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MUSIC EMOTION CLASSIFICATION: A LITERATURE REVIEW

Samadara Dhanapala[1], Kamani Samarasinghe[2]

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Abstract

Music, as an art form, combines rhythm and sound to form a functional melodic structure, uniquely capable of conveying emotions non-verbally. Within the domain of Music Information Retrieval (MIR), Music Emotion Classification (MEC) represents a specialized subset dedicated to the identification and labeling of emotional attributes in songs. This is achieved by extracting and comparing features from musical compositions. This research aims to discern the contemporary landscape of research and its associated research gaps in this domain. The study comprised a collection of publications found through searches conducted on Google Scholar between the years 2006 and 2023, with the search terms: Music Emotion Classification, Music Emotion Classification in Sri Lanka, Music Emotion Recognition, and Emotion Classification in Music. This study was narrowed down to the research that utilized audio files for classification. Among the initial set of 42 studies, 20 were selected for detailed analysis using the purposive sampling method. The review encompassed essential aspects, including acoustic feature analysis, emotional modeling, classification methodologies, and performance evaluation. The findings highlighted a paucity of research considering cultural, regional, and linguistic variations. The most often used acoustic features encompassed rhythm, pitch, timbre, spectral, and harmony whereas the most frequently used emotion categories for the classification were happiness, anger, sadness, and relaxation. Support Vector Machine (SVM) was the most used machine learning algorithm for classification, although regression methods, neural network-based approaches, and fuzzy classifications were also explored. Notably, the adoption of multi-modal approaches for emotion classification, as well as multi-labeled emotion classification, remained limited. These insights underscore the need for future research to address the cultural and language diversity of datasets, explore innovative classification techniques, and embrace multi-modal and multi-labeled emotional classification methodologies in the context of music emotion classification within MIR.

Keywords

Emotion Classification in Music, Music Emotion Classification (MEC), Music Emotion Recognition (MER), Music Information Retrieval (MIR)

[1] Department of Information Technology, University of the Visual & Performing Arts, Sri Lanka. Email: samadara.d@vpa.ac.lk
[2] Department of Information Technology, University of the Visual & Performing Arts, Sri Lanka. Email: kamani@vpa.ac.lk

Introduction

Music is an art form that uses rhythm and sound to build a functioning melodic structure that can transmit emotions nonverbally. Music can elicit emotions in people broadly. Emotion is a complicated psychological and physiological response to stimuli. It includes subjective feelings, physiological changes, and behavioral reactions. Emotions play a significance role in human experiences, decision-making, and interpersonal relationships. (Ekman, 1992). People listen to music because it makes them feel better. Music is known as the language of emotions since it has the potential to move people to tears or happiness. Music can be utilized as a therapeutic tool to improve physical, mental, and emotional health and well-being. (Kathleen A et al., 2013).

The use of modern technology has changed the way we create, consume, and interact with music. For example, platforms like Spotify, Apple Music, and YouTube have changed the way we access and discover music. In these platforms, personalized playlists for users are created using algorithms based on listening history and preferences. Further, those platforms recommend songs for listening to the next what? (Lekamge et al., 2016). The field of Music Emotion Classification (MEC) involves analyzing and classifying the emotional content of music using computational techniques. The goal is to develop algorithms and models that automatically recognize and categorize the emotional characteristics expressed in a piece of music. Music Emotion Classification has several practical applications across various domains such as Music Recommendation Systems, Film and Media Production, Gaming Industry, Health and well-being, Marketing and Advertising, and Social Media and Content Creation.

According to the literature, researchers have explored various approaches, including machine learning, signal processing techniques, and deep learning methods. Some studies have focused on identifying suitable features of audio signals that can capture emotional content. These features may include features such as spectral characteristics, tempo, rhythm, and tonal aspects (Panda et al., 2023). There is substantial research that has applied traditional machine learning algorithms such as support vector machines, and random forests, and assembled learning approaches to them to classify music emotions based on extracted features (Joseph & Lekamge, 2019a). Another trend in the classification of music emotion is utilizing deep learning methods, including Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs),

which have gained popularity for their ability to automatically learn from audio data (Liu et al., 2017).

