Mood Tracking of Musical Compositions

Jacek Grekow

Faculty of Computer Science, Bialystok University of Technology,
Wiejska 45A, Bialystok 15-351, Poland
j.grekow@pb.edu.pl

Abstract. This paper presents a new strategy for the analysis of emotions contained within musical compositions. We present a method for tracking changing emotions during the course of a musical piece. The collected data allowed to determine the dominant emotion in the musical composition, present emotion histograms and construct maps visualizing the distribution of emotions in time. The amount of changes of emotions during a piece may be different, therefore we introduced a parameter evaluating the quantity of changes of emotions in a musical composition. The information obtained about the emotion in a piece made it possible to analyze a number of pieces, in particular the Sonatas of Ludwig van Beethoven. This analysis has provided new knowledge about the compositions and the method of their emotional development.

Keywords: Emotion detection, Mood tracking, Music visualization.

1 Introduction

Listening to music is a particularly emotional activity [1]. People need a variety of emotions and music is perfectly suited to provide them. However, it turns out that musical compositions do not contain one type of emotion, e.g. only positive or only negative. During the course of one composition, these emotions can take on a variety of shades, change several times with varying intensity. This paper presents a new strategy for the analysis of emotions contained within musical compositions. We present a method for tracking changing emotions during the course of a musical piece. The collected data allowed to determine the dominant emotion in the musical composition, present emotion histograms and construct maps visualizing the distribution of emotions in time.

There are several other studies on the issue of mood tracking. Lu et al. [2], apart from detecting emotions, tracked them, and divided the music into several independent segments, each of which contains a homogeneous emotional expression. Using labels collected through the game MoodSwings, Schmidt et al. [3], [4] tracked the changing emotional content of music. Myint and Pwint [5] presented self-colored music mood segmentation and a hierarchical framework. The use of mood tracking for indexing and searching multimedia databases has been used in the work of Grekow and Ras [6]. The issue of mood tracking is not only limited to musical compositions. The paper by Mohammad [7] is an interesting

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extension of the issue; the author investigated the development of emotions in literary texts. Also Yeh et al. [8] tracked the continuous changes of emotional expressions in Mandarin speech.

2 System Construction

The proposed system for tracking emotions in a musical composition is shown in Figure 1. It consists of a database of musical compositions, composition segmentation and result presentation module. The segmentation module was combined with classifiers of an external emotion detection system, which was described in a previous paper [9]. The resulting emotion labels were used to designate the consecutive segments of a musical composition. The collected data allowed for analysis of a musical composition in terms of the emotions contained therein.

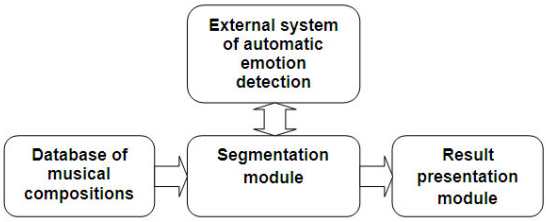

Fig. 1. Construction of the emotion tracking system

3 Mood Tracking

The model we chose in this work is based on Thayer's model [10]. Following its example, we created a hierarchical model of emotions consisting of two levels, L1 and L2 (Fig. 2).

The detection of emotion was conducted in our research on six-second segments. Each consecutive segment was shifted by 2 seconds. In this way, successive segments overlapped at a 2/3 ratio. This allowed to exactly track and detect even the slightest change of emotion in the examined musical composition. For a musical composition lasting $T = 120$ seconds, $N = 60$ segments $(S1, S2, ..., S59, S60)$ were analyzed, and for each L1 and L2 level of emotion detection was performed.

