

Concert for Smartphone Network - Guide for software installation and performance

Andreja Andric
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The project

Concert for Smartphone Network is a music work for distributed networked smartphone ensemble involving minimum two and maximum four performers. This Guide covers two things:

- 1) the installation and use of software for laptop/server and smartphones for a performance of the work
- 2) a guide for how to perform.

Apart from one smartphone per performer, you also need either

- 1) a single laptop or desktop computer if the performers are all in one place, or
- 2) a remote server in case of a performance from different locations.

The remote server or the laptop is needed to handle the network communication between the devices.

The software

The software for network performance consists of three kinds of programs: 1) Server, 2) Client, and 3) Monitor. In a given performance there can be only one Server, one Client per performer, and typically one Monitor.

The Server runs on the computer (either the laptop or the remote server as stated above), the Monitor runs on the laptop, while instances of the Client run on smartphones. The network is structured as shown in Picture 1 below.

The role of the Client program is to play the music and provide an interface for the performer's input.

The Monitor can play the music, display the status of all the performers and display visual effects, but cannot be used to control the music flow. When performing a streaming show, a Monitor window is streamed from a computer, alongside video feeds from each performer while they play on their smartphones. This is because smartphones have small screens and it would become impossible to combine all the elements on a smartphone screen plus handle the streaming itself at the same time. A Monitor is also used in a concert hall to display the status of all the performers to the audience alongside visual effects.

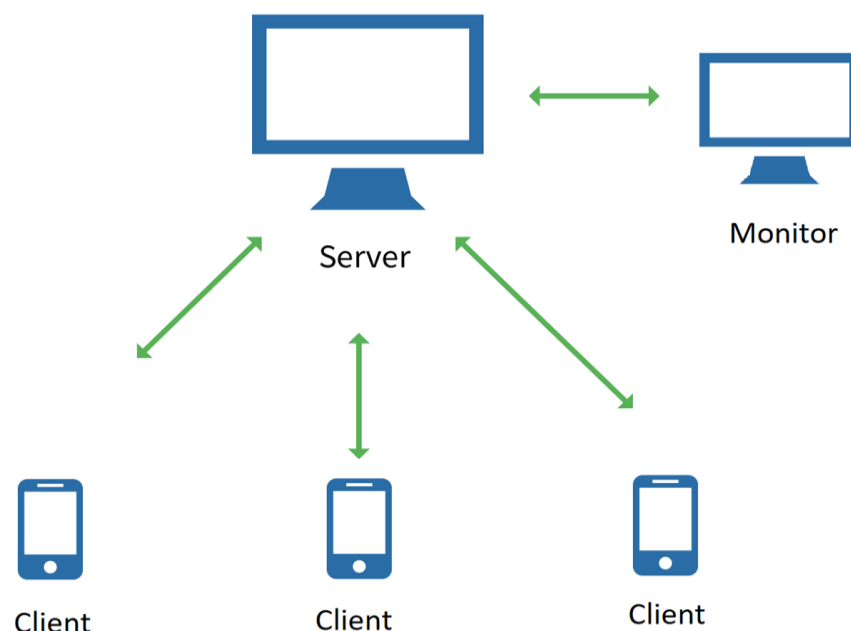
The role of the Server is to aggregate all the inputs, merge them together and send the combined result to each Client. The Server also performs other functions related to the overall flow of the performance.

The merging of the melodic fragments from each performer is done like mixing stacks of cards. The compound melody played by all the Clients consists of: first notes from melodic fragment belonging to each performer in order of enrolment; afterwards, second notes for each melodic fragment, and so on. Each performer controls exactly four notes at all times, therefore the length of the compound melody is always four times the number of performers.

In a performance, all the Clients will emit the exact same sound, so only one should be connected to a sound amplification system. The music flow will be synchronized at all times and eventual network delays (negligible, if the Server is running on the same local network but significant if the performance happens in different countries) will not cause interruptions in sound.