Some studies explore the integration of multiple modalities (audio, lyrics, video) to improve emotion classification accuracy (Edmonds Donald Bren & Sedoc, 2021) (Chen & Li, 2020a). Combining information from different sources can provide a more comprehensive understanding of emotion in music. Some studies have focused on the development of labeled datasets with annotated emotional content (e.g., happy, sad, angry) which is crucial for training and evaluating emotion classification models (Gómez-Cañón et al., 2023).

This research aims to identify research gaps in the domain of Music Emotion Classification. However, as mentioned above, several types of research have been performed in this particular domain. Therefore, this study was narrowed down to the research that utilized audio files for emotion classification.

Methodology

This study is a literature review of music emotion classification. Therefore, secondary data were used for conducting the research. The study was performed according to three steps. Those are: planning, conducting, and reporting. The planning phase defined the research objectives and research questions, the way we searched the relevant literature for the research, what the search terms were, and what the criteria for selecting papers for the study from the searched results were. The conducting phase included searching for studies according to defined search terms using the defined search way in the planning phase, filtering the papers according to selecting criteria, and finalizing the study set for the analysis. In the reporting phase, the selected studies were analyzed and the results were documented.

Research Objectives and Research Questions

Research objectives are an essential part of the research process as they provide a roadmap for the study, and guidance for decision-making. The objectives of this study were to explore commonly employed datasets in Music Emotion Classification, analyze emotion models used in such classification, explore acoustic features extracted for classification, and examine algorithms applied for emotion classification and their performance. The study defined the following research questions to address the above research objectives.

Table 1

Research Questions

No	Research Question
RQ1	What are the existing datasets in music emotion classification?
RQ2	What are the emotional models used for classification?
RQ3	What are the features that have been considered for classification?
RQ4	What are the AI-based algorithms used in music emotion classification and how does their performance?

The selection of relevant studies was performed concerning the Searching Method, Study Period, Search Terms, and the inclusion and exclusion criteria.

Searching method

The study used Google Scholar to search for papers through the internet. Google scholar is a freely accessible web search engine. It provides a simple way to search for scholarly literature broadly. (About Google Scholar, n.d.).

Study period

For this study, the papers published from the year 2006 to 2022 were selected.

Search terms

A search term includes text, numeric, or symbolic values submitted by a user into the search engine to find the desired results. These search terms serve the purpose of retrieving files and their contents, database information, and web pages. For this study 'Music Emotion Classification', 'Emotion Classification in Music', and 'Music Emotion Classification in Sri Lanka' were used as search terms.

The Inclusion and Exclusion Criteria

The search process was performed through Google Scholar using the above Search terms. Initially, 42 publications were found. The inclusion criteria (IC) for the study was that the audio file must be used for emotion classification. Consequently, lyrical and music video-based approaches, bio signal-based approaches, and dataset publications were excluded, while multimodal approaches were retained for consideration if they incorporated audio files in their methodology. Further, two exclusion criteria (EC) were also used to eliminate some studies.

Those were that the paper is not a primary study (EC1), and the paper was published just as an abstract (EC2). EC1 criteria led to the exclusion of literature reviews on Music Emotion Classification. Using the stated search terms, a total of 42 studies were obtained from Google Scholar. According to IC, 13 papers were removed. According to the EC1, 8 papers were removed. According to the EX2, 1 publication was removed. As a result, out of the initial 42 publications, 20 papers were filtered based on the specified inclusion and exclusion criteria.