4 Results of Mood Tracking

4.1 Emotion Histograms of a Musical Composition

The first method used for presenting the distribution of emotions in a musical composition is emotion histograms (Fig. 3a and Fig. 3b). On the presented graphs, the horizontal axis corresponds to the type of emotion, and the height of the bar indicates how often a specific emotion occurred. Figure 3a presents the histogram of

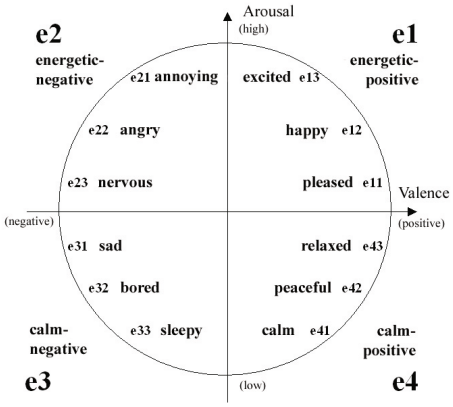

Fig. 2. Arousal-valence emotion plane

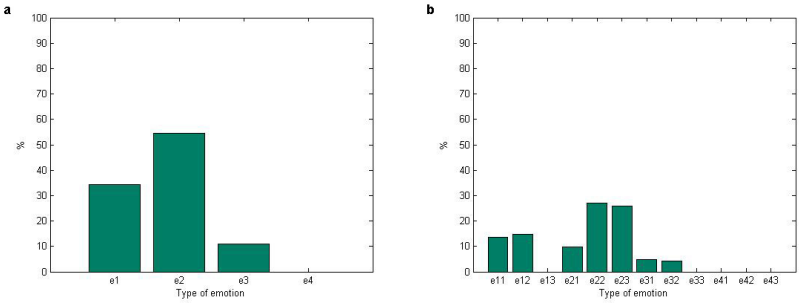

Fig. 3. Histogram of L1 (a) and L2 (b) level emotions in Appassionata sonata, part 1

L1 level emotions in Ludwig van Beethoven's Appassionata sonata. In this musical composition, emotion e2 (energetic-negative) occurs in more than 50% of the segments and is dominant. The second, most significant, emotion is e1 (energetic-positive). Notice that emotion e4 (calm-positive) does not occur at all.

Figure 3b presents the histogram of L2 level emotions in L.v.Beethoven's Appassionata sonata. Analyzing it and comparing it with the L1 level histogram (Fig. 3a), you can see that the emotions of the second quarter of Thayer's model (e2) that occur in this musical composition are e22 (angry) and e23 (nervous), and sub-emotions of the first quarter (e1) are e11 (pleased) and e12 (happy). The percentages of independent L2 level emotions are reduced but also dominant in the piece.

4.2 Emotion Maps

Another method used to analyze the emotion in a musical composition is detailed maps showing the distribution of emotion for the duration of the piece (Fig. 4a

and Fig. 4b). The horizontal axis shows the time in seconds and the vertical axis the emotions occurring at a given moment.

On Fig. 4a, presenting a map of L1 level emotions for L.v.Beethoven's Appassionata sonata, you'll notice that e2 is dominant throughout the entire piece with the exception of the central parts (s. 280-310). From the map, you can see when and which emotions occur simultaneously. For example, the beginning of the piece (s. 0-10) is a combination of emotions e2 (energetic-negative) and e3 (calm-negative), and the end (s. 510-540) is a mixture of emotions e2 (energetic-negative) and e1 (energetic-positive). By analyzing the map of L2 level emotions for L.v.Beethoven's Appassionata sonata (Fig. 4b), you can notice not only the detailed distribution of emotions but also the emotional structure of the piece composed of four sections.

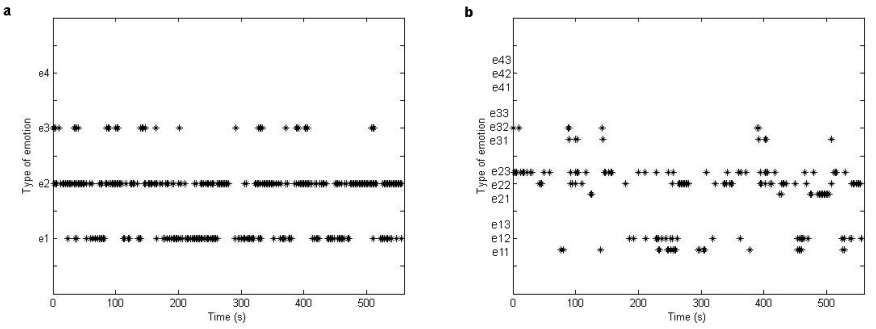

Fig. 4. Map of L1 (a) and L2 (b) level emotions in Appassionata sonata, part 1

4.3 Quantity of Changes of Emotion

Because some pieces may have many emotional changes (e.g., songs of varying moods) while others may be based on a single, dominant emotion (e.g. musical compositions with a steady pace, dynamics and rhythm etc.), we introduced the quantity of changes of emotion (QCE) in a musical composition.