However, the sound output from different Clients will not be possible to synchronize exactly. This slight offset is due to it being impossible for all the players to press “Start” button at exact same time, and the application start to also happen in exact same time. This slight, but inevitable offset will result in a blurry sound if more smartphones were to be connected to the sound system. If, by chance, the sound outputs were exactly synchronized, then they would be exactly the same, and then again there is no point in having more smartphones connected to the sound system. For this reason, only the smartphone connected to the amplification system should play with sound on, the others should be muted, as otherwise they will play from their own speakers which would be confusing for the audience and offer an inferior sound quality. The only exception is that if there are no more than three performers, then the minor time difference between them will create an additional “echo” effect which will not blur the music altogether. In this case it is possible to perform with everybody plugged in with sound on.

Each performer runs the Client software on their smartphone. The Server program runs either on the additional laptop if the performance happens in one room, otherwise on a remote server if it is a concert with livestreaming from different locations, as stated above. If the performance happens in one room, but some of the performers play remotely, then again, you will use a laptop to display the Monitor, and also to connect to the remote server to run the Server.



Picture 1. Client-Server architecture of Concert for Smartphone Network

The Server program

The Server program is implemented in C. The program is compatible with UNIX and MacOS operating systems, but not with Windows. The source code provided has to be compiled on the target server machine with command:

```
gcc -lpthread NetPhoneServer.c -o NetPhoneServer
```

File ServerConfiguration.txt contains the port number that the server will use to wait for connections from the Client programs.

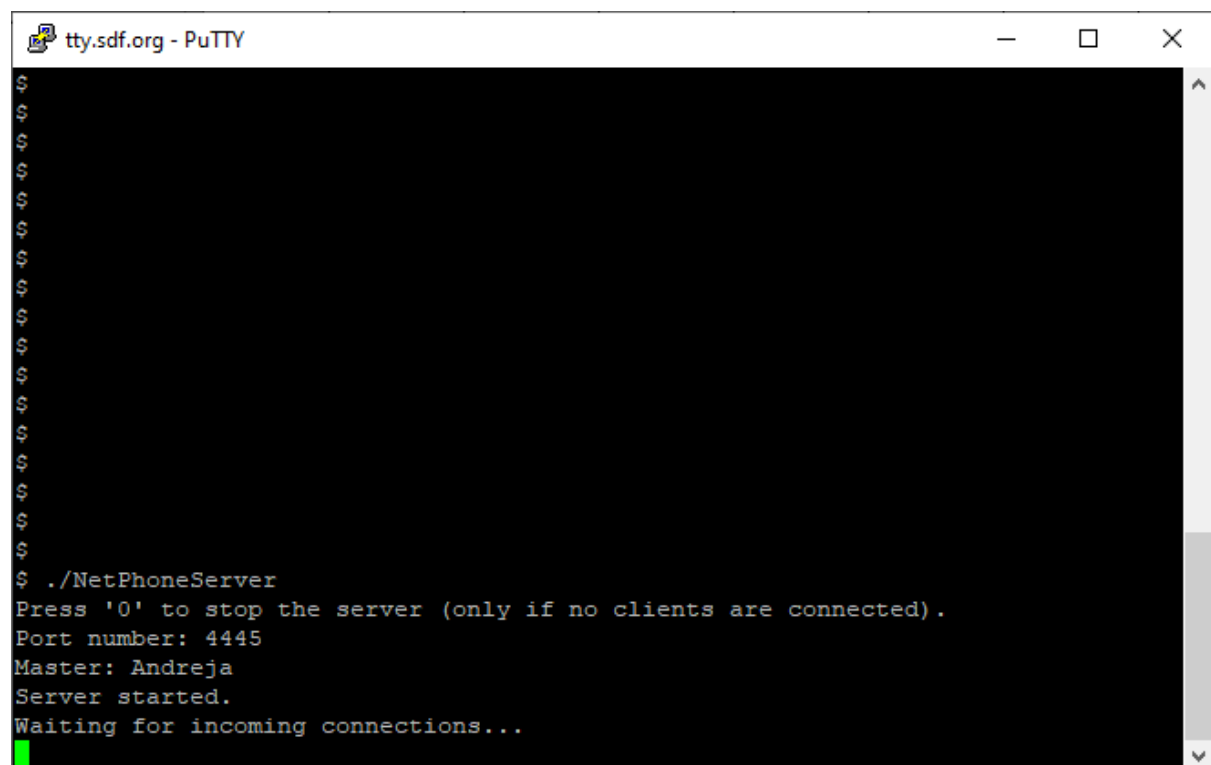
Example content of this file is:

