing phase.

JackTrip

JackTrip is an open-source software, making it freely accessible. The platform runs on Windows, MacOS, and Linux. JackTrip imitates spatial resonance to simulate the sound of live performances.

Both peer-to-peer and client-server setups are available, supporting both options based on the users' needs and number of participants. A wide range of settings are possible, allowing manual regulation of audio quality or latency based on transmission rate. For advanced users, additional settings are provided to configure audio data packets, playout buffering, or other adjustments. Due to the variety of options, the user interface can be quite complex and requires some time for initial configuration. JackTrip offers both a limited free version and paid versions, which may be required relatively quickly.

Advantages
- The open-source platform is freely accessible.
- The software is available for the common operating systems Windows, MacOS, and Linux.
- For users with limited IT knowledge, the JackTrip Virtual Studio version is available.
- No additional interfaces are necessary.

Nachteile
- Paid pro versions of the Virtual Studio are required relatively quickly when exceeding the number of participants or session duration.
- Stability may be affected by firewalls and settings.

Plattform	User-friendliness	Additional equipment required	Separate server required	Recordings possible	Costs
Jamulus	+	Separate microphone, headphones, possibly separate server	No, however, for larger groups, a separate server is recommended	no	none
Soundjack	+	Separate microphone, headphones, possibly separate server resp. external audiointerface	no, but possible	yes	none
JamKazam	++	Separate microphone, headphones, possibly separate server resp. external audiointerface	no, but possible	yes, from the paid Silver version onwards	Limited free usage, then staggered pricing from $4.99 to $19.99 per month
ELKLive	++	Separate microphone, headphones, external audiointerface, possibly separate server	no, but possible	yes	No costs in the beta version, paid subscriptions are planned
JackTrip	+	Separate microphone, headphones, possibly separate server, bridge and audiointerface	no	yes	No costs; when using JackTrip Virtual Studios Essentials, charges start at $8.25 per month

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About the project

The research project "Online Choirs: How to carry out virtual choir rehearsals with the help of digital tools" (Choir@Home: https://choirathome.com/) seeks to enable choirs to carry out online rehearsals. It was initiated by Dr. Janine Hacker (University of Liechtenstein, janine.hacker@uni.li), Univ. Prof. Dr. Heike Henning (Mozarteum University Salzburg), and Prof. Dr. Alexander Carôt (Anhalt University of Applied Sciences).
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