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# Music Recommendation System Based on Context Using Case-Based Reasoning and Self Organizing Map

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***Abstract***

*Choosing music from a music library in a computer that consists hundreds or thousands of music can be time consuming. An effective music recommendation can decrease listener's effort in choosing music that will be listened. Music recommendation is not only can be obtained based on genre or audio similarity, because listener's music choices are also influenced by the listener's context (mood, occasion, part of day, date, weather, region, month, and weekday). This research used Case-Based Reasoning (CBR) for determining music recommendation based on listener's context data and also Self Organizing Map (SOM) which is used as an indexing method in CBR. Inputs given by user to the system are user's occasion and mood desired by user. The system output is a playlist consists of music that suitable with user's context and desired mood.Precision value produced by the system that used SOM as an indexing method is 0.867. It showed that the recommendation produced by the system is 86.7% relevant according to the user.*

***Keywords****: music recemmendation, context, case-based reasoning, self organizing map*



## 1. Introduction

The development of technology and music diversity led to an increasing number of music or songs we usually listen in our everyday life. One of many problems arose is the music listeners are confused and spending much time in choosing music to be heard. Information recommendation systems are the one of the most effective tools to solve the problem of information overload [1].Themusic listeners need an effective music recommendation which can reduce the effort of music listeners in choosing the music to be heard at any given time.

However, in making music recommendations, most of the existing researches have focused on using the user's preferences and/or transaction data. They rarely considered other information as user's context at the time of making recommendation. Choosing music is not only influenced by genre or artist preferred by the music listeners, but also music listeners' context. Context is defined using three dimension, they are physical environment, human factor, and time. Physical environment context consist of location, infrastructures, and physical conditions such as light, temperature, and pressure. Human factor consist of user information such as habits and emotional conditions [2].

To manage these context-sensitive situations, recently, context-aware computing has been considered to automatically acquire and utilize context data in order to run the services that are appropriate for the particular people, place, time and events [3]. Researches about music recommendations based on context, music recommendation based on mood, and music classification based on mood has previously been performed by several other researchers. Other research on music recommendation based on context and mood data has been done. Emotion State Transitional Model (ESTM) and Context-Based Music Recommendation (Comus) is used to produce a list of music recommendation in [4]. Research conducted by [5] used reasoning and ontology using collaborative filtering technology to build a music recommendation system.

Research on music recommendation using context data and Case-based Reasoning is already done by [6]. An application called $C^2$_Music was built in the research. The application

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provide music recommendations which listened by a user with the same background and in the same context. Case-Based Reasoning is used in this research to define the music recommendation.

Research on music recommendation which used context data and several other methods and features also carried out by other research, such as researches conducted by [7-10] four of the research states that the situation or context data of the listener is helpful in the selection of music recommendations.Research that only uses the mood for recommending music has performed by [11] whom used Sequential Floating Forward Selection (SFFS) to select music features used for classification and Support Vector Music (SVM) was used to classify music based on mood.

This research discusses about music recommendation system based on context using Case-Based Reasoning (CBR) and Self Organizing Map (SOM) which is used as an indexing method in CBR. In general, the user will get music recommendation output based on their context in the form of a music playlist. In order to get the music playlist, the user input current user activity and user desired mood to the system. Other contexts used in this research were part of day, date, weather; region, month, and weekday were automatically retrieved by the system.

Case-based reasoning (CBR) is used in this research because CBR can be applied to various types of problems and CBR can provide a solution by using the accumulation of previous cases that exist in the case base. Music recommendations for a particular context can be determined based on the choices of music that has been done before, so the CBR can give recommendations based on music request cases in radio station that have happened. Self Organizing Map is used as an indexing method to reduce the time required to search cases in CBR's case retrieval stage. In this research, SOM categorize and index similar cases in the case base based on all case features.

The system created in this research can deliver music recommendations based on the user'scontext data (mood, occasion, part of day, date, weather, region, month, and weekday) using case-based reasoning which is expected to be more adaptable to new cases compared with a rule-based system. This research used 3,700 cases from more than 100 listeners. A larger number of cases expected to provide more diversity of contexts and can improve recommendation accuracy. The use of Self Organizing Map as a method of indexing, occasion (activity) and mood (the emotional state of the listener) features in the case base is expected to increase the recommendation accuracy.

## 2. Research Method

Explaining A name "Case-Based Context-Aware Music Recommendation System" (CB-Camurs) is given to the system built in this research. CB-Camurs users will get music recommendations output in the form of a music playlist. In order to get the playlist, the user gives the system input in the form of the current user activity and user desired mood.Determination of music recommendation is made by the steps of Case-Based Reasoning that use SOM-Indexing Model CBR as a method of case indexing.

### 2.1. Data Collection

The data used in the case base were obtained from music request data in the form of SMS owned by Elkoga Radio Bali. The music request data consist of request date, request time, listener's phone number and name, as well as music titles and artist. Weather data was taken from weather stations in Bali which has been published on Weather Underground website (www.wunderground.com). Mood data for the initial case base obtained through music classification process using Smart Player application [12] based on musical rhythm patterns.

