A short introduction to music

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Abstract

This paper introduces basic musical concepts like bars, rhythms and how notes corresponds to specific frequencies. It then shows some rules how notes can be combined in order to sound pleasant. Finally, it introduces the blues scheme as a practical example.

1 Introduction

While the main goal of the Soundgates project group is to develop a customizable synthesizer system, the project also comprises the realization of concrete interactive patches with this system that show its capabilities. A concrete installation however, which not only produces unpleasant noise but some kind of music, goes beyond the technical aspects of creating and manipulating waveforms. We will need to enter the domain of music and harmony to create something that actually sounds pleasant.

This paper tries to provide a short introduction to this field. It can definitely not condense years of musical experience into a few pages of text and enable anyone to be a great musician thereafter. In fact it rather tries to establish a common basis by introducing basic concepts of music and to show examples of what might sound good.

2 Related Work

Music might be almost as old as humans themselves and there are countless books on the myriad of different music genres. Unfortunately, I had very little previous experience in this field. As sources, I therefore used mostly introductory literature. "Physikalische und psychoakustische Grundlagen der Musik" [4] explores the physical basis of music and tries to explain on a scientific level why music sounds good. "Grundlagen und Erscheinungsformen der abendländischen Musik" [2], "Allgemeine Musiklehre" [7] and "Neue allgemeine Musiklehre" [1] introduce musical concepts on a musicians level.

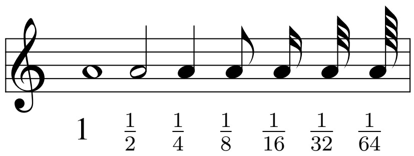

Figure 1: Note values

As long as not stated otherwise, all of the following informations are taken from these sources.

3 Basic musical concepts

Since this paper is part of a computer science course, this first section will shortly introduce basic musical concepts and notations, since it must be assumed that readers do not have any previous experience in this domain.

3.1 Rhythm

The first characteristic of a song is its rhythm. Rhythm means a sequence of durations of notes and pauses between them. A single drum for example has few possibilities to emit different actual sounds, but by varying in time it can still create many different structures.

Formally, a rhythm begins with a steady pulse (Grundschlag), that means beats with the same time in between them. Such a pulse is necessary because actual rhythms are not directly bound to absolute time, like playing the next note after x milliseconds but to this pulse. Fractions of a beat denote how long or when to play a note. Therefore, by choosing a slower pulse, the whole song will become slower while the proportions of single notes to each other stay the same. Those fractions are called *note values* and are displayed in a musical score as shown in figure 1.

It quickly becomes difficult to accurately match these timings correctly, if used in the simple manner that was just introduced. Practically, notes are furthermore grouped into bars (Takte). The notation of a bar is twofold: The first declaration indicates how many beats belong to one bar. The second one assigns a note value to the beat itself. Counting every beat as introduced before would correspond to a $\frac{1}{1}$ bar.

Default bars would $\frac{2}{2}$, $\frac{2}{4}$, $\frac{3}{4}$ and $\frac{3}{8}$. In these examples, one would count 1, 2 or 1, 2, 3 respectively. The first note in this sequence is furthermore played stronger such that one can identify the beginning of a bar by just listening.

Composed bars like $\frac{4}{4}$ assemble from the default bars. They often carry even more accentuation on their single notes, e.g. very strong - weak - strong - very weak.

In a setup with multiple instruments, one instrument or a conductor (Dirigent) indicates the bar to which the other instruments may align even more complex rhythms.

3.2 Pitch

So far a rhythm does not take into account how the played notes actually sound, apart from their intensity when grouping them into bars.

The second part that characterizes a song is the pitch of its notes, which corresponds to the frequency of the sound wave. The human ear perceives these frequencies in a logarithmic fashion within a range of around 20 to 20.000 Hertz. It is furthermore not a completely precise measure. Small changes in the frequency may not create a different audible sensation for a listener. ([4] p. 27)

3.2.1 Tone systems

Instead of playing arbitrary frequencies in a piece, actual notes arise from tone systems with specific rules. These systems assign functions to notes and relations between them. [6] Around the world different systems exist, each with its distinctive characteristics. This paper will only refer to the so called *diatonic*, *chromatic* and *enharmonic* system, which by far prevails in modern, western music in which notes are labeled from A to G and written down like already seen in figure 1. Together with the so called clef, which can be thought as an offset, the placement on the lines determines the actual note and depending on the tuning the frequency that needs to be played.

