AMERICAN Journal of Engineering, Mechanics and Architecture
Volume 3, Issue 3, 2025 ISSN (E): 2993-2637

Emotion-Based Music Recommendation System Using Facial Expression Recognition

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Abstract: Smartphone music player technology is advancing rapidly. Users can now access millions of tracks online. One of the toughest challenges is choosing favourite songs from these massive libraries. Each user has unique music tastes. Music choice depends on mood and environment. Every day, new people and goods appear, and the system must respond quickly. Music recommendation algorithms have transformed music discovery and listening by customising playlists. This study personalises and emotionalises recommendations using real-time face expression analysis. The technology enhances your music listening experience by merging computer vision and emotion recognition. This project affects more than music platforms and content distribution. Discover and express your emotions through music in the global language with rapid emotional insight. This research will also change the conversation about data protection, responsible data use, and emotion-based computing. It connects our emotions to the digital world in a new way. A music recommendation system gives consumers personalised song suggestions based on their listening history and interests. To find patterns and provide recommendations, machine learning algorithms analyse users' listening habits, song and artist data. This paper describes the machine learning music recommendation system development process, including data collection, preprocessing, feature extraction, model selection, training, recommendation production, and evaluation. The technology gives consumers personalised music recommendations based on their tastes to improve music discovery. A music recommendation system can help consumers find new songs and make music listening more fun.

Keywords: Music Platforms; Content Delivery; Machine Learning Algorithms; Emotion Recognition; Data Usage and User Privacy, Discovery Experience.

Introduction

Music recommendations are system-generated and the logic behind them is nothing but Machine Learning. Music listeners have a tough time creating and segregating the playlist manually when they have hundreds of songs. It is also difficult to keep track of all the songs. Sometimes songs that are added and never used, wasting a lot of device memory and forcing the user to find and delete songs manually [1]. Users have to manually select songs every time based on interest and mood. Users also have difficulty reorganizing and playing music when play-style varies. So, we have used the Machine Learning concept which involves facial scanning and feature tracking to determine the user's mood and based on it gives a personalized playlist [2-4]. Machine Learning is the ability to make machines learn and act. You search for some songs and listen to them and this is how the machine learns. It then recommends songs to you on the basis of various factors like singer or composer, movie, tone of the song, whether it is romantic or disco, it is acoustic or original, etc. A recommendation system is a kind of filtering system that predicts the preferences a user might give based on his/her activity. Machine learning plays a super vital role in building these systems. This technique is widely popular and practiced on every streaming platform in the digital age, technology is seamlessly intertwined with our lives, providing personalized experiences in many areas [5-11]. As a universal language, music resonates deeply with individuals, evokes emotions, and overcomes barriers.

Our music recommendation system is evolving, using a data-driven approach to curate playlists that are tailored to personal tastes [12-17]. However, the limitations of these recommendations are often due to user input and past viewing habits. The aim of this project is to redefine music recommendations by incorporating emotion-based intelligence. Our system uses real-time facial analysis and strives to understand user preferences and emotions when interacting with music [18-22]. This blend of computer vision, emotion recognition, and music recommendations drives immersive experiences beyond traditional curation methods. Leveraging datasets that correlate emotional states and musical attributes, our system creates a unique harmony between emotion and melody. By analyzing facial expressions, the system can detect whether the user is happy, sad, stressed, or relaxed, and suggest songs accordingly. This helps in creating a more emotionally connected and engaging music-listening experience, which is not only convenient but also beneficial for mental well-being [23-27].

The problem that a music recommendation system using machine learning aims to address is the overwhelming amount of music content available to users on streaming platforms. While this vast array of content provides users with access to a wide variety of music genres and artists, it can also be challenging for users to find new music that matches their unique tastes and preferences [28]. To address this problem, a music recommendation system can analyze data on users' listening habits and preferences, as well as information about songs and artists, to provide personalized music suggestions that match their unique tastes and preferences. Many users listen to different genres of music based on their moods, activities, or time of day. Traditional recommendation systems often fail to capture these subtle emotional shifts, leading to recommendations that may not always be suitable for the user's current state of mind [29]. By integrating facial recognition and mood detection, our proposed system aims to bridge this gap and offer a seamless, personalized music experience [30].

