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Implementation of Emotion in Music Composing Based on Nyquist

Yuya Meng[1,a,*]

[1]Olive Tree International Academy, Hangzhou, China
a. 22210860049@m.fudan.edu.cn
**corresponding author*

Abstract: Music has been considered as a tool to express emotions. This study aims to find relationships between emotions and musical factors. Final emotion sound samples have been produced based on a review of previous research findings. There are five emotions being selected， including joy, anger, fear, sadness and calmness. All sound examples are produced purely through Nyquist programming. By using computers to generate sounds, man-made effects on emotion demonstration due to different performance styles and personal feelings could be excluded. Also, lyrics are not considered, so there will not be any intended emotional orientation in the wording. Therefore, musical factors could be better compared without biases and factors that cause effective emotion modification could be identified. At the same time, how different valance and arousal correspond with and will be changed through differences in certain acoustic cues has been discovered. This article provides examples of using computer-generated sounds and identified acoustic cues to demonstrate the effectiveness of using only sound and melody to showcase emotion.

Keywords: Nyquist, music composing, emotion implementation

1. Introduction

Sounds started to be produced by computers in 1947 using Eniac [1]. In early 1960s, Max Mathews wrote the first real music program at Bell Labs and created a 17-second piece that was performed in New York on an IBM 704 computer [2]. In 1960, MUSIC III introduced the concept of a "unit generator", a subroutine that would create a specific kind of sound and only needed a few numbers from the composer. A huge part of development in analog synthesizers of the early 70's was in building larger and larger sequencers. In 1985, Barry Vercoe of MIT made a version of MUSIC that could be compiled for any computer that supported the C programming language. Having previously been used for sequencing external gear via MIDI, computers at last started to become audio recording devices in their own right in the early 1990s. The future of computer music might lean towards computers or AI writing music instead of humans [3].

There have been multiple researches on the relationships between music and emotions. Juslin and Laukka [4], researchers at Uppsala University, have found patterns between musical expressions and emotions by reviewing a massive number of studies related to the topic. They listed out the emotions and the acoustic cues each study was aiming for and divided most emotions into 5 categories- anger, fear, happiness, sadness and low-tenderness. Apart from the acoustic cues identified above, they also

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further detailed emotions' association with the proportion of pauses, jitter, articulation, vibrato and other factors. Anger is with a small proportion of pauses, high jitter, staccato articulation and large vibrato. Fear is with a small proportion of pauses, staccato articulation and small vibrato. Happiness is with a small proportion of pauses, high jitter and staccato articulation. Sadness is with a large proportion of pauses, low jitter, legato articulation and small vibrato. Tenderness is with a large proportion of pauses, legato articulation and small vibrato. However, certain emotions may not show a clear correlation with a certain factor. For instance, high or low jitter does not necessarily affect much the expression of fearful emotion, and the large or small vibrato also does not inevitably show a strong influence on the manifestation of happiness. An article from the American Journal of Psychiatry has concluded how vocal indicators suggest an emotional state [5]. According to the table, the relationships between voice and emotion on tempo and loudness are generally consistent with what Juslin and Laukka found. According to researchers from the University of Toronto at Mississauga, music emotions are also related to major and minor modes [6]. Analysis shows that people perceive and feel happiness more through a combination of fast tempo and major mode compared to slow tempo and minor mode. For sadness, slow-minor is the best combination. Consistent cues to emotions like fast-major and slow-minor show stronger relationships to emotions than conflicting cues like fast-minor and slow-major. However, when perceiving happiness, fast-minor ratings for happiness are higher than slow-major. Also, slow-major makes people much sadder than fast-minor. This might indicate a more inclination toward tempo and speech rate when feeling emotions. Similarly, other scholars suggested using major and minor chords to express joy and minor chords for sadness [7]. The book further claims that other intervals and chords are suitable for different emotions. Diminished chords and tritone could be used for scary music and create a sense of tension. Intervals like perfect fourth would be perfect for a joyful melody. Small intervals are good at representing both calmness and sadness, but calmness is better with major chords while sadness uses a minor one. Suspended chords and dissonant intervals can demonstrate angry music.