A common basis to many systems is the notion of an *octave*. An octave means the interval between one note and another with double or half its frequency. For example, an a' has a frequency of exactly 440 Hz. The note one octave higher is an a" and has a frequency of 880 Hz. Apparently, notes an octave apart sound similar to the human ear and therefore form a natural interval.

3.2.2 Further subdivision and tuning

Characterization of a tone system stems from the subdivision of octaves in smaller steps. An often employed system is an equidistant scale of 12 so called half-tones. Since an octave was just defined to have a proportion of 2:1 from one frequency to another, single adjacent half-tones within an octave therefore have a proportion of $\sqrt[12]{2} : 1$. The 12 half-tones correspond to the black and white keys on a keyboard as seen in figure 2.

The distinction between black and white keys is mostly historical. The seven white keys correspond to the notes from A to G and are called *natural notes* (Stammtöne). Since the lines in a score correspond only to the natural tones, a half-tone in between is noted by a preceding *sharp* or *flat* to either increase or decrease the notes value by a half-tone. These prefixes are called *accidentals*. This also leads to the possibility of *enharmonic equivalence* which means that the same note may be displayed in different ways. Figure 3 shows all notes from one C to an octave higher in an ascending and descending fashion. The full set of twelve notes from one octave to another is also called *chromatic scale*.

The lowest defined note is an A0 with a frequency of 27,5 Hz.

Different epochs and cultures employ other tunings. The pythagoraen tuning for example was common in medieval Europe and based around the idea of tuning notes in a

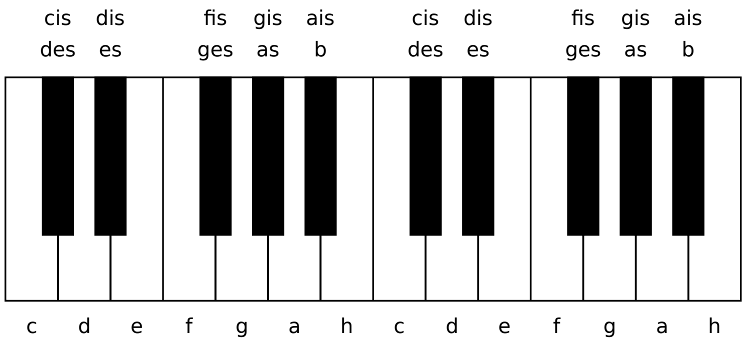

Figure 2: Normal Keyboard

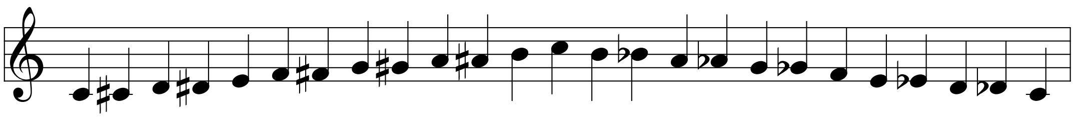

Figure 3: Ascending and descending chromatic scale

proportion of 3:2 and octavating notes if they become to high or to low (i.e. dividing the frequency by powers of two if it is outside the range of two times the base frequency). However, the pythagorean tuning is unable to exactly reach the next octave precisely. To fix this issue the last notes pitch is reduced to match it. Furthermore, the enharmonic equivalence is not necessarily given anymore.

3.3 Timbre

Lastly, different instruments can often play the same notes frequency wise, yet they still sound differently. This is due to the fact, that the emitted sound of real instruments assembles from a multitude of overlapping frequencies. The lowest frequency is the fundamental frequency and determines the perceived pitch. Additionally many overtones, which are multiples of the fundamental frequency overlap and create the distinctive sound of an instrument called timbre, or sound color. The sound of combined overtones has something inherently well sounding, because it is a natural phenomenon. Pure sine waves can only be generated artificially and sound rather unpleasant when played alone.

