International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2016): 79.57 | Impact Factor (2015): 6.391

Trends and Challenges in Developing Context-Aware Music Recommendation Systems

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Abstract: ***The development of computer technology and the Internet influence how people buy, save, and listen to music. Today, there are millions of songs that everyone can choose to listen anytime and anywhere. One of many problems arise is, the music listeners are often spending too much time and giving much effort in choosing music to be listened, thus a music recommendation system is needed. Context are important in music recommendation system; people prefer different music for certain activities, or in other words, people would have a different music selection for a certain context. For example, a user who is exercising will prefer a loud and energizing music, a user who is relaxing will prefer a soft and soothing music.This review is focused on trends and challenges in developing context-aware music recommendation system, which uses context as primary features or data to recommend music.Developing context-aware music recommendation system is challenging, it is complicated to meet the user's needs and requirements. The challenges are come from the great amount of data needed, how to choose context used in the research, cold start, and generating a dynamic playlist.***

Keywords: context awareness, context-aware music recommendation, music information retrieval, music recommendation

1. Introduction

Music is a part of everyone's everyday life. People usually listen to music ina certain situation or activity;people listen to music from the radio when they travel, people listen to music when theyexercise, people also listen and choose music according to their mood. The development of computer technology and the Internet influence how people buy, save, and listen to music. Today, there are millions of songs that everyone can choose to listen anytime and anywhere. One of many problems arise is, the music listeners are often spendingtoo much time and giving much effort in choosing music to be listened. It is difficult for someone to pick suitable tracks to listen to without pre-determined organization such as albums, playlist, or computationally generated recommendation [1].

There are several methods to recommend music, such as collaborative filtering, content-based method, hybrid approaches, dynamic music recommendation, and context-based methods. Collaborative filtering methods recommend music based on music ratings by other music listeners who have similar music taste to the primary user. Content-based method computes similarity of acoustic features in music to find similar piece of music to be recommended. Acoustic features are extracted directly from the audio signal of a music (e.g. rhythm, timbre, and tempo). Hybrid approaches to give music recommendation combine music content with other information. Dynamic music recommendation improves recommendation given by considering the user's feedback; which piece of music is actually played and which piece of music is removed. Context-based recommendation methods considerate context; environment-related context and/or user-related context in giving music recommendation. This review is focused on context-aware music recommendation system, which uses context as primary features or data to recommend music. Other recommendation methods, beside context-based method, would generally give a long-term music recommendation to the users, which will not change in a long period of time. Users' short-term music needs are usually influenced by the users' context, such as their environment, activity, or mood [2]. People prefer different music for certain activities, or in other words, people would have a different music selection for a certain context [3] [4] [5].For example, a user who is exercising will prefer a loud and energizing music, a user who is relaxing will prefer a soft and soothing music.

The importance of using context in recommendation system is even greater when people start to use advanced technologies such as handheld smart devices which also can play music.This situation has created opportunities for researchers to use contextual data in music recommendation systems. The needs of users may vary depending on context, and context-aware systems can adapt to provide the relevant services [6].

The following sections describe contextual aspects related to music recommendation, such as environmental context (e.g. location, time, and weather) and user-related context (e.g. activity and mood), as well as trends and challenges in developing context-aware music recommendation systems by reviewing some research about music recommendation.

2. Contextual Aspects Related to Music Recommendation

A recommendation system depends on an understanding of a user's predefined preferences. The system's main objective is to predict items needed by users and to recommend items suited to user's interest [7].Situational information of the user, such as environment condition, emotional state, past and future events can help the system to understand the current needs of the user [6].

Some researchers have defined context in many ways. In general, context is any information which can describe the condition of an entity. The entity can be human, location, physical or computational object that relevant in the interactions between the user and the application [8]. Context is also can be described using three different dimension, physical environment, human factor, and time [9]. Physical

environment context consists of location, infrastructure, and physical condition such as light, temperature, and pressure. Human factor consist of user information such as routines and emotional state.

Context is an important factor in developing context-aware music recommendation system, because user's preferences can differ according to user's context at the time he/she access the system [10]. In general, people can get music recommendation based on different context, such as the environmental context or the user context.

2.1. Environment-Related Context

The environment has an indirect influence on user's musical preferences, because a certain environmental situation can influence user's state of mind. For example, people tend to listen to different music in different part of day (e.g. in the morning or at night) or different weather (e.g. snowy, rainy, or sunny). The environment-related context is classified into three general categories; location of the user, time-related information, weather-related information, and other parameters [6].

Location of the usercan be represented in various ways. It can be represented by a country's area (e.g. province, region, states), type of landscape (e.g. city, village, mountain, beach), or a more detailed location (e.g. office, café, fitness center). A specific location influences the user's preferences in music, because a different location will trigger a different emotion or state of mind. For example, being in a busy street of a big city will trigger a different state of mind compared to being in a peaceful traditional village.