4445

Run the Server program with command:

```
./NetPhoneServer
```

When configured correctly and run, the Server appears as in the screenshot in Picture 2 below. If it doesn't run because the Port 4445 is not available, then edit the file `ServerConfiguration.txt` by changing the port to 4446 or some other number and try again until it works.



Picture 2. Running the Server

In both cases, when no clients are connected, the Server will wait for connections. Stop the program by typing 0 (when all clients disconnected).

The Client and the Monitor

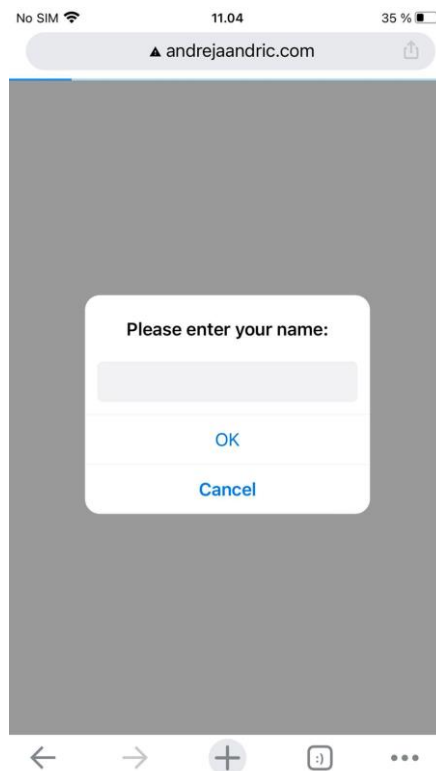
The Client program is a script inside the web page NetPhoneConcert.html. Once you have configured the Server as described above, you have to modify the line

```
connection = new WebSocket('ws://faeroes.sdf.org:4445', "Player");
```

so it contains the name of the server or its IP address and the port that you have configured in the Server part above. Then you have to upload the page to a web server from which you can access it with your mobile phone. Typically it will be a web-hosting provider, perhaps the one that is hosting your homepage. Otherwise you can consider running your own web server. This can be simplified if you run the Server on a public server on sdf.org (requires a one-time donation of 36\$). Then you can use the below page from the composer's website without any further changes, because it is already configured to point to faeroes.sdf.org server:

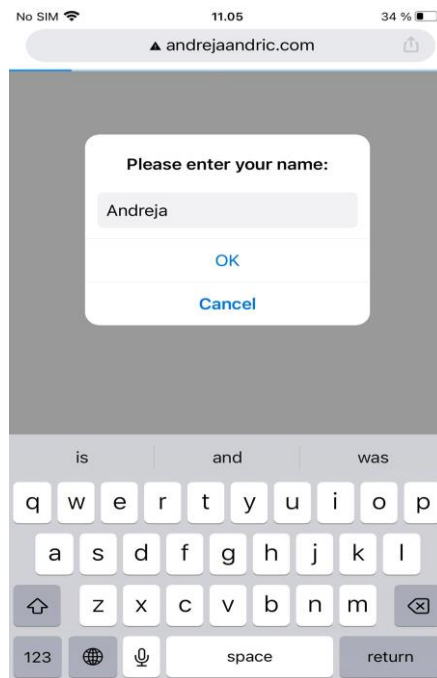
<http://andrejaandric.com/NetPhoneConcert.html>

Start the Server as described above, and open the NetPhoneConcert.html page on your phone. The first time you open it, you will be prompted for your name (Picture 3).