4 Combining single notes

4.1 The major scale

The *major scale* (Dur Tonleiter) is, as the name implies, one of the most important scales in classic and also popular European music. Remember how the equidistant scale was constructed in section 3.2.2. Any subset of these twelve notes that uses only eighth notes

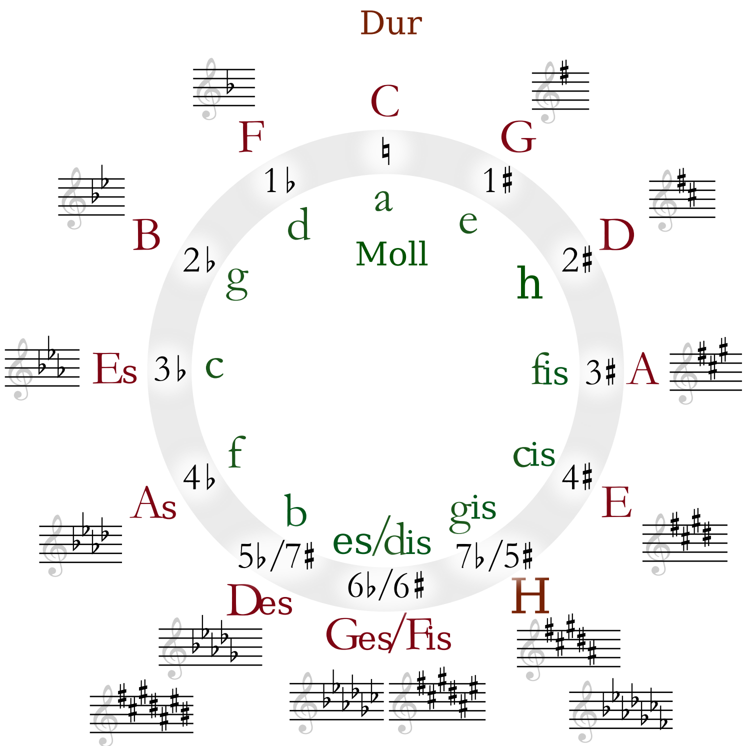

Figure 4: Circle of fifths [3]

and still spans an octave is called a *diatonic scale*. It follows that a diatonic scale comprises of five whole steps and two half steps. The major scale arranges these steps in a pattern $11\frac{1}{2}111\frac{1}{2}$. In the case of C major (i.e. starting at note C) this overlaps with the layout of the white keys on a keyboard.

The notion of such a reduced scale is in so far useful as typical music pieces do not leverage the whole chromatic scale in equal parts but prefer a smaller set of notes, as they generally sound harmonic in combination with each other, at least to the European ear. Section 4.2 elaborates a little further on the backgrounds. The remaining notes that are not present on the major scale are of course used as well, but to a smaller degree.

4.1.1 Circle of fifths

An important tool in combination with the major scale is the circle of fifths (Quintenzirkel). Not all pieces need to be C major, but can use any other note as a starting point. In order to still match the $11\frac{1}{2}111\frac{1}{2}$ pattern, some black keys need to be used. The circle of fifths shows which ones that are for a chosen base note by displaying on which line to put accidentals.

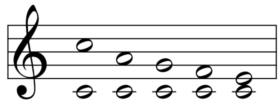

Figure 5: Consonant intervals

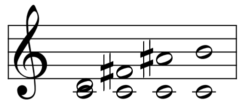

Figure 6: Dissonant intervals

4.2 Consonance and dissonance

Whether we find single combined tones pleasing (consonant) or not (dissonant) cannot be answered universally, because it differs from culture to culture. As a general rule of thumb, however, it can be said that tones sound more consonant the easier their frequency proportions are. I already mentioned the *octave* as a fundamental interval with frequency proportions of 2:1[1]. Other, generally pleasing intervals are the *perfect fifth* (Quinte) with proportions 3:2, which was used to construct the phytagorean scale and the *perfect fourth* (Quarte) with 4:3 and of course the *unison* which is the same note played again. These are also called *perfect consonances*.

Furthermore there are also four *imperfect consonances* namely *major and minor thirds* (große/kleine Terze) 5:4 / 6:5 and *major and minor sixths* (große/kleine Sexte) 5:3 / 8:5. Instead of expressing these intervals as proportions, one can also see them as note steps on our scale. A *major second* (große Sekunde) is one note step, for example from a C to D. A *major third* is then two seconds (C to E), and so forth. All other intervals not mentioned here are generally considered as dissonances.

Figures 5 and 6 show examples for consonant and dissonant intervals. Note that the notes do not need to be played simultaneously as a *chord* to appear consonant or dissonant. Subsequent notes that form a *melody* are also subject to it.

It is not the case that dissonances are generally a bad thing that needs to be avoided. Songs that are composed of only consonant notes might even sound rather boring and less lively because dissonances add tension. This tension, however, needs to be resolved by playing further notes. Figure 7 shows a dissonance which is preceded and followed by consonances.

