

# Implementation and Analysis of Mood-based Music Recommendation System

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**Abstract**—This paper presents probability based music mood model and implementation of music recommendation system using the mood model. We implement three types of mood-based music recommendation players, for PC and mobile devices, and web. We make users' satisfaction test through web-based music recommendation service for three months. This paper shows analysis result of users' satisfaction and mood reappearance test after listening to music, two months apart.

**Keywords**—music mood, recommendation, arousal-valence

## I. INTRODUCTION

With growing the amount of music content an effective search and recommendation method is getting more and more important. In music information retrieval, music can be searched by artist, title, genre, etc. Keyword based search such as title or artist is a quite good performance, but we have to know this information, artist, title, etc. in advance to use keyword search.

Music mood is also used for music classification and recommendation, some studies[1],[2] had been proposed. Most of existing mood based music recommendation systems categorise some moods and these moods are mapped into discretely regions on two or three dimensional plane.

But music mood is subjective and ambiguous. So it is difficult to classify and express a song to a mood tag or one region in valence-arousal plane. Kim[8] shows that some regions can be identified by representative mood tags like previous models but some mood tags are overlapped in almost regions. Therefore, the mixture model is necessary to express music mood.

In this paper, we present probability based music mood model and implementation of music recommendation system using the mood model. Proposed system can express complex mood of a song and generate similar songs list for multiple inputs, mood tags, a song, and valence-arousal value. We show analysis result of users' satisfaction test through web-based music recommendation service for three months and mood reappearance test after listening to music, two months apart.

This paper is organized as follows. Section 2 describes probability based music mood model and implementation of the mood model based music recommendation system. Section 3 shows analysis result of users' satisfaction and mood reappearance test. Section 4 concludes this paper.

## II. IMPLEMENTATION OF MOOD BASED MUSIC RECOMMENDATION SYSTEM

Section 2 presents probability based music mood model and describes implementation of the mood model based music recommendation system.

### A. Music Mood Model

Generally, music mood model have been studied by two approaches: categorical and dimensional. In categorical model [3], moods were classified into basic elements such as anger, fear, sadness, happiness and disgust. Hevner[4],[5] examined the affective value of six musical features such as mode, tempo, pitch, rhythm, harmony, and melody and studied how they relate to mood. The study categorised 67 adjectives into eight different emotional groups with similar moods and compared musical characteristics in 8 affective states.

In dimensional model, moods were presented by two or three axes. Russell[6] presented circumflex model of mood arranging 28 adjectives in a circle on two-dimensional bipolar space(arousal-valence) keeping away the opposite emotions. Thayer[7] proposed energy-stress model in two-dimensional spaces. The dimensional approach can represent characteristics of mood simply and visualize mood and relationship between moods effectively.

In this paper, we use hybrid approach, probability based music mood model. For 446 constant music clips, we gathered valence-arousal values and mood tags from 10 paid persons. The subjects entered a mood tag and clicked a point on two dimensional valence-arousal plane after listening to a song[8]. For those mood tags, we calculate mood tag distribution matrix between song and mood tag. From this matrix, we measure the similarity of mood tags by cosine distance and classify mood tags into 8 categories by k-means clustering. For each mood category, we estimate the distribution of valence-arousal values[9]. Figure 1 shows the valence-arousal distribution of each mood category. The each category has its own area and some are overlapped.

Generation of mood probability from a song is processed as shown in Figure2. Audio feature is extracted from a song and valence-arousal value is estimated from regress function with the feature. And mood probability of estimated valence-arousal value is calculated with mood probability model.

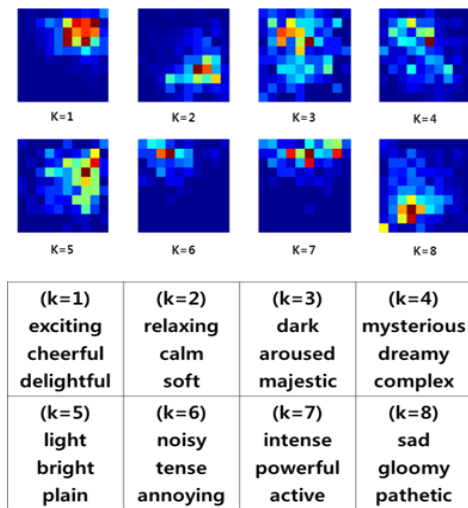


Figure 1. Valence-arousal distribution of each mood categories

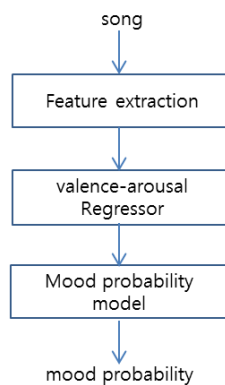


Figure 2. Generation process of mood probability from a song

Figure 3 shows example of estimated mood probability of a song. We can know that this song has high probability of mood category 1, ‘exciting, cheering’ and category 5, ‘light, bright’. The category 1 ranks top and category 5 ranks second among the 8 categories.

