

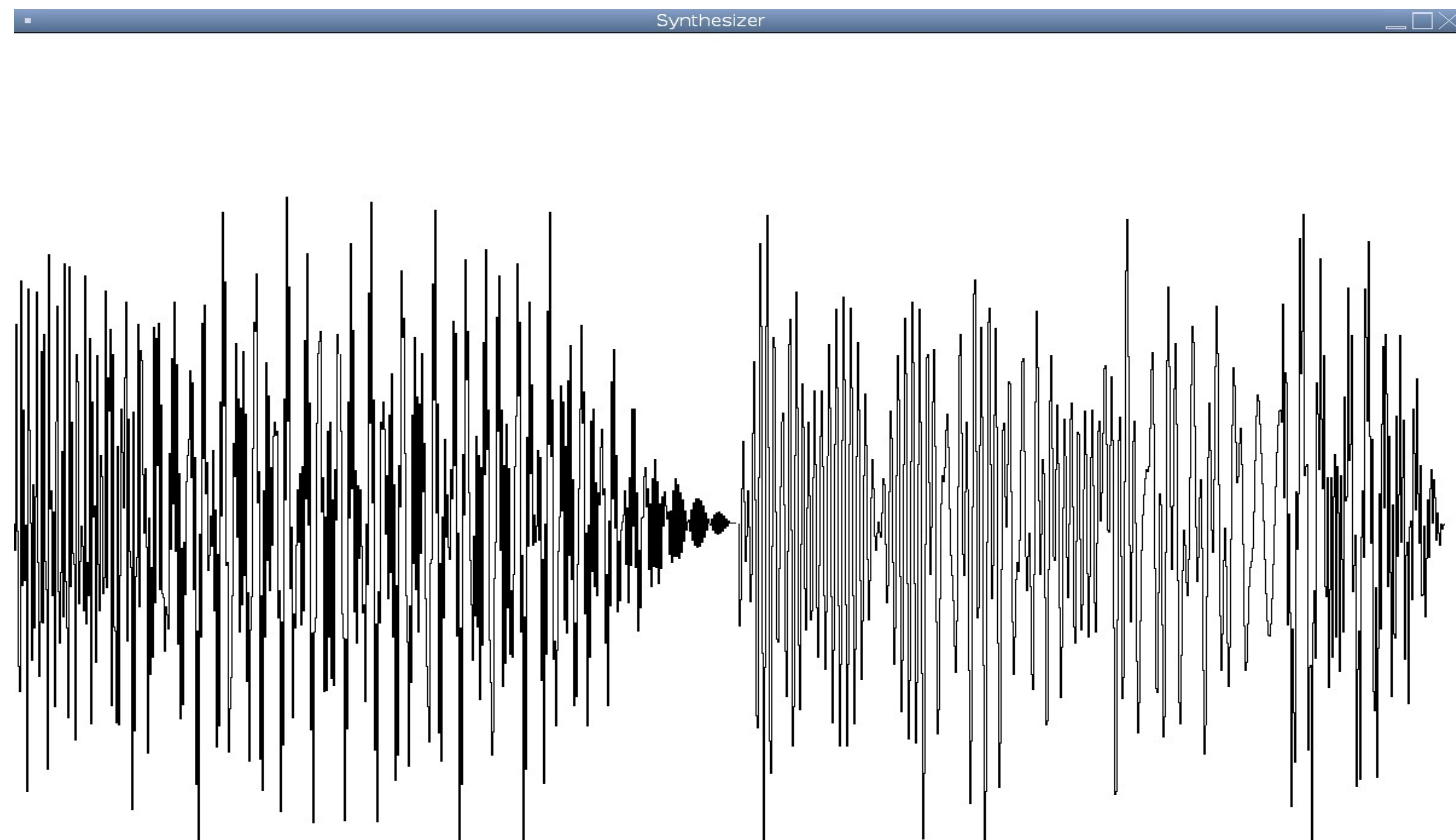
# Designing a Music Scripting Language

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## Abstract:

The problem addressed in this project is finding a way to describe music and implement turning it into a sound file. The language will cover basic notes with rhythms and articulations. It will take into account different instruments as well as multiple of the same instrument and allow continuous changes of certain factors like pitch, volume, and tempo, known as glissando, crescendo or diminuendo, and accelerando or ritardando. Currently, notes of different pitches and modifiers on the pitches can be recognized. An additional goal will be to expand it to include transposing and other computational music theory functionality.



## Background:

There has been a lot of work done in the area of computer music. A good survey of early work on computer music is Programming Languages for Computer Music Synthesis, Performance, and Composition, by Gareth Loy and Curtis Abbott. The focus of this paper is first to outline the various difficulties in designing a programming language for music, then discuss sound synthesis, and finally review many of the languages already created up to the time of publication (June 1985). There had already been a lot of advances in this area by 1985 as it was one of the earlier hard problems attempted by computer scientists.