Time-related informationalso useful in developing a context-aware music recommendation system. The time can be referred to time of day (morning, afternoon, evening), day of week (Sunday, Monday, Friday), month (January, June, December), or another category of time-related information such as days can be categorized into working day (Monday-Friday) and weekend (Saturday-Sunday). Time-related information influences user's preferences in music, for example, the music chosen may be different when a user start a working day in the morning to when a user relax at night after working.

Weather-related information may refer to weather conditions, temperature, and season. The weather generally categorized into sunny, overcast, rainy, etc., the temperature is cold, moderate, or hot, the season is summer, autumn, or spring. The user's music preferences may differ according to the weather-related information, for example in a cold snowy winter or a hot sunny summer.

Other parameters of environment such as light level, noise level, traffic, pollution level, electromagnetic activity, enclosure, slope, and presence of metal.

2.2. User-Related Context

The user-related context is categorized into three general categories; activity or state of the user, demographical information about the user, and emotional state of the user [6]. Activity and emotional state of the user is a fast-changing context of the user; it may always change within a day. Demographical information of a user is considered to be static; it may change, but it takes a longer time than the user's activity and the user's emotional state.

Activity of the user give the user a direct influence on the musical preferences. The activity can be represented by an action (e.g. relaxing, running, working, studying, exercising). Activity also can be represented by a number generated from heart rate or walking pace [6]. The user might have different music preferences when exercising compared to when relaxing.

Demographical information of the user is also called user profile or user properties, is a static or slowly changing characteristics of the user (e.g. gender, age, nationality, lifestyle, genre preferences).

Emotional state of the user has a direct influence to the user's music preferences. Researchers use a wide variety of adjectives to represents emotions to develop a context-aware recommendation system, such as happy, graceful, sad, triumphant, vigorous, and frustrated. The user selects music to augment the emotions perceived [6]. For example, the user will select a different music to listen in a happy moment compared to music to listen to in a sad moment.

3. Trends in Developing Context-Aware Music Recommendation System

In developing a context-aware music recommendation system, user-related context is often combined with environment-related context. There are several researches that used environment-related context and/or user-related context.

Park, et. al.[10] designed a music recommendation system based on weather-based context, time-based context, and demographical user information. Weather-based context used are temperature, humidity, current weather, weather forecast, and season. Demographical user information used are age and gender. Other environment-related context used are noise and illuminance. In this research, fuzzy logic is used in this study to handle information from different sources, Bayesian Network is used for context data inference, and Utility Theory is used to consider contextual user preferences.

Research on music recommendations using context data and case-based reasoning method done by Lee and Lee [11]. An application called C2_Music was developed, the application provides music recommendations based on user-related context and environment-related context. The data is obtained from a music streaming company in Korea, from 659 listeners in 6 months. Context data used in this research consist of time-related context such as date, weekday month, and season, location of the user that represented by country region, weather-related information such as weather and temperature, and demographical user information such as gender and age. This research compared the recommendation system result from a system which used context data and a system which not used context data. The accuracy of

recommendation given by the system with context data is 0.542 which is 0.081 points higher than the system which not used context data.

Su, et. al. [12] used more user's context such as user's activity and user's health condition besides another context information such as location, motion, and calendar. Modified Discrete Cosine Transform (MDCT) coefficient is used to represent the extraction of music features and two levels of clustering; Frame-based Clustering and Sequence-based Clustering are used to group music.

Hu and Ogihara [1]using a different approach to recommend a suitable music based on user behavior. User behavior is the user's attitude towards the song played. If a song played from the beginning to the end, it means the user likes the song, vice versa. The system built recommend pieces of music that are favored by the user which are new to the user and fit the user's listening pattern. The music played next (a recommendation) is determined by five perspectives, genre, year, favor, freshness, and time pattern. Context in this research is user favor and time pattern. User's favorite songs determined by active play times, passive play times, skip times, and delete. Time pattern is obtained from the user's log. The system records the time of day and week the music is played. Expectation Maximization algorithm is used to estimate the probability of the song being played at that time.

Research conducted by Baltrunas, et. al. [4] built an Android-based context-aware music recommendation system for car drivers. The system aims to recommend music suitable for certain driving conditions. There is various context used in this research, environment-related context such as road type, landscape, traffic conditions, weather, and natural phenomena. User-related context used are driving style, sleepiness, and mood of the driver. In the research, the users gave ratings for multiple items using a web application before using the app. Collaborative filtering and Matrix Factorization methods are used for the determination of music recommendations, and the probability distribution method is used to estimate the relevancy of context factors.

Wang, et. al. [2] developed a mobile music recommendation for daily activities using Adaptive Context-Aware Content Filtering Model (ACACF). The model uses a Bayesian framework to integrate context-aware activity classification and music content analysis. To provide a more personalized recommendation, ACACF used user-feedback; a positive feedback is obtained when a user listen to a song completely (it means that the user likes the song), a negative feedback is obtained when a user skipped the song after a few seconds (it means that the user dislikes the song). The ACACF model was implemented in a prototype system with two components; the music audio content analysis on a remote server and a context-aware music recommender application on a mobile phone. To collect context data, Wang used sensors such as gyroscopes, accelerometers, GPS receivers, microphones, and ambient light sensors collected by a mobile application. User-related context user were activities, consisting running, working, sleeping, walking, shopping, and studying.