Based on an article published in Psychology of Music, instruments with different musical characteristics were associated with emotions [8]. Participants in the test were asked to classify different instruments with different durations to certain emotions. Five-second of piano with major mode, strong timbre, rapid tempo, five-second of guitar with large intervals and three-second of Tuba with staccato and high volume were considered happiness by the majority of people. Four-second of cello with "shivering" vibrato, low volume and four-second of Guitar with rapid touch and ascending volume and tempo were declared by the majority of the participants as fear. A high majority of participants believed sadness could be heard from five-second of electric bass with minor mode and five-second of a piano with low volume, slow tempo. None of the three angry sounds was correctly identified by a large majority of people, with the most suitable one being the three-second Tuba sound with staccato, low pitch and short intervals between tones. In order to have a clearer understanding of how sound affects our emotions and how different characteristics of sound could alter emotional expressions, based on others' work and personal interpretations, this work create different pieces of sounds that could be identified by most people as music with certain emotions. The emotions are joy, anger, fear, sadness and calmness. However, barriers to success may be the inconsistent thoughts on how an emotion would sound between audiences and researchers.

2. Data and model

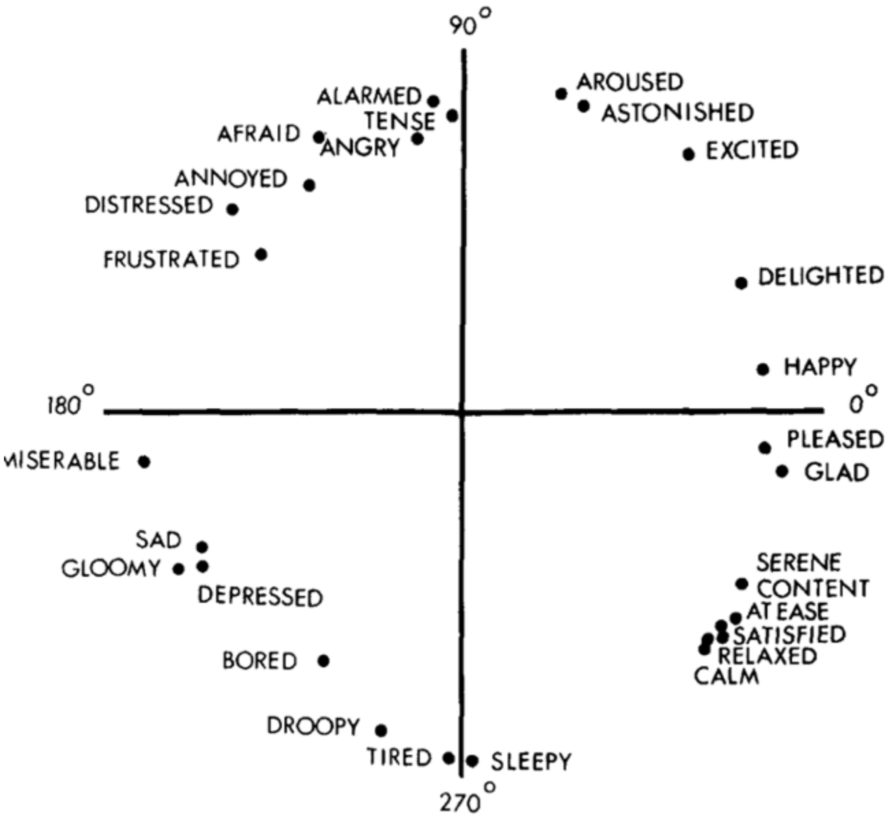

Figure 1: Model identified by Russell [8].

According to Russell [8], a professor at British Columbia University, emotions have inter-relationships with each other and could be represented in a spatial model with pleasure-displeasure and degree-of-arousal dimensions, as shown in Figure.1. To explain in a simpler way, arousal is the intensity of an emotion and valence is about the positivity and negativity. To better understand how emotions perform differently in sounds, one emotion has been chosen from each dimension. To compare how emotions in the same dimensions would be dissimilar with slight variances in arousal and valence, two emotions from the same dimension were selected. In total, there are five emotions – joy, anger, fear, sadness and calmness. Joy is with high arousal and positive valence, sadness is with low arousal and negative valence, calmness is with low arousal and positive valence, both anger and fear have high arousal and negative valence. By choosing these emotions, there might be a chance to find relationships between arousal-valence and other musical factors. During the process of generating sound, references to musical factors were used.

All sounds are generated through Nyquist directly. No sounds were processed externally. During the process, this study uses Nyquist as the only programming tool and occasionally used Audacity only to join two sounds together. Nyquist is a language for sound synthesis and music composition [9]. It is implemented in C and C++ and runs on Win32, OSX, and Linux. Nyquist combines a powerful functional programming style with efficient signal-processing primitives. Nyquist is also embedded as a scripting language in Audacity. Nyquist is a sound synthesis and composition language offering a Lisp syntax as well as an imperative language syntax and a powerful integrated development environment [10]. It is an elegant and powerful system based on functional programming.