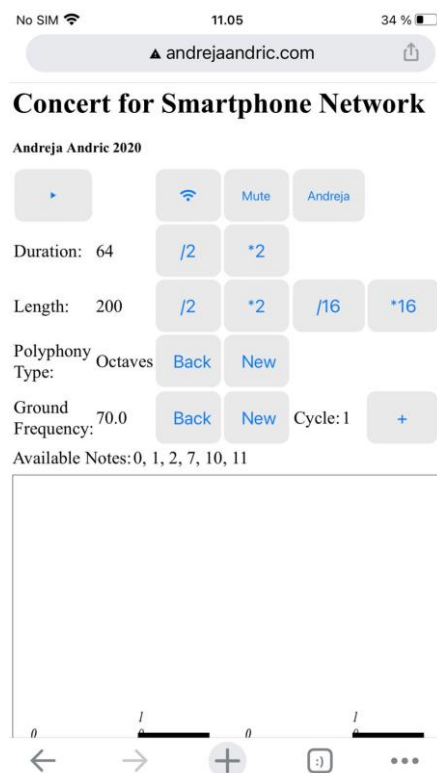
Picture 3. Prompt for entering your name

Type your name and press OK. Your name will be recorded in a cookie in your browser, and as long as cookies are not deleted and you use the same browser, the name will be recorded. See Picture 4.



Picture 4. Entering your name at the start of the performance

After successfully entering your name, you can see the interface to start and play the music (Picture 5).



Picture 5. Interface for playing the music

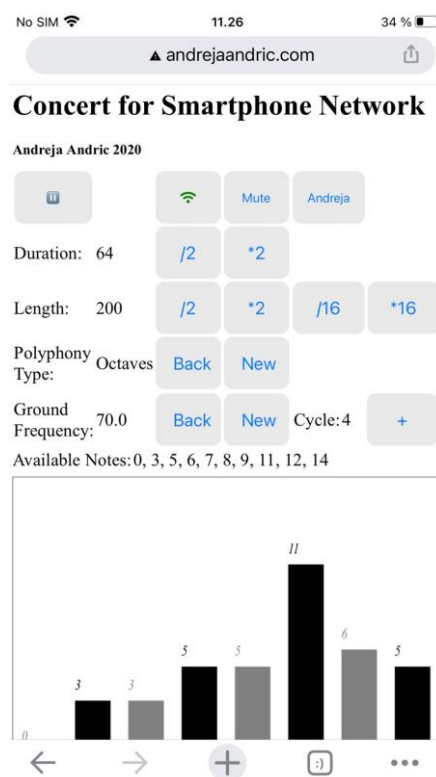
You can notice a button in the top right corner with your name. You can use this button to change your name if you need to. Press the button Connect. If everything is OK the network symbol will turn green. If there are problems, then it will turn red. In that case make sure that all the steps above have been made correctly, that the

Server is running and that you entered the server name or IP and the port correctly. If your performance is using a Monitor as well, connect it in the same way. The Monitor runs on a computer and you have to set the address in the same way as above: find the following line in the NetPhoneMonitor.html code:

```
connection = new WebSocket('ws://faeroes.sdf.org:4445', "Monitor");
```

and modify it to contain the name of your server and the correct port.

When the Server is running, all the performers' smartphones have been connected to it as described, and either one of the smartphones, or the laptop running the Monitor are connected to the PA system, the performance of the piece may begin. Everyone should press the Play button and the music will start. The Client interface, while playing, can be seen on Picture 6. In the following section we'll look at its controls in detail.



Picture 6. Client user interface, while playing

The Client User Interface

The User interface of the Client program consists of two sections:

- 1) Controls for activating the network connection and starting/stopping the performance (the top row of four buttons);
- 2) Controls for playing and guiding the music flow (all the other controls);

The controls to activate the connection and to start and stop the performance are the following:

1. Button Play – the Client starts/stops playing. If Muted is on, there will be no sound, but it will interact with other devices on the network.