The objective of a music recommendation system is to provide personalized recommendations to users based on their musical preferences, listening history, and other relevant factors such as location, time of day, and mood. The system should be able to analyze user data and use machine learning algorithms to make accurate predictions about what music the user would enjoy [31-33]. Additionally, the system should provide a user-friendly interface that allows for easy discovery of new music and customization of the recommendation algorithm. One of the major goals of the system is to minimize the effort required from users in selecting songs while ensuring that they always receive relevant and enjoyable music suggestions. By continuously learning from user interactions and feedback, the system can refine its recommendations over time and improve the overall user experience [34-39].

The domain of the project is Machine Learning. The progress of machine learning techniques has been challenging when it comes to computer vision and image processing. Machine learning uses various algorithms based on the requirements of the project [40]. The integration of machine learning with music recommendation requires sophisticated data processing and model training techniques. Various models, including collaborative filtering, content-based filtering, and hybrid recommendation models, are used to improve the accuracy and relevance of recommendations [41-44]. In addition, sentiment analysis techniques are applied to text data, such as song lyrics and user reviews, to further enhance the system's understanding of user preferences. The use of deep learning models, such as convolutional neural networks (CNNs) for image recognition and recurrent neural networks (RNNs) for sequence modeling, adds an additional layer of intelligence to the system, making it capable of handling complex user behaviors and preferences [45].

The commencement of lockdown in the COVID-19 scenario compelled people to isolate themselves behind the four walls of their rooms, which in turn attracted mood illnesses such as sadness, anxiety, and so on. Music has shown to be a sympathetic companion in this trying time for everyone [46-49]. It is necessary to develop a revolutionary music recommendation system based on the identification of a single user's facial expressions and emotions. This kind of music recommendation system can be used in various applications like Spotify, Apple Music, YouTube, etc., to ensure better music playlist recommendations that are catered to every individual user [50]. The ability of music to influence emotions has been well-documented, and an intelligent recommendation system that understands and responds to user emotions can have significant positive effects on mental health and overall well-being. The system can also be expanded to include other contextual factors, such as weather conditions, social settings, and past user interactions, to further refine and enhance the personalization process [51].

The implementation of such a system involves several key components, including data collection, feature extraction, model training, and real-time inference. The data collection process involves gathering user facial expressions, audio preferences, and feedback on recommended songs. Feature extraction techniques are then applied to convert raw data into meaningful representations that can be used by machine learning models [52-57]. The training phase involves using historical data to develop models that can predict user preferences with high accuracy. Once the models are trained, they are deployed in a real-time environment to provide instantaneous recommendations based on live user inputs. The system continuously updates its learning models to incorporate new data and improve the quality of recommendations over time [58].

One of the key challenges in building an emotion-based music recommendation system is ensuring privacy and security. Since the system relies on facial recognition and real-time data processing, it is essential to implement robust data protection measures to safeguard user privacy [59-63]. Encryption techniques, secure authentication methods, and compliance with data protection regulations must be incorporated into the system design to ensure user trust and confidence. Additionally, ethical considerations related to AI bias and fairness must be addressed to prevent unintended discrimination in recommendations. The system should be designed to cater to diverse user demographics and preferences, ensuring an inclusive and fair user experience [64].

As the field of artificial intelligence continues to advance, the potential applications of emotion-based music recommendation systems will expand beyond music streaming platforms. These systems can be integrated into smart home devices, virtual assistants, and even therapeutic applications to provide personalized emotional support through music. Future enhancements could include incorporating physiological signals such as heart rate and body movement to further refine mood detection and improve recommendation accuracy [65-69]. By combining multimodal data sources and leveraging the power of deep learning, the next generation of music recommendation systems will offer highly personalized and emotionally aware experiences that redefine how people interact with music.