$$QCE = \frac{\sum_{i=1}^{N-1} f(i)}{N} * 100 \tag{1}$$

$$f(i) = \begin{cases} 1, & \text{if } Emotion(i) \neq Emotion(i+1) \\ 0, & \text{if } Emotion(i) = Emotion(i+1) \end{cases} \tag{2}$$

where i is the number of the segment in the piece, N the number of segments in the composition and $Emotion(i)$ represents the emotion of the i segment. The function $f(i)$ indicates whether the adjacent segments have a different (value 1) or same (value 0) emotion. The more changes of emotion in a musical composition, the greater the QCE value.

Table 1. List of L. v. Beethoven's Sonatas with the dominant emotion and the QCE

Piece	QCE	Dominating emotion / in percentage
Appassionata, part 1	53.38	e2 / 55%
Appassionata, part 2	44.28	e3 / 54%
Appassionata, part 3	46.67	e2 / 69%
Waldstein, part 1	36.71	e2 / 54%
Waldstein, part 2	36.89	e3 / 60%
Waldstein, part 3	44.16	e1 / 44%
Pathetique, part 1	50.97	e2 / 45%
Pathetique, part 2	38.51	e4 / 44%
Pathetique, part 3	55.08	e1 / 47%

4.4 Comparison of Beethoven's Sonatas to Chopin's Preludes

The results of analysis of emotions in 3 three-piece L.v.Beethoven Sonatas are presented below (Table 1).

From the presented results, we can conclude that in Beethoven's Sonatas, in parts 1 and 3 dominate the emotions of the top half of Thayer's model: e1 (energetic-positive) and e2 (energetic-negative), and in part 2 emotions from the bottom: e3 (calm-negative) and e4 (calm-positive). The percentages of these emotions are in the range 44-69%. QCE at the beginning and end of the sonatas usually has a larger value (44-55) than in the central part (38-44), which indicates more frequent changes of emotion in parts 1 and 3 (usually fast) than part 2 (slow).

Table 2. List of Chopin's Preludes with the dominant emotion and the QCE

Piece	QCE	Dominating emotion / in percentage
Prelude No.1	27.27	e2 / 77%
Prelude No.5	8.33	e2 / 100%
Prelude No.7	30.00	e4 / 100%
Prelude No.8	21.95	e2 / 97%
Prelude No.15	43.97	e4 / 57%
Prelude No.18	33.33	e2 / 84%
Prelude No.19	3.57	e1 / 100%
Prelude No.22	35.29	e2 / 80%
Prelude No.24	41.07	e2 / 57%

Comparing Chopin's Preludes (Table 2) to Beethoven's Sonatas (Table 1), you can notice that the dominant emotion percentages are much higher in the Preludes (57-100%) than in the Sonatas (44-69%). Also, the quantity of changes of emotion (QCE) in the Preludes posses smaller values than the Sonatas. Based on these results, we can state that Chopin's Preludes are more emotionally homogeneous with a greater dominance of individual emotions and Beethoven's Sonatas are more diverse emotionally.

5 Conclusion

This paper presents a new strategy for the analysis of emotions contained within musical compositions. We present a method for tracking changing emotions during the course of a musical piece. The collected data allowed to determine the dominant emotion in the musical composition, present emotion histograms and construct maps visualizing the distribution of emotions in time. Emotional analysis of musical pieces can be developed in the future through a search for new parameters describing the changes of emotion in a piece, as well as by expanding the collection of studied compositions of various composers.

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