Table 2

Titles of the selected studies

Paper Title	Author(s)	Year
Evaluation of Musical Features For Emotion Classification	Yading Song, Simon Dixon, Marcus Pearce	2012
Music Emotion Classification: A Regression Approach	Yi-Hsuan Yang, Yu-Ching Lin, Ya-Fan Su, and Homer H. Chen	2007
Music Emotion Classification: A Fuzzy Approach	Yi-Hsuan Yang, Chia-Chu Liu, and Homer H. Chen	2006
Toward Multi-modal Music Emotion Classification	Yi-Hsuan Yang, Yu-Ching Lin, Heng-Tze Cheng, I-Bin Liao, Yeh-Chin Ho, and Homer H. Chen	2008
SMERS: Music Emotion Recognition using Support Vector Regression	Byeong-jun Han, Seungmin Rho, Roger B. Dannenberg, Eenjun Hwang	2009
CNN Based Music Emotion Classification	Xin Liu, Qingcai Chen, Xiangping Wu, Yan Liu, Yang Liu	2017
Exploiting Online Music Tags for Music Emotion Classification	Lin, Y.-C., Yang, Y.-H., and Chen, H. H	2011
A Multimodal Music Emotion Classification Method Based on Multi-feature Combined Network Classifier	Changfeng Chen, Qiang Li	2020
Music Emotion Recognition System	Braja Gopal Patra, Dipankar Das and Sivaji Bandyopadhyay	2015
Music Emotion Classification based on Lyrics-Audio using Corpus based Emotion	Fika Hastarita Rachman , Riyanarto Sarno , Chastine Fatichah	2018
Multi-label classification of music by emotion	Konstantinos Trohidis, Grigorios Tsoumakas, George Kalliris, Ioannis Vlahavas	2011
Emotional classification of music using neural networks with the MediaEval dataset	Yesid Ospitia Medina, Jose Ramon Beltran, Sandra Baldassarri	2020
A Novel Music Emotion Recognition Model Using Neural Network Technology	Jing Yang	2021
Multi-Modal Music Emotion Recognition: A New Dataset, Methodology and Comparative Analysis	R. Panda , R. Malheiro , B. Rocha , A. Oliveira and R. P. Paiva	2013
An Ensemble Learning Approach for Automatic Emotion Classification of Sri Lankan Folk Music	Joseph Charles, Sugeeswari Lekamge	2021
Classification of Sinhala Songs based on Emotions	K.M.H.B.Abeyratne, K.L.Jayaratne	2019
Machine Learning for Emotion Classification of Sri Lankan Folk Music	Charles Joseph, Sugeeswari Lekamge	2019

Melody Analysis for Prediction of the Emotions Conveyed by Sinhala Songs	M.G. Viraj Lakshitha, K.L. Jayaratne	2016
Music Emotion Classification Method Using Improved Deep Belief Network	Guiying Tong	2022
Music emotion recognition using convolutional long short-term memory deep neural networks	Serhat Hizlisoy , Serdar Yildirim, Zekeriya Tufekci	2020

The selected studies were reviewed considering essential aspects such as datasets, acoustic features, emotional modeling, classification methods, and performance evaluation.

Results and Discussion

Datasets Used for Classification

A majority of the studies in this field have utilized online databases, with a notable emphasis on Western songs for classification purposes. Out of the 20 selected papers, 45% (9 papers) exclusively employed Western songs for their classification models. Additionally, 15% (3 papers) incorporated a mix of Western and other songs, bringing the total percentage of studies utilizing Western songs to 60% (12 papers). It is noteworthy to mention that languages like Chinese, Japanese, Turkish, Hindi, and Sinhala (Charles & Lekamge, 2021; Hizlisoy et al., 2021; Joseph & Lekamge, 2019b; Lakshitha & Jayaratne, 2016; Patra et al., 2015; Y. H. Yang et al., 2006, 2007)songs were also included in the classification process. However, individually, they constituted a relatively low percentage. These findings underscore the necessity for conducting more inclusive classifications to account for cultural and linguistic diversity.

Features Used for Classification

Acoustic features are measurable characteristics extracted from audio signals that describe various aspects of the sound, including its temporal, spectral, and rhythmic properties. These features are widely used in the field of music and audio signal processing for tasks such as music emotion classification, genre recognition, and speech recognition. According to the study, pitch, timbre, rhythm, spectral and harmony were the frequently extracted features for the classification. These features play a crucial role in music emotion classification, reflecting the multifaceted nature of sound.

Table 3

Summary of frequently used acoustic features

Feature	No of the papers used
Rhythm	9
Pitch	8
Timbre	7
Spectral	6
Harmony	5

Multimodal approaches in the context of Music Emotion Classification involve combining information from many sources or modalities to improve the accuracy of the classification. These modalities can include not only audio features of the piece of music but also additional sources like lyrics, album artwork, user reviews or even physiological data from listeners. The objective of the multimodal approach is to use different types of information to capture a more complete understanding of the emotions in a piece of music. It is aimed to improve the accuracy of the emotion classification models by combining features from different models. (Lin et al., 2011; Panda et al., 2013).