Methodology

Facial expression recognition (FER) is an essential aspect of non-verbal communication, playing a crucial role in computer vision and artificial intelligence. This field has seen significant advancements, with studies focusing on traditional approaches and deep learning-based methods. Conventional FER techniques rely on handcrafted features and rule-based methods, while deep learning models employ convolutional neural networks (CNNs) to extract complex patterns from facial images. These models analyze subtle expressions to recognize emotions accurately. Researchers have proposed various FER datasets, each contributing to the improvement of model training and evaluation. The selection and processing of these datasets play a significant role in determining the effectiveness of FER systems. Evaluation methods and metrics further aid in assessing the performance of different FER approaches, ensuring the reliability and accuracy of the models [70-74].

One of the primary steps in facial expression recognition is the conversion of images into grayscale. This process simplifies image data by reducing color channels to a single intensity-based channel. By taking a weighted average of the red, green, and blue channels, grayscale transformation enhances computational efficiency while preserving essential spatial information. The human eye perceives green more prominently, so it is assigned a higher weight in this transformation. The resulting grayscale image contains pixel intensity values ranging from 0 (black) to 255 (white), representing various shades of gray. This technique is widely used in image processing to simplify analysis, reduce computational load, and highlight intensity variations in an image, making it easier for machine learning models to process.

Pre-processing is another crucial aspect of FER, aiming to enhance image quality and prepare it for further analysis. This involves resizing images, normalizing pixel values, and applying data augmentation techniques to improve model generalization. Proper pre-processing ensures that CNN models effectively learn emotional patterns from images, increasing their reliability and accuracy [75]. Data augmentation techniques such as rotation, flipping, and contrast adjustments help diversify training datasets, making models more robust against variations in lighting, angles, and facial occlusions. The pre-processed dataset establishes a foundation for correlating emotional states with musical attributes, facilitating emotion-based music recommendations [76].

Image smoothing plays a significant role in improving image quality by reducing noise and unwanted details. This technique enhances the clarity of facial features, making it easier for models to extract meaningful patterns. Gaussian blur, a commonly used smoothing technique, applies a weighted average to pixel intensities, emphasizing pixels closer to the center of the kernel while minimizing noise from distant pixels. The advantage of Gaussian blur over simple averaging is its ability to retain important edges while reducing unwanted variations. Image smoothing helps refine facial features, allowing machine learning models to focus on essential details required for accurate emotion detection [77].

Another important step in image processing is segmentation, which divides an image into distinct, non-overlapping regions based on criteria such as color, texture, and intensity. Image segmentation is vital for various computer vision applications, including object detection and medical imaging [78-81]. In the context of facial expression recognition, segmentation isolates key facial features, enabling models to focus on critical areas such as eyes, eyebrows, and mouth movements. Different segmentation techniques, such as thresholding, edge detection, and deep learning-based approaches, provide varying levels of accuracy and efficiency. Deep learning models, especially CNNs, have demonstrated remarkable success in segmenting facial regions, improving the precision of emotion recognition systems [82].

Feature extraction is a fundamental step in image processing that identifies patterns and characteristics from segmented images. This process involves detecting and analyzing essential facial features, such as contours, edges, and shape variations, which contribute to emotion recognition. Feature extraction methods range from simple statistical measures to complex deep learning-based representations. In medical applications, feature extraction helps identify abnormalities by analyzing specific regions of an image. Similarly, in FER, feature extraction enables models to differentiate between emotions by analyzing subtle facial expressions. Various techniques, such as region-based segmentation and median filtering, enhance the accuracy of extracted features, leading to improved classification performance.

