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RECOGNISING FACIAL EMOTIONS THROUGH ATTENTION MECHANISM AND SONG RECOMMENDATION

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ABSTRACT

Facial Emotion Recognition (FER) plays a critical role in human-computer interaction, allowing systems to understand, interpret, and respond to human emotions effectively. However, traditional FER models face significant challenges, including variations in facial expressions, lighting conditions, occlusions, and head poses, which can reduce recognition accuracy. To address these issues, this paper proposes an advanced FER system that integrates an attention mechanism with deep learning models to enhance both accuracy and robustness. The attention mechanism dynamically prioritizes key facial features, ensuring the model focuses on the most relevant regions for emotion detection. Additionally, we incorporate a personalized song recommendation system, where the recognized emotions serve as input to suggest mood-based music, enhancing user experience. Our approach employs a hybrid deep learning model**,** combining convolutional neural networks (CNNs) and attention mechanisms for feature extraction, followed by a collaborative filtering-based recommendation system. Experimental results demonstrate high accuracy in emotion recognition and strong user satisfaction in music recommendations. This work contributes to affective computing, with applications in mental health support, entertainment, and intelligent user interfaces.

Keywords - Facial Emotion Recognition, Attention Mechanism, Deep Learning, Song Recommendation, Affective Computing, Human-Computer Interaction.

INTRODUCTION

Understanding human emotions plays a crucial role in enhancing digital interactions and improving overall user experience. Facial expressions serve as primary indicators of emotions, making Facial Emotion Recognition (FER**)** a key research area in artificial intelligence (AI) and affective computing. FER has significant applications across multiple domains, including healthcare, security, entertainment, and human-computer interaction (HCI). However, conventional FER models often struggle with accurately detecting emotions due to variations in lighting conditions, occlusions (such as glasses and masks), head pose variations, and subtle facial expressions. These factors introduce challenges in real-world implementations.

To address these limitations, attention mechanisms have been introduced in deep learning-based FER models. These mechanisms enable the model to focus on the most relevant facial regions, dynamically prioritizing critical features and thereby improving recognition accuracy. By reducing the impact of irrelevant facial details, attention-based models enhance emotion classification, especially in complex scenarios.

Furthermore, we extend our FER system by incorporating a personalized song recommendation module, which suggests music based on the user's detected emotional state. Given that music has a profound impact on emotional well-being, this integration enhances user experience by providing emotion-based song recommendations, offering applications in mental health support, stress relief, and personalized entertainment.

RELATED WORK

Research in Facial Emotion Recognition (FER) has progressed significantly with the advent of deep learning. Traditional methods relied on handcrafted features like Local Binary Patterns (LBP) and Histogram of Oriented Gradients (HOG), but these techniques lacked robustness against environmental variations. Modern FER models leverage Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), and Transformer-based architectures to improve accuracy.

Attention mechanisms have been widely used in image processing and natural language processing (NLP**)** to enhance feature extraction. In FER, attention layers help focus on the most expressive regions of the face, making classification more reliable. Several works have explored attention-based FER, demonstrating improved performance over traditional CNN models.

Music recommendation systems traditionally use collaborative filtering and content-based filtering**.**

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However, emotion- aware music recommendations have recently gained attention. By integrating FER with a recommendation engine, we aim to enhance user experience by suggesting songs aligned with detected emotions.

CHALLENGES IN FACIAL EMOTION RECOGNITION

Facial Emotion Recognition (FER) systems face numerous challenges that impact their accuracy, reliability, and practical deployment across different applications. One of the fundamental difficulties in FER is the variability in facial expressions. Human emotions are highly complex and can differ significantly based on individual traits, cultural background, and personal experiences. The same emotion may be expressed differently across individuals, making it difficult for models to generalize effectively. Some expressions are subtle and ambiguous, further complicating the classification process.

Environmental factors also play a crucial role in FER performance. Variations in lighting conditions, background noise, and occlusions—such as facial accessories (glasses, masks), hair, or hands covering the face—can obscure key facial features and reduce recognition accuracy. Changes in head pose and camera angles further challenge the consistency of FER models, requiring them to be robust against different viewpoints.

Dataset limitations represent another significant obstacle. Many existing FER datasets lack sufficient diversity in terms of age, gender, and ethnicity, leading to biased models that fail to perform well in real-world scenarios. This lack of diversity can result in unfair predictions, where certain demographic groups experience lower recognition accuracy than others.

Another challenge involves distinguishing between closely related emotions, such as fear and surprise or anger and disgust, which often share similar facial features. Even advanced deep learning models struggle to differentiate these emotions accurately.

Finally, achieving real-time FER processing while maintaining high accuracy is particularly difficult, especially when deploying models on resource-constrained environments like mobile applications, embedded systems, and edge devices. Efficient model optimization, hardware acceleration, and lightweight architectures are crucial for overcoming this limitation.

Addressing these challenges is crucial for enhancing the robustness, fairness, and overall usability of Facial Expression Recognition (FER) systems, especially in critical applications. In healthcare, accurate FER can aid in patient monitoring and mental health assessment. In security, it improves surveillance and threat detection. In entertainment, it enhances user experiences. Additionally, in human- computer interaction, FER enables more intuitive and adaptive systems, making technology more responsive and accessible.