In this study, among the 20 papers examined, five (25%) employed multimodal approaches for classification (Chen & Li, 2020b; Lin et al., 2011; Rachman et al., 2018; J. Yang, 2021; Y. H. Yang et al., 2008), showing that the use of multimodal approaches produces higher results.

Table 4

Sources used for multimodal approaches

Multimodal Sources	Number of Papers
Audio and lyrics	3
Audio and online tags	1
Audio, MIDI, and lyrics	1

Based on the information presented in the table, it is evident that 4 out of 5 instances (80%) utilized lyrics for the classification process.

Emotional Models Used for Classification

In emotion classification, researchers have employed various emotion models, most probably by utilizing the categorical or dimension approach (Trohidis et al., 2011). Discrete emotion theories show that there are basic emotion categories such as happiness, sadness, anger, fear,

and disgust, and that all other emotions are derived from those basic emotion categories. Emotions are expressed in a two-dimensional system in the dimensional approach. The two axes are valence and arousal. This model has been modified later by several people such as James Russell (Russell et al., 1980).

Out of a total of 20 studies, 55% (11 studies) have opted for the classification based on emotion classes. A substantial 30% (6 papers) have used Arousal and Valance values. Moreover, 15% of the studies (3 papers) have used both approaches (Abeyratne & Jayaratne, 2019; Patra et al., 2015; Y. H. Yang et al., 2008).

Table 5

Summary of Emotion Models

Emotion type	No of papers	Percentage
Emotion classes	11	55%
AV values	6	30%
both emotion classes & AV model	3	15%

Further investigation showed that the commonly used emotion classes for classification were happiness, anger, sadness, and relaxation.

Music often evokes a wide range of emotions, and a single piece of music can express a combination of feelings. Multi-label classification enables assigning and predicting multiple emotion labels to a given single musical piece (Trohidis et al., 2011). Within the 20 papers examined, only one paper accounting for 5% of the total, has used the multi-label classification approach.

Classification Algorithms

In artificial intelligence, three significant paradigms; namely, machine learning, neural networks, and deep learning, have emerged as transforming forces that reshape the way computers learn and process information. Machine Learning enables computers to learn from data without programming explicitly. It involves algorithms that improve their performance

over time as they encounter more data. Machine learning algorithms adapt and make predictions or decisions based on patterns and insights gleaned from the provided information.

Neural Networks are a class of algorithms within machine learning. These networks consist of interconnected nodes, or neurons, organized into layers. Each connection is assigned a weight. The network adjusts these weights to optimize its ability to perform a specific task, such as image recognition, natural language processing, or pattern recognition through the network training process. Deep Learning advances neural networks by introducing deep neural networks with multiple layers (deep neural networks). This architecture enables the model to automatically learn hierarchical representations of data, extracting intricate features at different levels of abstraction.

Artificial intelligence (AI) falls within the realm of data science and includes classical programming and machine learning (ML). ML contains many models and methods, including deep learning (DL) and artificial neural networks (ANN) (Choi et al., 2020).