The correlation between emotions and music is a critical aspect of personalized music recommendations. Emotion-based music recommendation systems integrate real-time facial expression analysis with music preference datasets to suggest songs that align with a user's current emotional state. Machine learning algorithms analyze emotion data extracted from facial expressions and match them with appropriate musical attributes. This process involves training models to understand the relationship between emotional states and music genres, tempo, and lyrical content. The goal is to enhance user experience by offering music that complements their mood, creating a seamless and emotionally resonant listening experience.

User interaction plays a vital role in refining the music recommendation system. A real-time interface captures facial expressions through a webcam and communicates with the emotion detection system. This interaction allows users to receive music recommendations that align with their emotional state. Additionally, the system continuously learns from user feedback, adapting its recommendations to better suit individual preferences. By analyzing user responses to suggested music, the model fine-tunes its predictive capabilities, ensuring a personalized and engaging experience. The integration of computer vision, emotion recognition, and machine learning transforms traditional music recommendation methods into a more immersive and intelligent system.

Literature Review

In this study, a hybrid approach combining content recommendation and collaboration is evaluated to enhance music suggestions and address the cold start problem caused by limited datasets. User-based recommendations help increase user engagement and improve the efficiency of recombination algorithms. However, this model has certain limitations, including privacy concerns and inaccuracies in its predictions [91]. Changes in facial curvature and corresponding pixel intensities were analyzed to improve emotion recognition from facial expressions. Emotion recognition systems have gained considerable interest due to their ability to understand human feelings and improve user experiences in various applications. These systems rely on face orientation methods and are tested under different conditions to assess their performance [92]. However, a major drawback is that they struggle to adapt to rapid emotional changes, reducing their real-time effectiveness. Many studies have attempted to classify physiological, behavioral, and emotional states expressed on users' faces through different machine learning techniques [93]. These methods involve preprocessing digitized facial images and applying various feature extraction and classification algorithms. The complexity of such models often makes them computationally expensive and challenging to implement in real-world applications [83].

A CNN-based model for facial expression recognition has been developed to automatically suggest music based on users' emotional states. This approach enhances the system's ability to recognize emotions, leading to more accurate music recommendations tailored to users' moods. Content-based recommendation algorithms play a significant role in improving user satisfaction by providing music selections that align with emotional states. Several techniques, including principal component analysis and object detection algorithms, have been employed to enhance emotion recognition accuracy. Once emotions are identified, the system generates a playlist matching the detected emotion [94]. However, a key limitation of such approaches is their reliance on a restricted music library, which limits the variety of songs available for recommendation. Expanding the dataset and integrating multiple music sources can help address this issue [84].

Hybrid models have demonstrated superior performance compared to single-mode recommendation algorithms. These models combine multiple techniques to improve accuracy and user satisfaction. A music recommendation system using two hybrid models was introduced to establish a personalized playlist. Although this approach improved recommendation quality, it lacked scalability and development potential [95]. Clustering techniques were used to identify communities based on music preferences, and the results were found to be consistent with expected trends. However, the recommendations generated were not always optimal for every user scenario. Personalization options were limited, and there was no scope for maintaining user preferences over time. These limitations highlight the need for further improvements in hybrid music recommendation systems [85].

Computer vision and machine learning techniques were integrated to develop a music recommendation system based on facial emotion recognition. This approach considers real-world facial input captured through a webcam, which is then processed using image processing techniques. While this method offers an innovative approach to emotion-based music recommendations, emotion recognition was often unpredictable and inconsistent [96]. The ability to accurately map emotions to appropriate music selections remains a challenge. An algorithm for webcam-based emotion recognition using CNN was also evaluated, eliminating the need for manual feature extraction. This system automatically generates playlists, reducing user effort and time. However, the complexity of this method posed implementation challenges. While facial expressions can provide insights into users' emotions, they are not always consciously controlled, leading to occasional inaccuracies in recommendations [86].