Hariri, et. al. [5] designed a music recommendation system that uses contextual information based on the latest music sequences favored by users. Other researches use environmental context such as weather and time or user context such as age and activity to determine recommendations, whereas this study uses user habits and preferences to determine recommendations. Hariri uses topic modeling to define a collection of hidden topics for each music that represents different contexts. Hidden topics are generated from the most tags that related to the musical sequence owned by the user. Sequence patterns found fill be used to predict the next topic in the playlist. The K-NN method is used in this research to calculate music resemblance, get similar music, and make recommendations.

Temporal context and session-based collaborative filtering used by Dias and Fonseca [13] to build a music recommendation system. The system built predict the next song to be played in the current active session. Hit ratio and the Mean Reciprocal Rank is measured. Two algorithms are compared in this research, the one with explicit characterization of sessions (TSSCF) and a simple Session-Based CF algorithm. TSSCF models the listening patterns over time by grouping similar sessions based on temporal properties (time of the day, weekday, day of month, and month) and a diversity feature, a ratio between number of different songs and total songs played in one session. Expectation Maximization unsupervised clustering algorithm is used in this research.

Schedl [14] built "Mobile Music Genius", an intelligent music player for Android platform. MMG can adapt the music playlist according to the music preference of the user in a given context. Some context attributes monitored by MMG are time (day of week, hour of day), location (provider, nearest relevant city, longitude, latitude, etc.), meteorological (clouds, temperature, humidity, weather condition, etc.) ambient (light, proximity, noise), physical activity (acceleration, orientation of user, orientation of device), task activity (screen state, docking mode, recently used tasks) phone state (state of data connection, operator, network type) connectivity (mobile network, Wi-Fi, Bluetooth, etc.), device (battery status, memory, etc.), and player state (player type, repeat mode, shuffle mode). Schedl used some context that are related to the mobile phone/device, such as phone state, connectivity, task activity, and device that rarely used in other researches. MMG monitors contextual user data, user feedback (play, pause, stop, and skip), and the music meta-data such as artist name, album, and track name.

4. Challenges in Developing Context-Aware Music Recommendation Systems

Designing and developing a personalized music recommendation system is complicated. It is always challenging to understand completely about the users' needs and requirements. Every research mentioned in the previous section have different choice of context and method to recommend music to the listeners. There are challenges in developing context-aware music recommendation system, from choosing context data to choosing recommendation method.

In order to make an accurate recommendation system, a great amount of dataset is needed. The dataset contains context data from various user with different context. Emotional state of the user may help a lot in determining recommendation, but emotion itself is hard to define and describe. The same adjective used in expressing emotional state (happy, sad, cheerful, etc.) might be experienced differently by users. Some research including emotional state used basic emotion of the user (sad, happy, angry, depressed, etc.) but it cannot describe human perception of emotional state perfectly.

Collaborative filtering method is widely used for music recommendation system. The method gives recommendations based on the choices of other similar user. Instead of recommending similar items, this method is recommending items based on items that also liked or given good ratings by 'nearest-neighbor users'. This method is one of the most successful approaches in recommendation systems, but the assumption that users with similar behavior also have similar taste has not been widely studied [15]. Other problems that may arise when using collaborative filtering method are popularity bias and cold start. Collaborative filtering mainly recommends the popular music to the listeners because generally, popular music can get more ratings by various users. This problem is called popularity bias, where the popular music always gets ratings, but the unpopular ones just get a few ratings. Cold start might happen at the early stage of recommendation system, when there are only few ratings available. Because of there are only few ratings, the recommendation result will not likely suitable for the users.

Playlist generation in music recommendation system has a different challenge. A playlist has to be flexible and have a main theme based on activity, event, or mood to increase user's satisfaction when listening a complete playlist. A music piece which belong to a different theme can disturb the user because it could change the atmosphere that built by previous music in the playlist. A dynamic playlist can be generated by concerning about the users' behavior when listening to the playlist, assuming if the users dislike the song, they will skip the music; thus the system can remove any similar music in the playlist.

5. Summary

A successful recommendation system should be able tominimize user's effort in choosing music from a large music database and consistently matches user's preferences. Music is a subjective matter; to recommend music, a user-centered approach should be considered. Using both environmental context and user-based context will improve the quality of a music recommendation system.

Some researches have conducted to design and build a context-aware music recommendation system. The advanced technologies such as smartphones or other handheld devices which connect to the Internet and can play music gives the researchers opportunities to use context data. Various types of context data and methods have been used by researchers to recommend music.

Developing context-aware music recommendation system is challenging, it is complicated to meet the user's needs and requirements. The challenges are come from the great amount of data needed, how to choose context used in the research, cold start, and generating a dynamic playlist. Future context-aware music recommendation system should understand the user more, intensive participation of researchers from other fields such as psychology and music will help building a good quality music recommendation system.

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