While this example certainly is not a great piece of music, at least it does not leave the listener unsatisfied. If the last note was omitted, it would create an anxiety for resolving the dissonance. Likewise, if the piece started directly with the dissonance, the entry would sound somehow unpleasant and sudden.

[1]These proportions here relate to the so called Just or Pure tuning, which differs slightly from the equal tuning

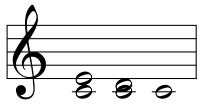

Figure 7: Employing a dissonance

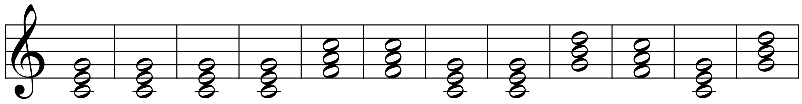

Figure 8: Blues scheme as notes

4.3 Chords

From the major scale emanate characteristic chords. These are just three (or more) notes played simultaneously. The chords of the major scale consists of the base note (which also identifies the chord), a third and a fifth. In the case of a C chord in C major, these would be C E G. Chords sometimes serve as a conceptual basis for musical genres, e.g. the blues as described in section 5 and some instruments also revolve more around playing chords than single notes. On a guitar for example, usually multiple strings are played at once in a way such that they create a major scale chord.

5 Example: Blues

The basics that have been discussed so far should now be combined into a practical example.

Musical genres are often defined by some self imposed rules that define basic structures of a song. One can then play with variations of these structures and extend them to create something unique. If not already reached, at least this is the point where science ends and art begins.

One of these basic schemes will now exemplarily be presented here, namely the blues with 12 bars. Variations for 8, 16 or 32 bars exists, but they are omitted here. Firstly, one picks a base note and looks up the accidentals in the circle of fifths. The blues scheme now assigns one specific chord to each bar, as seen in table 1 [5]. Exemplarily C major is used as a scale.

Written out as notes this would look like in Figure 8.

While this already sounds quite nice and a bit familiar, one might only barely associate it with blues. After all, only full notes are employed which results in a very slow tempo, but this is the basis for a blues. We will now modify this further.

Assuming a $\frac{4}{4}$ bar we can split the chord into a melody of two quarter and one half notes. This adds some dynamic and speed. Since the notes are no longer played in unison but in sequence, it sounds a bit different of course, but still comparable.

Bar	Level	Chord
1	1	C
2	1	C
3	1	C
4	1	C
5	4	F
6	4	F
7	1	C
8	1	C
9	5	G
10	4	F
11	1	C
12	5	G

Table 1: Blues scheme chords

Figure 9: Boogie Woogie

The imbalance in note values might leave us somewhat unsatisfied. Unfortunately we cannot fit three notes cleanly into a $\frac{4}{4}$ bar. What we can do is just to add another quarter note that is consonant. It still remains a blues because we still have the chord in the beginning and then just some filling material.

Let us enhance what we have got so far even further. We reduce our notes to eights and add further ones. The notes seen in Figure 9 would correspond to the first bar of a blues. This particular scheme is called a boogie-woogie.

So, what can we do with this now? These note patterns surely are much simpler than a classical piece of Mozart or Beethoven. These patterns usually are not meant to stand on their own but to be played along with other instruments and maybe a singer. We could for example transfer them into the bass line and play something else as a melody. Or we could have a singer sing along. The benefit of these schemes is, that we do not have to think that much whether some sequence of notes sound well, because well sounding sequences are already given. We may modify them and improvise a bit without having to worry that much that the result might sound bad.

6 Conclusion

In this paper, I tried to work out the basics of music and to answer the general question which rules exists that define whether a piece of music will sound pleasantly or not. The latter however can hardly be answered easily and universally. We can observe, that predefined patterns and variations thereof exist as exemplary shown with the blues. Such schemes could also be implemented relatively easy and rules that may apply could be triggered interactively.

However, complex automatic compositions that go beyond basic rhythms are much more difficult. There exist more general rules in harmony that outline the interactions between notes but grasping and implementing those is beyond our reach.

Overall, I would propose to leave the creation of music to the musicians. It is difficult enough to grasp the theoretical music concepts with no prior experience in playing an instrument. One simply does not have a feeling for what they really mean and sound. Many musical concepts have not even been mentioned in this paper. Even knowing some of the theoretical music concepts and physical properties that lie beneath cannot replace practical experience in actually making music, which musicians acquire over the course of many years. Finally, creating music is not a hard science that can be reduced to atomic parts, but an art.

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