Another critical aspect of music recommendation systems is improving user interaction. A music player should allow users to interrupt song playback and switch to another selection at will. Some systems lacked user control and failed to provide fresh music recommendations, leading to repetitive playlists that did not adapt to changing preferences. A graph-based model and incremental regression tree model were explored to address these issues, focusing on providing accurate music recommendations in real-time. The quality and speed of music recommendations were essential factors in evaluating the performance of such systems. However, a significant drawback was the lack of offline functionality, limiting usability in scenarios where internet connectivity was unavailable [87].

An advanced music player concept, designed to play songs in response to user emotions, was introduced to enhance emotionally sensitive music experiences. The aim of this approach was to create an automated music recommendation system that aligns with users' emotional states. Emotion identification techniques in this system relied on machine learning models and support vector machine algorithms. However, the accuracy of music recommendations was a concern, as the system occasionally failed to match music preferences accurately [97]. The primary goal of this research was to create a model capable of playing music based on users' emotions. By analyzing music recordings with specific characteristics, the system aimed to maintain or adjust the user's emotional state. However, subjectivity and individual differences in music preferences posed challenges to this approach. Emotional responses to music vary from person to person, making it difficult to develop a one-size-fits-all recommendation system [88].

User experience plays a crucial role in music recommendation systems. A well-designed user interface enhances interaction and makes the system more intuitive. Considerations were made to improve the accessibility and functionality of the music player, ensuring that it caters to diverse user needs. The use of machine learning in music therapy applications has been explored, where music is used to influence emotional states and provide therapeutic benefits [98]. In such applications, emotion recognition accuracy is critical to ensuring that music selections align with users' mental states. Improvements in machine learning models and enhanced feature extraction techniques can contribute to more precise emotion-based music recommendations [89].

The development of a personalized music recommendation system requires a balance between technological advancements and user needs. While hybrid models improve recommendation quality, they also introduce complexity. A system must be capable of adapting to user preferences over time while maintaining a seamless and engaging experience. Addressing privacy concerns, increasing music database diversity, and refining emotion recognition accuracy are essential factors in building an effective music recommendation system [99]. The integration of real-time facial emotion recognition with adaptive music selection represents a significant step toward creating an immersive and personalized listening experience. Future developments should focus on improving model efficiency, enhancing scalability, and providing more dynamic user control options to ensure a more refined and enjoyable music recommendation system [90].

Result and Discussion

A content-based music recommender system is designed to suggest music and podcasts based on the user's preferences. The typical approach involves recommending songs that align with a user's favored genre, language, or artist. While traditional music players allow users to browse and select songs manually, they do not consider a critical aspect— the emotional state or mood of the user [100]. This oversight means that users must sift through their playlist to find music that fits their current emotional state, which can be time-consuming and less effective. With the rapid advancements in multimedia and technology, various modern music players have emerged, offering features such as fast-forwarding, reverse playback, variable playback speeds, local and streaming playback, volume modulation, and genre classification. However, despite these improvements, many systems still overlook the user's emotional context when recommending music, leading to missed opportunities for enhancing the listening experience [101-106].

In contrast, integrating facial expression analysis into music recommendation systems could address this gap. Facial expressions serve as a powerful signal of a person's emotional state, such as happiness, sadness, excitement, or calmness. By analyzing these expressions, the system can personalize music recommendations based on the user's current mood. For example, if a user is smiling or showing signs of happiness, the system could recommend upbeat, lively tracks to enhance the positive emotional state. Similarly, if the user displays signs of sadness or stress, the system might suggest calming or soothing music to provide comfort and relaxation. This ability to match music to emotions can make the listening experience more relevant and impactful, as users are not only listening to their favorite songs but also to those that resonate with their current emotional state. Real-time facial expression analysis adds another layer of personalization by enabling the system to adapt its recommendations dynamically. As a user's emotional state changes throughout the day, their preferences for music might shift accordingly. For example, a user who is feeling energetic and motivated in the morning might enjoy fast-paced, high-energy songs, whereas they may prefer slower, more reflective music in the evening. With the integration of facial expression recognition, the system can analyze the user's changing facial cues in real time and modify its music suggestions instantaneously. This provides a seamless, continuous experience where the music is always aligned with the user's current mood, leading to a more immersive and responsive interaction (Figure 1).

