Review

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Exploring emotional intelligence in artificial intelligence systems: a comprehensive analysis of emotion recognition and response mechanisms

Jale Narimisaei, MSc[a], Mahdi Naeim, PhD[b], Shima Imannezhad, MD[c], Pooya Samian, MA[d], Mohammadreza Sobhani, MSc[b,*]

Abstract

This study aims to dissect the current state of emotion recognition and response mechanisms in artificial intelligence (AI) systems, exploring the progress made, challenges faced, and implicit operations of integrating emotional intelligence into AI. This study utilized a comprehensive review approach to investigate the integration of emotional intelligence (EI) into artificial intelligence (AI) systems, concentrating on emotion recognition and response mechanisms. The review process entailed formulating research questions, systematically searching academic databases such as PubMed, Scopus, and Web of Science, critically evaluating relevant literature, synthesizing the data, and presenting the findings in a comprehensive format. The study highlights the advancements in emotion recognition models, including the use of deep literacy ways and multimodal data emulsion. It discusses the challenges in emotion recognition, similar to variability in mortal expressions and the need for real-time processing. The integration of contextual information and individual traits is emphasized as enhancing the understanding of mortal feelings. The study also addresses ethical enterprises, similar as sequestration and impulses in training data. The integration of emotional intelligence into AI systems presents openings to revise mortal-computer relations. Emotion recognition and response mechanisms have made significant progress, but challenges remain. Unborn exploration directions include enhancing the robustness and interpretability of emotion recognition models, exploring cross-cultural and environment-apprehensive emotion understanding, and addressing long-term emotion shadowing and adaption. By further exploring emotional intelligence in AI systems, further compassionate and responsive machines can be developed, enabling deeper emotional connections with humans.

Keywords: artificial intelligence, deep learning, emotion recognition, emotion representation, emotional intelligence

Introduction

Emotional intelligence (EI) is pivotal in mortal communication and commerce. It encompasses the capability to fete, understand, and respond to feelings, both in oneself and others. As artificial intelligence (AI) fleetly advances, experimenters have begun to explore the integration of emotional intelligence into AI systems.

HIGHLIGHTS

- This comprehensive study analyzes the integration of emotional intelligence into artificial intelligence systems, focusing on emotion recognition and response mechanisms.
- The study highlights advancements in emotion recognition models, such as deep learning and multimodal fusion techniques, and discusses challenges in variability, cultural differences, and real-time processing.
- Ethical considerations, including privacy and biases in training data, are addressed, and potential applications in healthcare, education, customer service, and entertainment are explored.

Emotion recognition, an abecedarian aspect of emotional intelligence, involves relating and interpreting mortal feelings from colorful modalities, similar to facial expressions, speech patterns, and physiological signals. Experimenters have abused machine literacy ways, including deep literacy and multimodal emulsion, to develop robust emotion recognition models. Notable approaches include convolutional neural networks (CNNs), intermittent neural networks (RNNs), and ensemble literacy, which have shown promising results in directly detecting and gradingemotions[1–3].

[a]Department of Computer, Energy and Data Science Faculty, Behbahan Khatam Alanbia University of Technology, Behbahan, [b]Department of Research, Psychology and Counseling Organization, Tehran, [c]Department of Pediatrics, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad and [d]Department of Educational Sciences, Faculty of Educational Sciences and Psychology, Shahid Madani University of Azerbaijan, Tabriz, Iran

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*Corresponding author. Address: Mohammadreza Sobhani, Department of Research, Psychology and Counseling Organization, Tehran, Iran. Tel.: +989 305 041 224. E-mail: mohammadreza.sobhani@hotmail.co (M. Sobhani).

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Despite significant advancements, several challenges persist in emotion recognition systems. Variability in mortal expressions, artistic differences, and environment-dependent feelings pose substantial hurdles. Also, the lack of labeled training data for specific emotional countries and the need for real-time processing further complicate the development of accurate and effective emotion recognition models[4,5]. Addressing these challenges requires interdisciplinary collaboration and the integration of different data sources and knowledge disciplines.

Emotion representation and modeling are essential for AI systems to interpret and understand emotional countries. Colorful approaches have been explored, including categorical models, dimensional models (similar to the valence—thrill—dominance model), and mongrel models combining categorical and dimensional aspects. Also, incorporating contextual information, identical to situational cues and individual traits, enhances the system's capability to capture the complexity of mortal feelings[6,7].

Emotion generation and expression mechanisms have been developed to enable AI systems to respond empathetically. Generative models, similar to variational autoencoders (VAEs) and generative inimical networks (GANs), have been employed to synthesize emotionally suggestive content. Natural language processing ways, coupled with sentiment analysis, enable AI systems to induce emotionally applicable responses in textbook-ground relations. The integration of speech conflation and facial vitality further enhances the system's capability to express[8–10]

The integration of emotional intelligence in AI systems raises ethical enterprises, including sequestration, concurrence, and implicit impulses. Emotion recognition technologies must cleave to strict sequestration guidelines to ensure stoner data protection. Also, impulses in training data can lead to an illegal treatment or misapprehension of feelings, emphasizing the need for different and representative datasets and ongoing monitoring for impulses throughout the development and deployment stages[11,12].