### 2.2. Context Analysis

Contexts used in this research were mood, occasion, part of day, date, weather, region, month, and weekday. Details of these contexts are shown in Table 1. The weight of each feature value was used to calculate cases similarity in case retrieval phase. The values of weights were determined by five music experts who work at Elkoga Radio Bali as an announcer or music director based on each context's importance in giving music recommendation.

The announcers and music directors stated that the mood desired by the listeners is the most influential context in choosing music. Listeners who want happy mood will tend to choose music with a faster tempo to boost their spirit.Occasion also affect listeners in choosing music; for example, a listener who is resting will choose the type of music that is different from a listener who is exercising.

Table 1. Context Details

| Context | Weight | Details |
|---|---|---|
| *Mood* | 0,76 | Emotional state that is desired by the user. Consists of 4 different moods, Exuberance, Relax, Anxiety, and Depression [13]. |
| *Occasion* | 0,68 | The activities performed by users when using the system. Consists of 16 different activities, namely No Activity, Resting, Studying, Working, Driving, Sports, New Year, Birthday, Valentine's Day, Independence Day, Islamic Feast, Christian Feast, Hinduism Feast, Buddhism Feast, Gathering, and Marriage. |
| *Part of day* | 0,6 | Part of the day in one day. Consists of 5 different parts of day, namely Dawn, Morning, Afternoon, afternoon, evening, and night. |
| *Date* | 0,4 | Date in a month. Consists of 31 different date from 1 to 31. |
| *Weather* | 0,36 | Weather conditions in the area where the user is currently using the system. Consists of 13 different weather conditions, i.e. Cloudy, Partly Cloudy, Light Rain, Heavy Rain, Rain, Thunderstorm, Light Thunderstorms, Heavy Thunderstorms, Light Thunderstorms and Rain, Hazy, Heavy Thunderstorms and Rain, and Clear. |
| *Region* | 0,36 | The area where the user is currently using the system. Consists of 9 different regions in Bali, namely Denpasar, Badung, Tabanan, State, Singaraja, Karangasem, Bangli, Klungkung and Gianyar. |
| *Month* | 0,36 | Months in a year. Consists of 12 months, namely January, February, March, April, May, June, July, August, September, October, November, and December. |

Time of request, as in part of day also influences listeners to choose music. Music requested in the morning is always more powerful than music requested at night, to boost the listeners' spirit for working or studying. Region where the listeners live influences the listeners because there are different popular artists or music in different region, such as artist ST 12 was more popular in Klungkung and Karangasem and artist NOAH was more popular in Denpasar and Badung.

### 2.3. Music Recommendation using CBR and SOM

Case-based reasoning (CBR) is used in this research because CBR can be applied to various types of problems and CBR can provide a solution by using the accumulation of previous cases that exist in the case base.

#### 2.3.1. Case Representation

One case in the general knowledge represents one music request from a radio listener at a time. A case consists of two parts, namely the problem part and solution part. Case representation techniques used in this research is a relational database approach representation. The relational database model has been widely adopted in many case-based reasoning applications [14]. Each objects (or case) represented by rows in relational tables in which the columns are used to define the attributes of the object.

#### 2.3.2. SOM-Indexing CBR Model

SOM-Indexing CBR Model is a method of indexing in CBR that uses Self Organizing Map (SOM) algorithm [15]. In the process of indexing, cases which are classified in the same group will have the same index.

Self Organizing Map network consists of an input layer and output layer [16]. The input layer consists of 8 input neurons which symbolize context (date, region, month, part of day, weather, occasion, mood, and weekday). The output layer consists of 4 output neurons which were determined by choosing the best value of cohesion, separation, purity, and silhouette coefficient in cluster evaluation of 4 to 10 output neurons.

#### 2.3.3. Case Selection and Retrieval

Similarity function is used to find *k* old cases that are similar to the new case. The value of the similarity between a new cases N with an old case C is calculated using equation (1).

Similarity value is between 0 and 1. If the similarity value closer to 1, the old case and the new cases are increasingly similar, and vice versa.

$$Similarity\ (N,C) = \frac{\sum_{i=1}^{n} f(N_i,C_i)\times W_i}{\sum_{i=1}^{n} W_i} \quad (1)$$

Where $N_i$ is the $i^{th}$ feature value of the new case, $C_i$ is the $i^{th}$ feature value of the old case, $n$ is the total of features, $f\ (N_i, C_i)$ is a similarity function between $N_i$and $C_i$, and $W_i$ is weight of the $i^{th}$ feature.

### 2.3.4. Case Adaptation

Method used for case adaptation is feedback-based substitution method. This method uses feedback from users of the system to adapt cases. Adapted cases will not be directly used in the base case. A music expert, in this research is a music director in a radio station, will select the cases which are likely to be included in the case base.

### 2.4. System Evaluation

In system evaluation, 10 participants were invited to use the application to get testing data. The participants try several different system conditions, which are a system which use SOM-Indexing CBR MOdel, a system which does not use an indexing method, and a system that does not use mood and occasion features to determine the music recommendation. To evaluate system, the value of precision, recall, and F-measure were calculated.