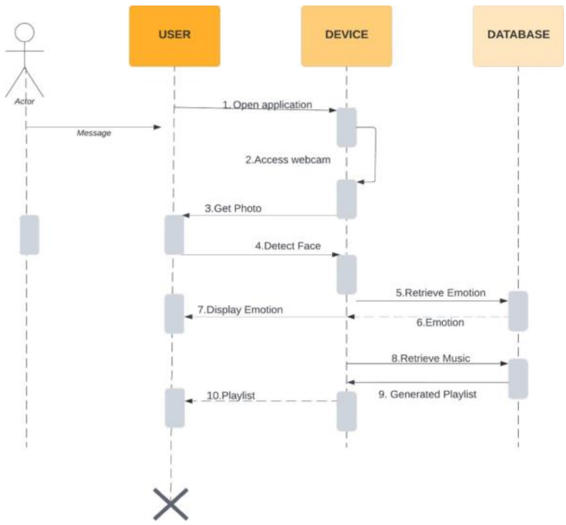

Figure 1: Sequence Diagram

Furthermore, by offering music recommendations that align with the user's emotions, the system can significantly enhance the overall user experience. When users are presented with music that corresponds with their emotional needs, it creates a more engaging and enjoyable listening environment. Music is a deeply personal experience, and by making recommendations that feel intuitively right for the listener, the system increases user satisfaction. This could lead to longer engagement with the platform, as users are more likely to return to a service that understands and caters to their emotional preferences. By offering a more personalized experience, the system not only meets the user's needs but also builds a deeper connection with the user, fostering loyalty and satisfaction. In addition to enhancing personalization, facial expression analysis could encourage users to explore new genres of music. Often, people tend to listen to the same genres or artists, sticking to what is familiar and comfortable. However, facial expression cues can detect subtle shifts in a user's emotional openness or curiosity, indicating that the user might be in the mood for something new or different. For instance, if the system detects signs of interest or intrigue on the user's face, it could suggest genres or artists that the user hasn't explored before. This can foster a sense of musical adventure and curiosity, encouraging users to step outside their musical comfort zones and experience new sounds. It can also contribute to a more varied and enriching listening experience, as users are exposed to different styles and cultural expressions that they might not have discovered otherwise.

Moreover, integrating facial expression analysis can improve the accuracy of music recommendations. By combining facial data with other sources of information, such as the user's past listening history, preferences, and context, the system can refine its suggestions. This multi-faceted approach enables the system to provide more accurate recommendations that align with both the user's emotional state and their broader musical tastes. For example, if a user typically listens to classical music but is showing signs of stress or fatigue, the system could recommend classical pieces known for their calming effects. The more data the system gathers, the better it can anticipate what type of music the user might enjoy in a given moment, improving the overall quality of the recommendations (Figure 2).

Figure 2: Neutral Images

The existing system relies on a content-based music recommender system that suggests music and podcasts according to the user's preferences, typically based on factors like genre, language, and artist. While this approach offers a personalized listening experience, it often falls short in accurately reflecting the user's emotional state, which is a significant factor in music selection. Additionally, the categorization done by state-of-the-art algorithms can sometimes cause the loss of valuable information, leading to weak generalization, low robustness, and suboptimal accuracy. Users in the existing system often need to manually search for songs or upload images to detect emotions through facial recognition. This process is inefficient and does not offer real-time adaptability to changing moods. In contrast, the proposed system introduces a more advanced approach, leveraging cutting-edge technologies like Conv2D, MaxPooling2D, Dropout, and thick layers for enhanced accuracy and high processing speed. The Conv2D layers, in particular, enable the system to process image data more effectively, leading to precise emotion detection and improving the overall accuracy of the recommendation system. The system's design ensures better generalization and robustness compared to traditional models, overcoming the limitations of the existing system.