### B. Implementation of Music Recommendation System

In this paper, we implement music recommendation system using probability based music mood model described in section 2.1. Proposed system provides recommendation method using mood ranks and probabilities and valence-arousal value of a song.

Mood rank based recommendation method searches songs holding same mood rank. For example, if three moods are selected, all possible permutations  $p(\text{mood ranking sequences})$  on three elements are calculated. And songs holding mood ranking same as calculated mood ranking sequences are recommended.

Mood probability information can be used to adjust search result carefully. For example, we expect uniform search

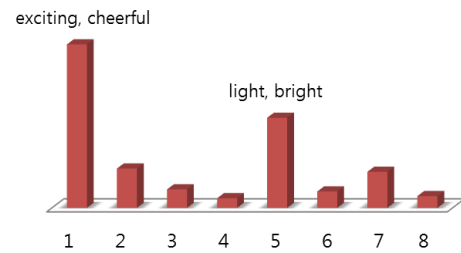


Figure 3. Example of estimated mood probability of a song

results by the following condition:  $\min \leq \text{probability value of ranking No.1 mood} \geq \max$ . Also probability condition is used with mood ranking condition. If difference of probability value of ranking No.1 mood and ranking No.2 mood is more than a certain value songs with dominant mood, ranking No.1 mood are recommended. If difference of probability value of ranking No.1 mood and ranking No.2 mood is less than a certain value songs with two dominant moods, ranking No.1 and No.2 moods are recommended.

Distance based recommendation method recommends songs around input valence-arousal values. Then, the distance value from input coordinate is variable according to the number of songs and mood distribution of songs

Figure 4 shows recommendation process of proposed system according to inputs, valence-arousal coordinate value, songs, and mood tags.

In the case of a song input, we extract mood probability and ranking from the song as shown in figure 2. Then songs with same mood ranking are recommended.

If mood tags are selected, all possible permutations  $p(\text{mood ranking sequences})$ . And songs holding mood ranking same as calculated mood ranking sequences are recommended.

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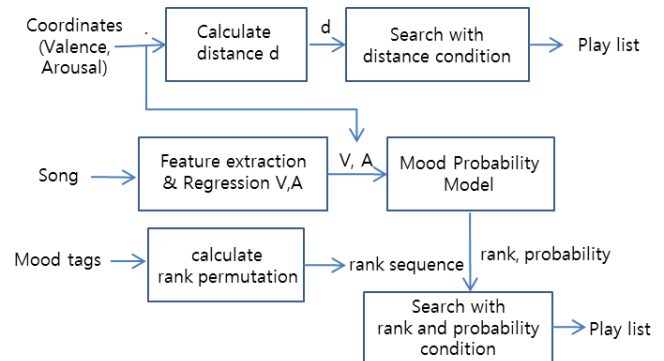
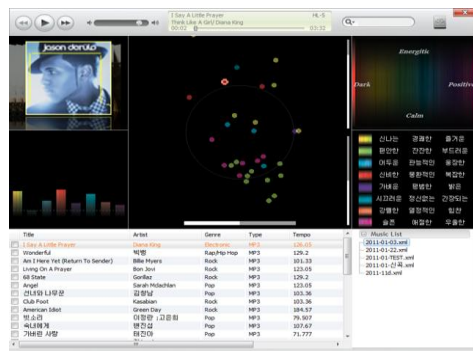
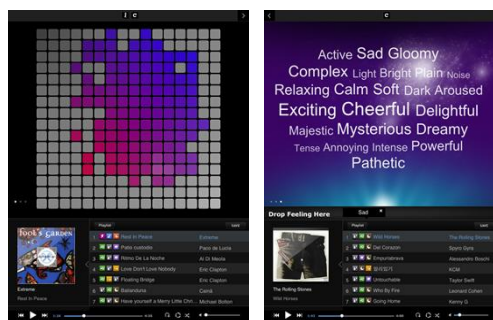


Figure 4. Music recommendation method according to inputs

In the case of valence-arousal value input, recommendation processes are divided two, mood ranking and distance based recommendation method. In mood ranking based recommendation, after extracting mood ranking information of the valence-arousal coordinates from probability mood model, same process is performed as second step of song input process. In distance based recommendation, after calculating distance to set around area of input coordinates songs are recommended in the area.