## 3. Results and Analysis

CB-Camurs system testing using SOM as an indexing method produces an average precision of 0.867, an average recall of 0.533, and an average F-measure of 0.594. Table 2 shows the values of precision, recall, and F-measure from application testing result with SOM-Indexing CBR Model.

Table 2. System Testing Result of System Which Use SOM as an Indexing Method

| User | Precision | Recall | F-Measure |
|---|---|---|---|
| 1 | 0.867 | 0.361 | 0.443 |
| 2 | 0.867 | 0.867 | 0.867 |
| 3 | 0.933 | 0.366 | 0.506 |
| 4 | 0.933 | 0.523 | 0.578 |
| 5 | 0.800 | 0.475 | 0.551 |
| 6 | 0.800 | 0.548 | 0.561 |
| 7 | 0.800 | 0.491 | 0.527 |
| 8 | 0.933 | 0.511 | 0.589 |
| 9 | 0.867 | 0.810 | 0.833 |
| 10 | 0.867 | 0.380 | 0.482 |
| Average | 0.867 | 0.533 | 0.594 |

Table 3.Time used to Determine Music Recommendations

| User | Total Time (ms) |
|---|---|
| 1 | 352.00 |
| 2 | 357.00 |
| 3 | 460.00 |
| 4 | 392.00 |
| 5 | 342.67 |
| 6 | 437.67 |
| 7 | 371.67 |
| 8 | 378.67 |
| 9 | 356.33 |
| 10 | 347.67 |
| Average | 379.57 |

Precision value indicates that 86.7% of the music recommendations testing results had been considered appropriate to the mood and context of the user. Recall value indicates that 53.3% of cases that are relevant to the database have been retrieved by the system. Combination of precision and recall value is indicated by the F-measure value.

Based on the recommendation searching time, the average time taken by the system which usesSOM-Indexing CBR Model to search for music recommendation is 367.57 milliseconds. Table 3 shows details of the time taken by the system to determine music recommendations.

### 3.1. System Indexing Evaluation

In system indexing evaluation, we compare the system which used SOM-Indexing CBR Model with a similar system without an indexing method. Systemwhich usedSOM-Indexing CBR Model had 11.33 points greater in recommendation precision compared to systems that did not use an indexing method. System that used SOM-Indexing CBR Model was also 7.59 points higher in recommending music that is relevant. Details of the comparison can be seen in Table 4.

Table 4. System Evaluation Result Comparison

| Evaluation | Precision | Recall | F-Measure |
|---|---|---|---|
| With SOM Indexing(%) | 86.67 | 53.30 | 59.37 |
| Without Indexing(%) | 75.33 | 45.71 | 51.12 |
| Difference | 11.33 | 7.59 | 8.25 |

The use of SOM-Indexing CBR Model also speed up the system in determining music recommendations if it is compared to a system that does not use an indexing method. Because the system with an indexing method only needs to compare the similarity of new cases with old cases that are in one cluster. In system that did not use methods of indexing, the system must compare the similarity of new cases with all the old cases. The average time of the system whithout indexing to determine recommendationwas 672.83 milliseconds, which is 293.26 milliseconds slower than the system which used SOM-Indexing CBR Model.

### 3.2. Mood & Occasion Evaluation

Mood & occasion evaluation was done by comparing system which used mood and occasion features (complete context features) with system that did not use those features. The evaluation results can be seen in Table 5. The average value of precision, recall, and F-Measure is lower than the previous system evaluation which use complete context features.

Table 5. System Mood & Occasion Evaluation Result Comparison

| Evaluation | Precision | Recall | F-Measure |
|---|---|---|---|
| With *Mood & Occasion* (%) | 86,67 | 53,30 | 59,37 |
| Without *Mood & Occasion* (%) | 63,33 | 38,48 | 42,70 |
| Difference | 23,33 | 14,82 | 16,67 |

The system which didn't use the complete complete context features had a lower precision value by 23.33 points, a lower recall value by 14.82 points, and also a lower F-measure value by 16.67 points compared with the system which used the complete context features. This proves that user's mood and occasion can influence music preferences. Playlist resulted by the system that used mood and occasion features is more relevant for users; the total of music in a recommended playlist that replaced with another music by user is less when compared to systems that do not use mood and occasion features.The resulting recommendation is more appropriate for users because users feel more of the mood and occasion context compared to other contexts such as the date, month, day, and others.

## 4. Conclusion

A music recommendation system can be constructed using Case Based Reasoning with Self Organizing Map as a method of case indexing. Precision value of the system showed that the recommendation produced is 86.7% relevant according to user's mood and occasion.

System that used occasion and mood context in determining recommendation had a higher precision value compared with the system which did not use occasion and mood context. It showed that the presence of mood and occasion context in music recommendation system based on context can increase system precision in determining music recommendation.

Time calculation in music recommendation process shows the average search time on systems that use SOM as an indexing method is shorter than a system that does not use SOM as an indexing method, because the system with indexing method only compare the similarity of new cases with old cases that are in one cluster.

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