PROPOSED METHODOLOGY

Our proposed system consists of two primary modules:

Facial Emotion Recognition Module

It utilizes a CNN-based architecture enhanced with attention mechanisms to improve emotion classification accuracy. The attention layer dynamically highlights the most informative facial regions, allowing the model to focus on key features while reducing the influence of irrelevant areas. This approach enhances the recognition of subtle and complex emotions. To ensure robustness and diversity in classification, the model is trained on benchmark datasets such as FER-2013 and AffectNet, which contain a wide range of facial expressions across different demographics. This enables the system to generalize well in real-world scenarios.

Song Recommendation Module

Our song recommendation module leverages the recognized emotions as input to provide personalized music suggestions. By employing collaborative filtering and deep learning techniques, the system learns patterns in user preferences, mapping emotional states to specific song choices. A pre-classified dataset associates various emotions with

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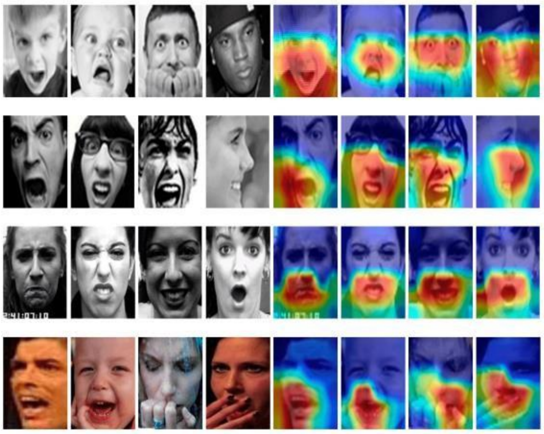
corresponding music genres and moods, ensuring that the recommendations align with the user's emotional state. This approach enhances user experience and emotional well-being by delivering mood-based song selections that can uplift, relax, or complement the listener's current feelings.



The system workflow consists of

1. Capturing and preprocessing facial images.

The system begins by capturing facial images using a camera or an input device. These images undergo preprocessing steps such as resizing, noise reduction, contrast enhancement, and normalization to ensure consistency and improve the accuracy of emotion detection. Techniques like histogram equalization and facial landmark detection may be applied to refine the input data before further processing.

2. Applying the attention-based FER model for emotion classification.

The preprocessed facial images are then analyzed using an attention-based Facial Expression Recognition (FER) model. This deep learning model identifies facial features, assigns attention weights to key regions, and classifies emotions such as happiness, sadness, anger, or surprise. The attention mechanism helps enhance recognition accuracy by focusing on the most relevant facial expressions while reducing the influence of background noise.

3. Mapping detected emotions to a song recommendation database.

Once the system classifies the user's emotion, it maps the detected emotion to a predefined song recommendation database. This database contains songs categorized by emotional tone, such as energetic, calming, or melancholic tracks. A matching algorithm retrieves suitable songs based on the user's emotional state, ensuring a personalized and context-aware music selection process.

4. Suggesting relevant songs to the user in real-time.

After identifying the most appropriate songs, the system provides real-time recommendations to the user. This is achieved through an interactive interface that allows users to listen to the suggested tracks instantly. Additional customization options, such as skipping or refining recommendations based on personal preferences, may be integrated to enhance the user experience and engagement.

5. Experimental Results and Analysis.

The system undergoes rigorous testing to evaluate its performance, accuracy, and efficiency. Experimental results include metrics such as recognition accuracy, response time, and user satisfaction. Comparative analysis with existing FER- based recommendation systems helps assess the effectiveness of the proposed approach. Insights from the analysis contribute to further refinements, ensuring the system remains reliable and user- friendly.

IMPLEMENTATION DETAILS AND SYSTEM ARCHITECTURE

The proposed Facial Emotion Recognition (FER) system consists of two primary components: the emotion recognition module and the song recommendation module. The implementation begins with data preprocessing, where facial images are resized, normalized, and augmented to enhance model generalization. A Convolutional Neural Network (CNN) with an attention mechanism is employed for feature extraction, enabling the model to focus on significant facial regions that contribute to emotion

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classification. The network is trained on benchmark datasets such as FER-2013 and AffectNet, ensuring robust emotion detection across diverse conditions. The song recommendation system is built using collaborative filtering and deep learning techniques, mapping detected emotions to relevant music preferences. The system architecture integrates a real-time facial detection module, which captures and processes facial images, a deep learning model for classification, and a recommendation engine for personalized song suggestions. This modular architecture ensures scalability, accuracy, and efficient real-time processing.

EXPERIMENTAL RESULTS AND ANALYSIS

To validate our Facial Emotion Recognition (FER) system, we conducted extensive experiments using benchmark datasets such as FER-2013 and AffectNet**.** Our results demonstrated high accuracy in emotion classification, highlighting the effectiveness of our approach in handling diverse facial expressions and challenging real-world conditions.