(a) Music Recommendation player for PC



(b) Music recommendation App. for mobile device



(c) Web-based music recommendation service[10]

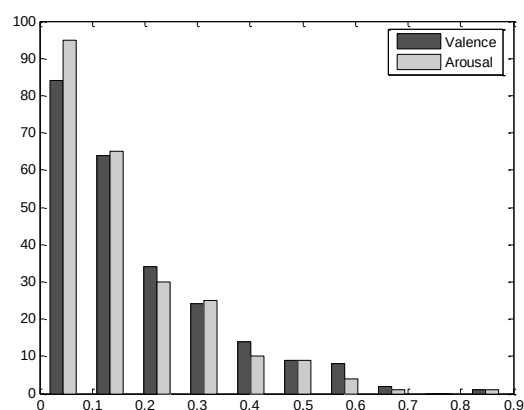
Figure 5. Implementation pictures of music recommendation system

Figure 5-(a) and (b) shows implementation picture of music recommendation players for PC and mobile App., respectively. This system provides recommendation interface by valence-arousal plane, mood tags, and similar songs with playing music. Figure 5-(c) shows web-based music recommendation service applied to commercial music service site[10]. This service provides recommendation interface by mood tags with colors.

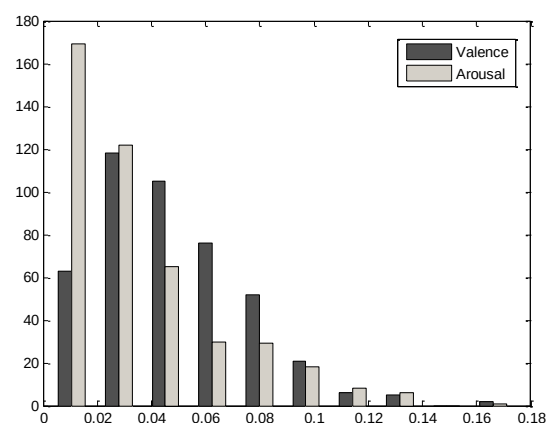
We progress beta service for two months with a hundred fifty thousand songs DB. Average page view per week is seven thousand views. According to users' feedback about recommendation, about 70% of users are satisfied with the recommendation result. Mood condition is 'relaxing, calm', 'exciting, cheerful', 'mysterious, dreamy', 'sad', 'gloomy', and 'noisy', 'tense' in high recommendation satisfaction order.

### III. ANALYSIS OF USERS' SATISFACTION

We test mood reappearance to analyse of recommendation satisfaction. For 240 songs, we collect valence-arousal values and mood tags from 8 subjects, each 30 songs. The subjects entered a mood tag and clicked a point on valence-arousal plane after listening to a song, two months apart. As a result, only 35% of subjects feels same mood in first and second test.



(a) Histogram of the difference in valence-arousal by subjects



(b) Histogram of variance of valence-arousal values by songs

**Figure 6.** Program used in experiment

Figure 6-(a) shows histogram of difference of valence-arousal value entered by subjects in first and second test. In the case of difference by subjects less than 0.2, percentage of valence and arousal is 60.42% and 66.67%, respectively. Average valence and arousal of difference and is 0.1802 (MSE: 0.0572) and 0.1589(MSE: 0.0471), respectively. Figure 6-(b) shows histogram of variance of valence-arousal values by songs. In the case of variance less than 0.04, percentage of valence and arousal is 45.42% and 67.86%, respectively.

Figure 7 shows distribution of valence-arousal value by users for same songs. Blue points are average values of users and red points are individual distribution.

As a test result, we know that people feel differently after listening to same songs, case by case. To improve performance, we need to consider personalization of music mood model and tracing of mood transition of users with play list and search keyword, etc.

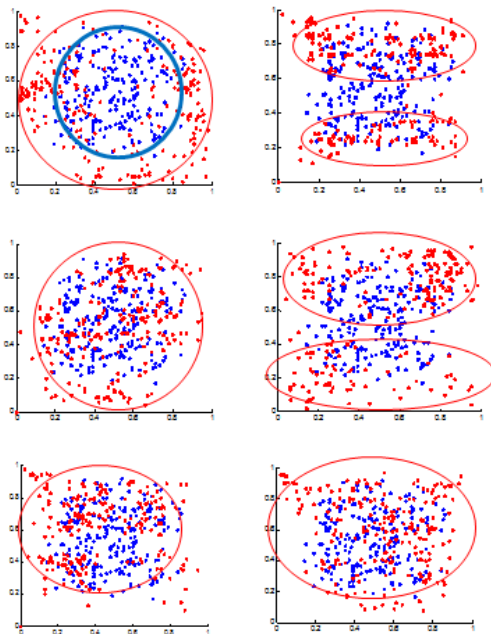


**Figure 8.** Valence-arousal distribution by users

## IV. CONCLUSIONS

In this paper, we implement three types of mood-based music recommendation players, for PC and mobile devices, and web using probability based music mood model. And users' satisfaction and mood reappearance test is progressed. Proposed system provides high level recommendation satisfaction. We can know that people feel differently after listening to same songs, case by case. To improve performance, we need to consider personalization of music mood model and tracing of mood transition of users.

## ACKNOWLEDGMENT

This research project was supported by the Government Fund from Korea Copyright Commission [2012-cloud-9500: Development of content-based usage control technology for clean cloud] and IT R&D program of MSCT/KEIT [10035229, Development of contents protection and distribution technology on DRM-free environment].

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