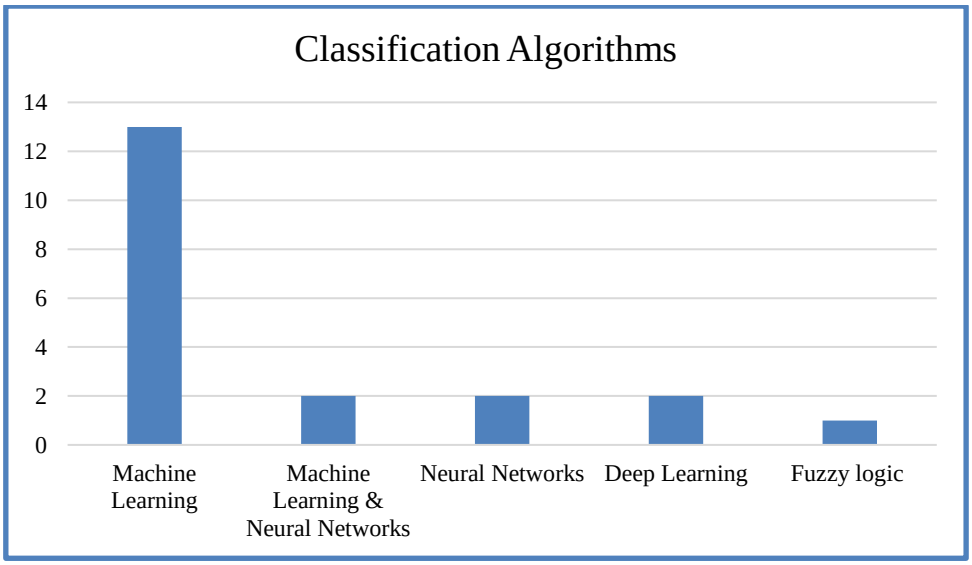

Figure 1. Classification Algorithms

According to the analysis of the review articles, 65% (13 papers) have applied machine learning algorithms for the classification (Abeyratne & Jayaratne, 2019; Charles & Lekamge, 2021; Chen & Li, 2020b; Hwang et al., 2009; Joseph & Lekamge, 2019b; Lakshitha & Jayaratne, 2016; Lin et al., 2011; Panda et al., 2013; Rachman et al., 2018; Tong, 2022; Y. H. Yang et al., 2007, 2008) (Pearce et al., 2012). 10% (2 papers) have applied neural networks for the classification (Patra et al., 2015; J. Yang, 2021), and 10% (2 papers) have applied both machine learning and neural networks algorithms for the classification (Medina et al., 2022;

Trohidis et al., 2011). Further, 10% (2 papers) have applied deep learning algorithms (Hizlisoy et al., 2021; Liu et al., 2017) and 5% (1 paper) have applied fuzzy classifier (Y. H. Yang et al., 2006) for the classification.

The Support Vector Machine (SVM) algorithm emerged as the predominant choice among the classifiers used in the reviewed papers, Specifically, 50% of the papers have used SVM. Further, 20% of the papers have solely selected SVM as their classifier based on prior literature (Chen & Li, 2020b; Pearce et al., 2012; Tong, 2022; Y. H. Yang et al., 2008). Furthermore, from the selected studies, 30% of the papers (6 papers) have conducted a comparative analysis of classifiers, with SVM being considered as one of the methods. Notably, in three instances among those considered, SVM or an ensemble approach involving SVM was identified as the best-performing classifier. These results emphasize the importance and effectiveness of the SVM classifier in the context of the emotion classification explored in the literature.

Within the examined papers, 3 papers out of 20 (15%) were used regression approach (Hwang et al., 2009; Patra et al., 2015; Y. H. Yang et al., 2007) for the classification. Two papers, accounting for 10% of the total, showed the best performance with the Support Vector Regressor (SVR). This indicates a noteworthy but comparatively less common application of regression-based methods, with SVR emerging as a particularly effective choice in the instances where it was employed.

Within the examined set of papers, only 1 paper out of 20, accounting for 5% of the total, used fuzzy logic and a machine learning integrated approach for the classification (Y. H. Yang et al., 2006). Fuzzy logic is a mathematical framework that deals with reasoning and decision-making under uncertainty.

Conclusion

The findings of this study show that most researchers utilize Western datasets for classification. When considering feature extraction, pitch, timbre, rhythm, spectral and harmony were the most often extracted features for the classification. Happiness, Anger, Sadness, and Relaxation were the most often used emotion classes for classification. Further, the study reveals that machine learning algorithms were often used for emotion classification, while neural network, deep learning, and fuzzy logic-based approaches were also examined. The study identified the SVM as the most used classifier.

In conclusion, the study suggests the use of more diverse datasets representing different cultures and languages for classification and the exploration of both innovative classification approaches and multi-modal and multi-label strategies for music emotion classification. Further, the study shows the limited exploration of fuzzy logic-based classifications and suggests future potential for further research.

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