2. Button Mute - this will cause the Client to not emit any sound while playing. This command has to be applied on all the smartphones that are not connected to the AP system, otherwise they will also emit sound through their speaker, and that is undesired.
3. Button Connect – Connects or disconnects to/from the network as described above.
4. Button with your name - you can use this button to change your name if needed.

Client UI controls for playing and guiding the music flow consist of several buttons and a histogram area. The histogram area displays the current state of the common melody and can be swiped to change the notes you are responsible for. The controls are the following:

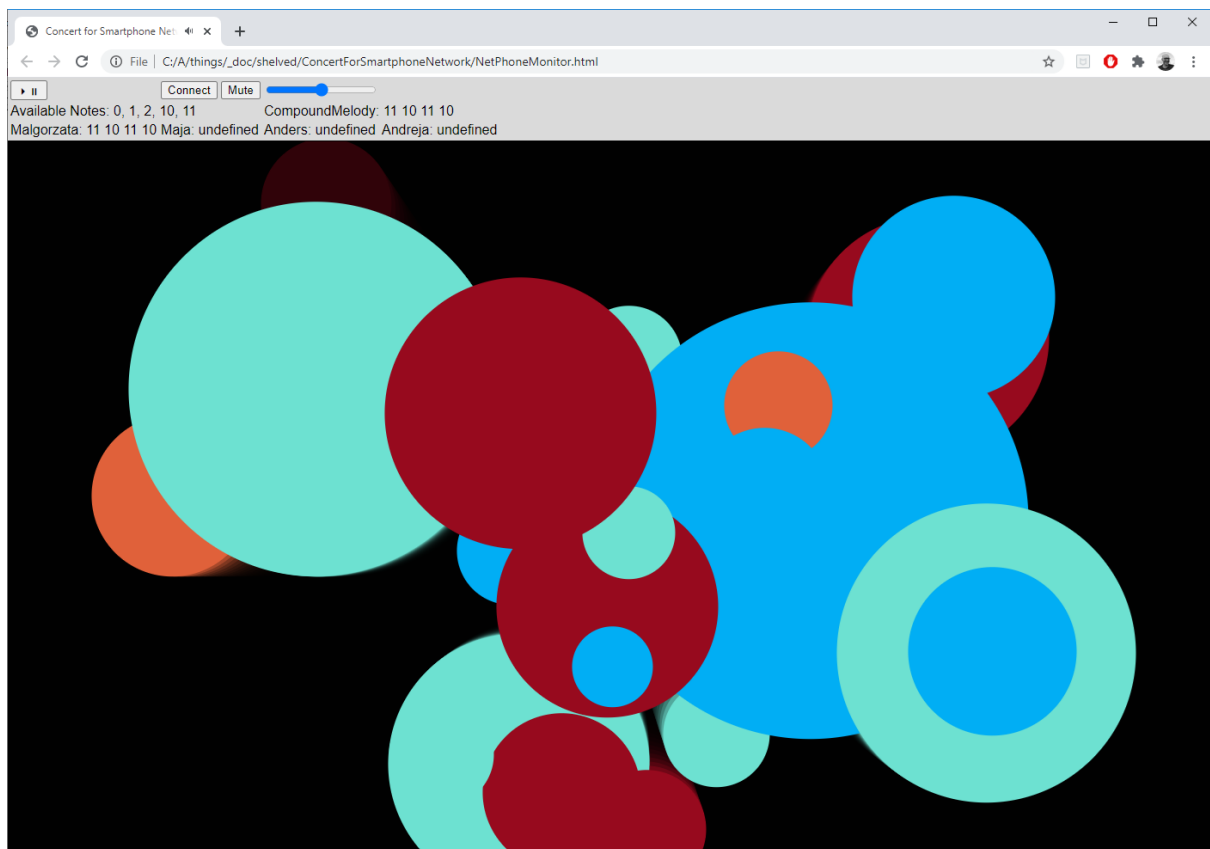
1. Duration - time in milliseconds between two subsequent notes. Can be doubled or halved using two buttons
2. Length - time in milliseconds between the start of a note and its end. Can be doubled or halved or multiplied divided 16fold using four buttons
3. PolyphonyType - a list of two fractions. The number of fractions indicates polyphony level: with two fractions there are always two voices. The music flow is rendered simply in two voices in parallel fourths, fifths, octaves, or in contrary motion, in short, equal rhythmical values. Can be either picked at random or reset to the start value using two buttons.
4. Ground Frequency - frequency in Hz of the note 0. Can be either picked at random or reset to the start value using two buttons.
5. Cycle + - starts a new section for all players.
6. Swipe up in the Histogram area – increases the pitch of the tone under your finger. You can influence only the four pitches that belong to you, which are in black color.
7. Swipe down in the Histogram area – decreases the pitch of the tone under your finger. You can influence only the four pitches that belong to you, which are in black color.
8. Swipe right in the Histogram area – swaps the tone under your finger with the next tone to its right.
9. Swipe left in the Histogram area – swaps the tone under your finger with the next tone to its left.