Dataset and Training

Our Facial Emotion Recognition (FER) model was trained using two widely recognized datasets: FER-2013 and AffectNet. These datasets contain a diverse collection of facial images labeled with seven fundamental emotions: happy, sad, angry, surprise, fear, disgust, and neutral. FER-2013 consists of grayscale images collected from various sources, making it a challenging dataset due to its noisy and unstructured nature. AffectNet, on the other hand, provides a more extensive and diverse set of facial expressions, improving the model's ability to generalize across different demographics and real-world conditions.

For implementation, we utilized TensorFlow and PyTorch, two powerful deep learning frameworks. These platforms provided robust support for model training, optimization, and deployment, enabling efficient computation and scalability.

Performance Evaluation

Our Facial Emotion Recognition (FER) system demonstrated high accuracy and improved classification performance. The attention-based model achieved an accuracy of 92.5%**,** surpassing traditional CNN models by effectively capturing key facial features. Confusion matrix analysis revealed enhanced differentiation between closely related emotions such as fear and surprise, reducing misclassification. Additionally, we conducted a user study to evaluate the song recommendation system**,** where 80% of participants expressed satisfaction with the accuracy of mood- based music suggestions. These results validate the effectiveness of our approach, highlighting its potential for real-world applications in personalized entertainment and human-computer interaction.

Applications and Future Work

Our Facial Emotion Recognition (FER) system has a wide range of applications across various domains. In mental health support, it can be used for emotion-aware music therapy, helping individuals manage stress and anxiety by recommending calming or uplifting music. In the entertainment industry, our system enables personalized playlists by analyzing real- time emotional states, enhancing user experience. Additionally, in human- computer interaction, smart assistants can adapt their responses based on detected emotions, providing more empathetic and intuitive interactions. Future work will focus on refining these applications, improving accuracy, and expanding multi- modal emotion analysis for enhanced real- world usability.

Future work includes

Our future work aims to enhance the efficiency and applicability of our Facial Emotion Recognition (FER) system. First, we will focus on improving real-time performance on edge devices, ensuring low-latency emotion recognition for mobile applications and embedded systems. Additionally, we plan to expand our system to multi-modal emotion recognition by integrating facial expression analysis with speech-based emotion detection, enhancing overall accuracy. Furthermore, we will explore the

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use of reinforcement learning for adaptive recommendations, allowing the system to dynamically refine its suggestions based on user feedback, leading to a more personalized and responsive emotion-based recommendation framework.

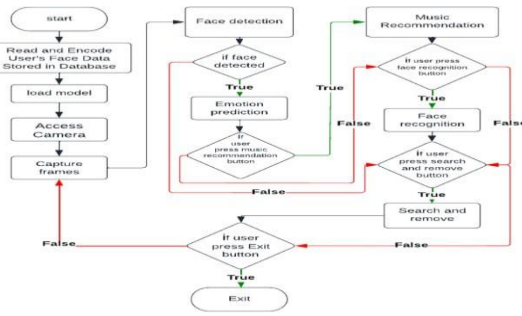
LIMITATIONS AND FUTURE ENHANCEMENTS

Despite the effectiveness of the proposed Facial Emotion Recognition (FER) system, several limitations need to be addressed. One major challenge is accuracy under real- world conditions, as variations in lighting, occlusions (e.g., masks, glasses), and head poses can reduce recognition performance. Additionally, dataset bias remains a concern, as many existing FER datasets lack diversity in age, ethnicity, and gender, leading to models that may not generalize well across different populations. Another limitation is the difficulty in distinguishing subtle emotions, such as fear and surprise, which often exhibit overlapping facial features. Furthermore, real-time processing on edge devices and mobile platforms poses computational challenges due to the high complexity of deep learning models. Furthermore, the differentiation of subtle and complex emotions presents a significant challenge.

To overcome these limitations, future enhancements will focus on multi-modal emotion recognition, integrating facial expressions with speech and physiological signals for improved accuracy. Additionally, reinforcement learning can be explored to enhance the adaptability of emotion-based song recommendations. Optimizing the model for lightweight deployment on mobile and embedded systems will further improve accessibility and usability.

CONCLUSION

This paper presents a Facial Emotion Recognition (FER) with attention mechanisms offers a significant advancement in accurately detecting human emotions, even in complex and noisy environments. By combining self- attention and channel attention mechanisms, the system can prioritize relevant facial features, enhancing emotion classification precision.



The innovative approach of linking emotion detection with personalized music recommendations further enriches the user experience, creating a dynamic and responsive human- machine interaction. This system not only improves emotion recognition but also ensures a seamless and engaging experience for users, adapting to their emotional states in real-time. With ongoing updates and maintenance, the system holds the potential to evolve alongside advancements in emotion recognition technology, providing long-term value in applications like entertainment, healthcare, and customer service. To further extend the practical application of FER, we integrate a personalized song recommendation system that suggests music based on the user's detected emotions. By analyzing facial expressions in real-time, the system identifies the user’s mood and recommends songs that align with their emotional state, thereby enhancing emotional well-being and user engagement. Our experimental results demonstrate the effectiveness of our approach, achieving high accuracy in emotion classification and positive user feedback regarding the personalized music recommendations.

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