



## Exploring user emotion in microblogs for music recommendation<sup>☆</sup>



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### ABSTRACT

Context-aware recommendation has become increasingly important and popular in recent years when users are immersed in enormous music contents and have difficulty to make their choices. User emotion, as one of the most important contexts, has the potential to improve music recommendation, but has not yet been fully explored due to the great difficulty of emotion acquisition. This article utilizes users' microblogs to extract their emotions at different granularity levels and during different time windows. The approach then correlates three elements: user, music and the user's emotion when he/she is listening to the music piece. Based on the associations extracted from a data set crawled from a Chinese Twitter service, we develop several emotion-aware methods to perform music recommendation. We conduct a series of experiments and show that the proposed solution proves that considering user emotional context can indeed improve recommendation performance in terms of hit rate, precision, recall, and F1 score.

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### 1. Introduction

Nowadays, there is a huge amount of digital music contents available on the Internet. For example, Apple iTunes offers more than 28 million songs and Amazon's MP3 store provides over 20 million songs. Given the huge amount and heterogeneity of online musical contents, it is nontrivial for users to obtain music that meets their preferences. Accordingly, recommender systems (Hyung, Lee, & Lee, 2014; Mocholi, Martinez, Jaen, & Catala, 2012; Yoshii, Goto, Komatani, Ogata, & Okuno, 2006) have emerged to reduce search cost and help the user to find their favorite music.

In general, people have different music tastes and preferences in different contexts. Thus, a good music recommender system should be personalized and context-aware, in which users' preference can be learned from historical behaviors of music selection and consumption. To date, many music recommendation systems begin to take into account various contextual information of users, including

time (Cebrián, Planaguma, Villegas, & Amatriain, 2010; Dias & Fonseca, 2013; Su, Yeh, Yu, & Tseng, 2010), location (Cheng & Shen, 2014; Kaminskas, Ricci, & Schedl, 2013; Schedl, Vall, & Farrahi, 2014), activity (Elliott & Tomlinson, 2006; Liu, Lai, Chen, & Hsieh, 2009; Wang, Rosenblum, & Wang, 2012), weather (Park, Yoo, & Cho, 2006), emotion (Cai, Zhang, Wang, Zhang, & Ma, 2007; Chang, Lo, Wang, & Chung, 2010; Han, Rho, Jun, & Hwang, 2010; Rho, Han, & Hwang, 2009; Shan, Kuo, Chiang, & Lee, 2009) and hybrid context (Hong, Hwang, Kim, & Kim, 2014; Knees & Schedl, 2013; Lee & Lee, 2007). Especially, since music is an emotion-loaded type of content often described by emotions, there exists a direct association between users' emotion and their preferred music (North & Hargreaves, 2008). For example, we all listen to different music in a sad mood compared to when being happy. However, emotional state of the user is an example of a secondary context (Abowd et al., 1999), since it cannot be measured directly, but needs to be derived from other types of contextual information. Therefore, it is a challenging task to obtain users' emotion and apply it in any emotion-aware recommendation. There are only a few works that try extracting and utilizing user's emotion in recommendation. Especially, no existing works focus on how emotion affects users' music preferences and music recommendation performance in details.

In this article, we propose to extract user emotion at different granularity levels and during different time windows from microblogs and explore the emotional contexts in music recommendation. With the prevalence of microblog services and smart phones, publishing microblogs frequently has become an indispensable part

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of many people's daily life, especially for young people. They share what they have seen, heard and thought instantaneously. Based on the assumption that microblogs can reflect a user's emotion (explicitly or implicitly) at the specific moment, we propose an emotion-aware recommender system that performs music recommendation based on user's music items and emotion extracted from microblogs. To validate the performance of the proposed system and investigate how emotion at different granularity levels and during different time windows can influence the recommendation, we conduct a comprehensive set of experimental studies with large-scale real-world data set crawled from Sina Weibo (<http://weibo.com/>, the most popular Chinese Twitter service). Experimental results demonstrate that incorporating emotion, especially fine-grained emotion of proper time window, can improve the performance significantly. To the best of our knowledge, our work is the first that explores user emotion at different granularities and during different time windows embedded in microblogs for music recommendation.

To summarize, the main contributions of this paper are: (1) we construct a real-world dataset of microblogs and music, from which the music listening records and corresponding context can be inferred; (2) we extracted users' emotional context from their microblogs, and develop several emotion-aware recommendation methods based on traditional approach, which can recommend music items appropriate for users' current emotional context; (3) we conduct extensive evaluations on a real world dataset, and the results prove that emotional context, especially fine-grained emotion with proper time windows, are indeed helpful in predicting users' music preference and improving recommendation performance. Especially, to the best of our knowledge, there are no existing works exploring how user's emotion at different granularities and during different time windows influence user's music preference and music recommendation in detail.