Duration, Length, PolyphonyType, and Ground Frequency are shared. This means that when one performer changes the value of one of them, it changes for the entire ensemble. The melody is not shared in this sense, but only part-wise: each performer controls exactly 4 notes in it as already explained.

The order of Installation and starting the programs

First install and configure the Server program as described above. Then open and configure the Client page on each performer's smartphone. Start the Server first, then the Clients. Connect the Clients using the button Connect. The performers not connected to the amplification system must press Mute button to mute the sound of their devices. Everybody presses Play on their devices and the music starts. When done performing stop each client with Play/Stop button and then Disconnect. Stop the Server by typing 0 if there are no connected clients.

The Monitor can be seen on Picture 7.



Picture 7. Monitor

How to perform

A typical performance of the Concert for Smartphone Network may last about 20-30 minutes, though the duration is free so it can be less or more depending on the circumstances.

Part of each performer consists of a series of sections, each of which is about 2-3 minutes long. Each section consists in a sequence of connected musical phrases. Each section starts with a simple repeating phrase which the performer gradually modifies through a series of steps until it reaches a new, different phrase which is also the beginning and "theme" of the next section.

To perform you need to know four things:

- 1) to construct a phrase out of tones,
- 2) to transform one phrase into another,
- 3) to use the above transformations to create a section out of phrases
- 4) to change the tone center or sound texture occasionally by modifying the value of one of the six global parameters (Ground Frequency, Duration, Length and PolyphonyType).

In the networked ensemble the sound output is merged from the inputs from all the performers. The merging of melodic fragments is done like mixing stacks of cards, as already described above.

Constructing phrases and creating sections

Each phrase in the Concert is a sequence of tones. There are only 15 tones from which all the phrases can be built. The frequency of the first tone, or ground frequency, is configurable via Ground Frequency parameter which states its frequency in Hz. This main frequency is usually between 100 and 180Hz. The main tone and the remaining tones form a scale tuned according to the following fractions with respect to the ground frequency: 1/1 6/5 5/4 4/3 3/2 8/5 5/3 2/1 12/5 10/4 8/3 6/2 16/5 10/3 4/1. This is summarized in Table 1.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1\1	6\5	5\4	4\3	3\2	8\5	5\3	2\1	12\5	10\4	8\3	6\2	16\5	10\3	4\1

Table 1. Each note shown as a fraction of the ground note

There are two ways in which the tones relate to each other:

1) Harmony: the higher numbers figure in a fraction, in other words, the more complex the fraction is, the more distant it is from the ground frequency in the harmonic sense and the more tense it feels compared to it. In this sense 7 and 14 are closest to 0. 4 and 11 are the next more distant. 3, 5, 10 and 12 are next more distant. 2 and 9 are the next. 1, 6, 8 and 13 are the most distant.