For those readers not completely familiar with music, some basic terms will need explanation. The tempo is how fast the music is going and is typically measured in beats per minute (bpm). An accelerando is when the music gradually speeds up and a ritardando or rallentando is when the music slows down. The pitch is what frequency the note vibrates at, a higher frequency equating to a higher pitch. An interval is a ratio of frequencies, specifically an octave is 2:1. A glissando is when the pitch changes gradually. Volume is how loud the music is, with forte meaning loud and piano meaning soft. A crescendo is a gradual increase in volume while a decrescendo or diminuendo is a decrease in volume. There are also modifiers to notes that change one or more of the parameters, such as accents, accidentals, and other articulations.

### Sample Program

```
{import tempos}
{import volumes}
{def $i (tuba,trumpet,horn)}
{(initInstr)$i}
${i(noteType basic)}
${i(timeSignature 4:4)}
${i(tempo $allegro)}
${i(volume $forte)}
${i(test)}
{(tuba,trumpet,horn)(
([C2:1/2],[D2:7/2]),
([C4:1],[B3:3]),
([G3:4] tenuto),
([C2:3],[D2:1]),
([E4:2],[G4:2]),
([F3:1],[E3:1],[D3:1],[C3:1])
)}
${i(play)}
```

### Sample Output

```
initInstr,tuba,tuba,
...
horn,play,
tuba ins. tempo: 120.0. volume: 0.6. time signature: 4 4
trumpet ins. tempo: 120.0. volume: 0.6. time signature: 4 4
...
trumpet ins. Start: 2.0 . Stop: 3.0 for note 2 counts of E4(329.6275569128699)
trumpet ins. Start: 3.0 . Stop: 4.0 for note 2 counts of G4(391.99543598174927)
horn ins. Start: 0.0 . Stop: 2.0 for note 4 counts of G3(195.99771799087463) tenuto
horn ins. Start: 2.0 . Stop: 2.5 for note 1 counts of F3(174.61411571650194)
horn ins. Start: 2.5 . Stop: 3.0 for note 1 counts of E3(164.81377845643496)
horn ins. Start: 3.0 . Stop: 3.5 for note 1 counts of D3(146.8323839587038)
horn ins. Start: 3.5 . Stop: 4.0 for note 1 counts of C3(130.8127826502993)
```

## Procedures and Methods:

The first problem that was dealt with was how to keep the language concise. With four parameters for each note in addition to modifiers, describing each note and all of its aspects could yield a long and unwieldy text file. The solution that I came up with is mapping, which can be described by an example. As an example of mapping, the line "([C2:1],[C2:1],[C2:1],[C2:1])(staccato, tenuto)" under mapping will turn into "([C2:1] staccato,[C2:1] tenuto,[C2:1] staccato,[C2:1] tenuto)". This loops over all of the items in the first list and appends it to the corresponding item in the second list. If either list runs out of items, it starts over from the beginning of that list. It keeps going until the longer of the two lists is completed. This, once the program is completed, should drastically reduce the number of lines that one needs to type in order to describe the whole piece of music. In order to have two lists that don't map, currently I use curly brackets to encompass a specific need of mapping.

The design of the classes in this object-oriented project is one of the integral parts. The whole program is run by the driver, as is typical. The driver reads in a file and sends the contents to the parser which returns a list of commands. The driver then reads through the commands and execute them. As the driver goes through a proper file, it will create Instruments in a Hash Table. The instruments in turn keep track of an array list of Notes, as well as certain other parameters such as tempo, volume, time signature (class TimeSignature). The note keeps track of what instrument it is played on, its volume, length, tempo, and pitch. The note also stores this pitch symbolically and has some methods for computational music theory like transposition by an Interval. All of the volume, pitch, and tempi are stored in a Parameter class, which has a duration and a Function. The function can be of various types to take care of constant functions or glissandos/accelerandos/decrescendos. Various key parameters (both parts of the key signature, duration of notes) could be stored as a double, but more exactness can be had by storing them in a Rational class that was written for this project, involving adding and multiplying with stored numerators and denominators.

I went about generating sound by a method known as additive synthesis. Using this, generating sound involves adding several different frequencies of sine waves to create a single instrument sound. All of these sounds are then added together to create the final piece of music. In a typical instrumental sound, like a wind or string instrument, there are a series of harmonics generated at frequencies twice, thrice, four times, and so on of the fundamental frequency. The various ratios of the magnitudes of these harmonics are what makes a clarinet sound different from a trumpet or cello. Currently, I only use the fundamental frequency. The next step is to add tone to the notes.

The first section of output has the parsed program. The second section describes all of the notes recorded by each instrument as well as when the notes start and stop.

## Results:

Some sample outputs are given above and to the left. The samples to the left are a sample script to input into my program and then a sample output describing the notes. As sound is hard to put on a poster, above is a picture of the wave generated. In summary, the project was successful, but has lots of room for expansion.