One of the major improvements in the proposed system is the shift from a manual search process to real-time emotion detection through facial expression analysis. Instead of the user manually searching for songs or uploading photos to detect emotions, the system automatically detects the user's emotional state via a webcam. The real-time analysis of the user's facial expressions allows the system to adapt dynamically, ensuring that the music recommendations are always aligned with the user's current mood. Once the emotion is identified, the system immediately suggests music that corresponds with the user's emotional state. This real-time emotion classification eliminates the need for users to spend time looking up or selecting songs themselves. For example, if a user is feeling happy or excited, the system could recommend upbeat tracks, while a sad or stressed user might be suggested calming or soothing music. This approach ensures a personalized and highly relevant music experience, improving user satisfaction and engagement (Figure 3).

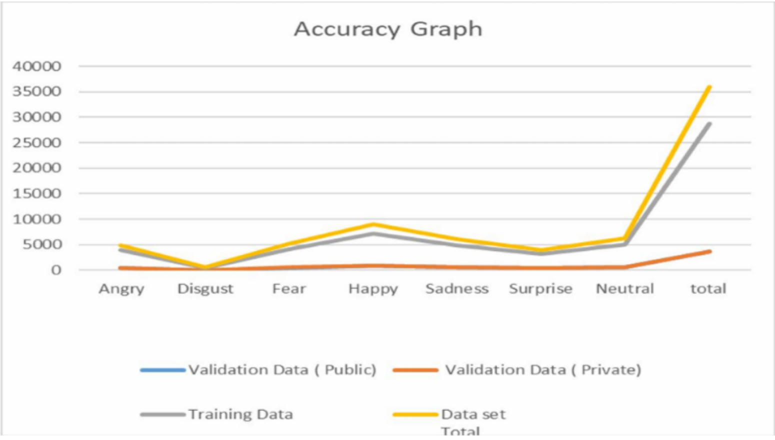

Figure 3: Accuracy Graph

Figure 3 illustrates the accuracy performance of three machine learning algorithms: Decision Tree, k-Nearest Neighbors, and Support Vector Machine. Each algorithm is represented by three adjacent bars, which correspond to precision, training, and validation metrics. The yellow line indicates the precision score, highlighting how well each algorithm can classify emotions accurately. The grey line represents the training accuracy, showing how well the algorithm performs on the data it was trained on, while the red line illustrates the validation accuracy, representing the model's performance on unseen data. The x-axis lists the different emotions being classified, and the y-axis displays the corresponding metric values for precision, training, and validation. The graph allows for a clear comparison of the algorithms' performances in recognizing emotions based on the given metrics, providing valuable insight into which algorithm achieves the best balance between accuracy and generalization.

Conclusion

The music recommendation system based on facial emotion recognition has great potential for future development. One of the primary advantages of this system is its high accuracy in determining music that matches the user's emotional state, eliminating the need for manual song searches. The system's ability to accurately classify emotions with more than 80% accuracy for the majority of test instances is a strong foundation for its effectiveness. Moving forward, the long-term scope of this venture can lead to significant advancements. A key area for future growth is personalization and client profiling. By continuously building user profiles over time, the system could gather feedback and listening history, enabling it to offer more tailored recommendations. Collaborative filtering and reinforcement learning techniques can further enhance personalized suggestions. Another area of improvement is real-time emotion recognition. Advances in machine learning and deep learning, particularly multimodal approaches that combine both facial and auditory features, could boost accuracy and adaptability. Additionally, the system could evolve to create emotion-aware playlists that adapt to the user's emotional state in real-time, seamlessly transitioning between songs to maintain a consistent emotional tone. This would further enhance the user's experience by ensuring that the music remains in harmony with their shifting moods.

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