2) Pitch: the more distant the number is in pitch, the more remote it feels compared to the ground in the melodic sense. In this sense, 1 is closest to 0, 2 is the next most closest, then 3 and so on.

The length of a compound melody, made out of melodic fragments from every performer, is four times the number of performers. Each performer's melody is merged into a single one. Each performer controls exactly four notes. Therefore if the work is performed as a duo, then the complete phrase is eight notes long. If performed as a trio, then it is twelve notes long, and so on.

When you make a change in a phrase, the current state of the phrase is played out to the end and only then your change will take place and a new, changed phrase will be heard.

A phrase usually forms an arc using notes above. An arc can be complete or incomplete, straight or inverted, simple and combined. When these three divisions

are taken into account, alongside the fact that each musician has only four notes to work with, then there are five kinds of arc:

- 1) Complete, straight arc: 0 1 2 1, 0 4 7 4, 0 3 4 3, 0 4 7 11 7 4 etc
- 2) Incomplete straight arc: 0 4 7 11, 0 3 5 7, etc
- 3) Complete Inverted arc: 0 7 4 7, 7 4 0 4, 3 0 3 4 etc
- 4) Incomplete, inverted arc, 7 4 3 0, 3 2 1 0 etc

Apart from these four possibilities, the performer can occasionally create something that is not in arc form, like a simple repeated note, or an ostinato: 0 0 0 0, 4 3 4 3 or 0 7 0 7 and the like.

Taking into account harmony and pitch, 0 feels like "ground", like the beginning and end. 7 and 14 feel also somewhat like ground as well, but they also are distant from ground in the pitch sense, therefore their role is also good as peaks of a phrase arc (if the arc is taken as a type straight and not inverted).

A starting phrase is always generated automatically by the Client software using Brownian motion of the pitch. This happens on loading of the program and also on each use of the *Cycle+* button.

Starting from there, the performer proceeds to change it step by step using swipes up or down in the histogram area.

Transforming phrases

Transforming phrases is a stepwise process which creates a section from a phrase. Transformation of a phrase is a small change in it that increases or decreases the tension of it or changes its sound in a small way. Transformations should follow one after another to create a section that also has an arc form of one of the types described above. There is only one possible transformation: increasing or decrease a tone by 1 by swiping up or down on that tone. This increases or decreases the tension in the phrase by having one tone be more or less harmonically or melodically tense than the previous one.

Global parameters and changing texture

Global parameters influence the way each note is performed and are applied to the sound of the whole ensemble. There are four global parameters and all of them influence the texture of the currently sounding phrase. Change these sparingly, for example between two sections, or in the middle of one section. There can, though, appear a section or a part of a section where a simple phrase is lead through a sequence of texture changes and transpositions by changing these parameters. This should also be used very sparingly.

Duration - time in milliseconds between two subsequent notes. Can be doubled or halved using two associated buttons.

Length - time in milliseconds between the start of a note and its end. Can be doubled or halved or multiplied divided 16-fold using four associated buttons.

PolyphonyType - this parameter contains a pair of fractions. Namely each tone above is accompanied by one additional tone as these fractions indicate. If these are, say, 1/1 and 1/2 then each tone is accompanied by another tone half its frequency. If it is 1/1 3/2 then each tone is accompanied by another one which is 3/2 its frequency. In other words, there are always two "voices". The performance always consists of two-voice polyphony in parallel fifths, fourths or octaves, or in contrary motion. Can be either picked at random or reset to the start value (Octaves) using two associated buttons New and Back.

Ground Frequency - frequency in Hz of the note 0. Usually between 100 and 180. Can be changed to a random value or reverted to the starting frequency using two associated buttons New and Back.

When you want to move to the next section, press the button **Cycle +**. This creates an entirely new phrase for the whole ensemble).

The ensemble has to find the way to work together in the best way through practice and experience.