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3. Results and discussion

3.1. Fear

For the Fear sound, the tritone was used. To make it shivering, fmosc and lfo were used and an envelope was added from outside. Noise and lfo were used to generate the shuffling sound, which was meant to mimic the sound of leaves and footsteps. Then two very low notes and lfo two were used to mimic the heartbeat. In general, it goes from crescendo to decrescendo. A period of silence was intentionally left blank, because under extremely nervous conditions like scare, people tend to ignore the sounds of the environment and focus on their heartbeat, while the speeding up of the heartbeat creates tension. At the end, a descending pitch makes a creepy sense of feeling that is like a wind blowing through.

3.2. Calmness

For calmness, it is slow and soft. The whole sound is continuous and the pitch attack is slow. A simple melody was first created on the computer and then Nyquist was used to output it. To further differentiate it from sadness, which is similar in many ways to calmness, the sound was made clearer and smoother. Thus, the state of calmness tends to be focused without many mood variations.

3.3. Sadness

To differentiate sadness from calmness, instead of major chords minor ones were used. Partial and the envelope were used to make the blurry sound. There are not only descending pitches but also echoes that ascend and then descend in a pattern as well. The reason for creating a blurry sound is to mimic the dizziness of the head when crying or being sad out of anxiety. The echoing behind is to show the long-lasting effect of sadness and how it is hard to stop crying immediately because there will still be constant sobbing going on afterward.

3.4. Anger

For anger, a higher pitch was generated using osc, while several different bumping sounds was generated independently using osc and lfo. They were then put in different time positions in Audacity to make the final one. However, this anger sounds calmer than madness and still needs further modifications.

3.5. Joy

The melody was first created on the piano. Buzz sound was used for high pitches as the shorter duration and attack time make people’s hearts less heavy. This piece of sound is created fully based on the references of related works with a fast tempo, major chords, perfect fourth intervals, pitch contours going up and tone attacking quickly. Buzz sound was not used for lower notes for it did not give a feeling of sustainability.

3.6. General

When creating sounds, synthesizers were first created according to previously identified traits. Then the melody was created using certain chords and intervals. When distinguishing different valence, changing chords and intervals could be considered as an effective method. Emotions with negative valence like sadness, anger and fear usually correspond with minor chords and dissonant intervals. On the other hand, emotions with positive valence tend to be perceived accurately when using major chords and intervals like perfect fourths. When considering arousal, higher ones could be better presented using fast tempo, high voice intensity and pitch contours going up. Vice versa, slow tempo, low voice intensity and its variability and pitch contours going down could be used to represent emotions with low arousal. Emotions in the same dimension of the arousal-valence model still show differences. Fear and anger have opposite sound levels and tone attacks. Apart from using arousal and valence to differentiate corresponding musical factors, personal perception of certain emotions could be added. The position of crescendo and decrescendo could be used in the process of change.

4. Limitations and prospects

The melodies created here are still quite simple. Instead of generating music that can evoke a certain kind of emotion, this study is more like using sounds to represent a certain kind of emotion. Moreover, there might be further effects that are hard to generate through Nyquist. For example, imitating instrument sounds that are not built in Nyquist could be difficult if people try to make new ones. A more detailed modification needing to be made is the emotion of anger. More than one person has failed to identify the anger sound, which means there are still potential improvement for it. Reflecting on the article from Psychology of Music, many participants indeed fail to recognize all three kinds of anger. Anger as an emotion is conflicting with different perception for various people. Adding some higher notes and a more distinct bumping sound might be a solution for further study.

To create a complete piece of music where every emotion sound piece is connected with each other naturally is the next step. Furthermore, the question on whether there exists a hierarchical list of the vocal cues that affect people's emotional perception is worth studying. During the process of sound generation, tempo and chords were noticed to bring the most effective emotion modification.

5. Conclusion

To conclude, this paper discusses different musical factors' relationships with different emotions and makes an attempt to compose sounds with emotions using Nyquist programming. By excluding lyrics and artist performance style, this article makes a comparison of sound effects, whose examples were generated according to patterns found in previous research findings based on five emotions- joy, anger, fear, sadness and calmness. All these emotions were selected based on the arousal-valence graph, with one from each dimension. Most sound examples reach common ground with listeners. Due to personal perception differences, to accurately demonstrate angry emotions, further modifications will be necessary.

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