The remainder of the paper is organized as follows. In the next section, we discuss several context-based music recommendation works. In Section 3, we introduce our proposed system. In Sections 4 and 5, we present the system in detail. Then, we provide an experimental evaluation of the proposed system in Section 6. Finally, we conclude the paper with a summary and directions for future work in Section 7.

## 2. Related work

Compared to works in collaborative filtering-based algorithms and content-based algorithms, research in context-based algorithms is relatively novel and starts to attract attention in the research field of music recommendation. In this section, we discuss several works on context-based music recommendation. Prior works considering context in music recommendation fall into two categories according to the context type: environment-related context approach and user-related context approach.

### 2.1. Environment-related context approach

Such research is based on the fact that the environment has an influence on the state-of-mind or emotional state of the user, and therefore may indirectly influence the user's music preferences (North & Hargreaves, 2008). For instance, people tend to prefer different types of music in summer and in winter (Pettijohn, Williams, & Carter, 2010). Consequently, music recommendation approaches with environment-related parameters will perform better. The environment-related context including time (Cebrián et al., 2010; Dias & Fonseca, 2013; Su et al., 2010), location (Cheng & Shen, 2014; Kaminskas et al., 2013; Schedl et al., 2014), weather (Park et al., 2006) and hybrid context (Hong et al., 2014; Knees & Schedl, 2013). In Dias and Fonseca (2013), the authors incorporate temporal information in session-based collaborative filtering method to improve the performance of music recommendation. Kaminskas and

Ricci (Kaminskas et al., 2013) explored the possibilities to adapt music to the places of interest (POIs) that the user is visiting. Reddy and Mascia (2006) present a mobile music recommender system named Lifetrak, which can generate a playlist based on the current context of the user. The environment-related context information used in their works includes location, noise or traffic level, and weather. Park et al. (2006) present a context-aware music recommender where the environment-related context information includes noise, light level, weather, and time. However, most of the prior approaches require researchers to label music with appropriate tags or map context with music, therefore restricting the application in real world. Another limitation is that the prior methods have only been evaluated based upon synthetic or small-scale datasets.

### 2.2. User-related context approach

Compared with environment-related context, user-related context has closer relationships with the user, and therefore can influence user's music preferences directly. The user-related context includes activity (Elliott & Tomlinson, 2006; Wang et al., 2012), demographical information, and emotional state (Cai et al., 2007; Chang et al., 2010; Han, et al., 2010; Rho et al., 2009; Shan, et al., 2009).

Elliott and Tomlinson (2006) present a research that focuses strictly on the user's activity context. They design a system that adapts music to the user's walking pace by matching beats-per-minute (BPM) of music tracks with the user's steps-per-minute. Rho et al. (2009) extract the emotional information from music, including scale, rhythm and harmonics, and represented emotion as vectors in Thayer's model. Then they use emotion vectors as a supporting feature to compute music similarity. Han et al. (2010) propose a context-aware music recommendation system, in which music is recommended according to the user's current emotion state and music's influence on user's emotional change. Cai et al. (2007) presented another contextual music recommendation approach-MusicSense, which can infer user's emotion from Web documents read by users and then match music to a document's content in terms of the emotions expressed by both the document and the music songs. However, most of existing works require the user to input contextual information, which restrains their application in practice. Especially, there are no works exploring how emotion at different granularities and during different time windows influences music recommendation.

## 3. Overview of emotion-aware music recommendation

As shown in Fig. 1, our proposed approach consists of two phases: pre-processing and prediction. In the pre-processing phase, we extract all the music pieces listened to by users and microblogs posted by these users within a certain time-window of the music timestamp, analyze emotional features of posted microblogs, and then form the historical associations of user, music piece and emotion. During the prediction phase, the system will acquire users' current emotion and then recommend music items appropriate for their emotional context based on the historical association data.

### 3.1. Pre-processing

In this phase, the main goal is to extract the association among user, emotions, and music pieces. Firstly, we construct a new and complete emotion lexicon based on existing resources. Secondly, all microblogs are represented as emotion vectors according to the number of emotion words appearing in microblog text. At last, based on the time dependence of microblogs and music pieces, we form the association data between emotion and music for all users, which is represented as a three-element tuple (user, emotion, music), where the emotion is composed of three emotion vectors representing emotion of different granularities.

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