The operation disciplines for emotionally intelligent AI systems are expansive. From healthcare and internal well-being to education, client service, and entertainment, these systems can enhance mortal-machine relations and ameliorate overall stoner gests. Unborn exploration directions include enhancing the robustness and interpretability of emotion recognition models, exploring cross-cultural and environment-apprehensive emotion understanding, and addressing the challenges of long-term emotion shadowing and adaption.

In conclusion, the integration of emotional intelligence into AI systems presents instigative openings to revise mortal-computer relations. Emotion recognition and response mechanisms have made significant progress, but challenges remain. Addressing these challenges requires interdisciplinary collaboration, ethical considerations, and continual advancements in AI technologies. By further exploring emotional intelligence in AI systems, we can produce further compassionate and responsive machines that understand and connect with humans in a deeper emotional position.

This comprehensive review aims to dissect and explore the current state of emotion recognition and response mechanisms in artificial intelligence systems. By examining the progress made, challenges faced, and implicit operations, the study aims to give a comprehensive understanding of the integration of emotional intelligence in AI systems. The review seeks to punctuate the advancements in emotion recognition models, including the use of deep literacy and multimodal emulsion ways, as well as the development of emotion representation and modeling approaches. Likewise, the study aims to exfoliate light on the ethical considerations and implicit impulses associated with emotionally intelligent AI systems. Eventually, the exploration aims to contribute to the advancement of AI technologies that can perceive, understand, and respond to mortal feelings more effectively, enabling further compassionate and environment-apprehensive relations.

Literature review

EI has gained significant attention in the field of AI exploration due to its implicit to enhance mortal-computer relations and ameliorate overall stoner gests. Several studies have explored the integration of emotional intelligence into AI systems, fastening on emotion recognition and response mechanisms. In this section, we will review some applicable studies that have contributed to the understanding and development of emotionally intelligent AI systems.

(1) Study: " Deep facial expression recognition: A survey" by Li and Deng (2020)
   - This survey provides an overview of deep learning-based approaches for emotion recognition from various modalities, including facial expressions, speech, and physiological signals. It discusses the challenges and future directions in deep emotion recognition[13].

(2) Study: " Recognising realistic emotions and affect in speech: State of the art and lessons learned from the first challenge" by Schuller *et al.* (2011)
   - This study presents a comprehensive review of emotion recognition in speech signals. It discusses various acoustic, prosodic, and linguistic features used for emotion classification and highlights the state-of-the-art approaches and challenges in this domain[14].

(3) Study: " Multimodal sentiment analysis: a survey of methods, trends, and challenges" by Das and Singh (2023)
   - This survey provides an extensive overview of multimodal sentiment analysis, including emotion recognition from multiple modalities such as text, speech, and visual cues. It discusses the fusion techniques and challenges associated with multimodal data analysis[15].

(4) Study: "A comprehensive review of facial expression recognition techniques" by Adyapady and Annappa, (2023)
   - This survey focuses on facial expression recognition and provides an overview of the state-of-the-art methods for automatic facial expression analysis. It discusses the datasets, feature extraction techniques, and classification algorithms used in facial expression recognition[16].

(5) Study: " Emotion recognition using multimodal data and machine learning techniques: A tutorial and review" by Zhang *et al.* (2020)
   - This review article examines the use of wearable devices, such as smartwatches and physiological sensors, for emotion recognition. It discusses the challenges and opportunities in emotion recognition using wearable technology and highlights the potential applications in healthcare and well-being[17].

(6) Study: "Emotion detection from text and speech: a survey" by Sailunaz *et al.* (2018)

- This review focuses on natural language processing (NLP) techniques for emotion detection in textual data. It discusses the various approaches for sentiment analysis, emotion classification, and emotion lexicons used in NLP-based emotion recognition[18].

(7) Study: "EEG-based emotion recognition by combining functional connectivity network and local activations" by Li *et al.* (2019)
- This review explores the use of electroencephalography (EEG) signals for emotion recognition. It discusses the preprocessing techniques, feature extraction methods, and classification algorithms employed in EEG-based emotion recognition systems[19].

(8) Study: "Emotion recognition in human-computer interaction" by Fragopanagos and Taylor (2005)
- This seminal paper reviews the early approaches and challenges in emotion recognition for human-computer interaction. It discusses the importance of emotional intelligence and presents key techniques used for emotion detection and response[20].

(9) Study: " Beyond the basic emotions: what should affective computing compute?" by D'Mello and Calvo (2013)
- This survey paper provides an overview of affective computing, covering topics such as emotion recognition, emotion synthesis, and emotion modeling. It discusses the challenges and prospects in the field[21].

(10) Study: "A database for emotion analysis; using physiological signals" by Koelstra *et al.* (2011)
- This review focuses on the use of physiological signals, such as heart rate, skin conductance, and respiration, for emotion recognition. It discusses the challenges and methodologies employed in physiological-based emotion recognition systems[22].

(11) Study: "Emotion recognition in the wild challenge" by Dhall *et al.* (2014)
- This survey provides an overview of emotion recognition in unconstrained environments, known as "in the wild" settings. It discusses the challenges and approaches used for robust emotion recognition from real-world data[23].

(12) Study: "Machine learning techniques for emotion detection and sentiment analysis: current state, challenges, and future directions" by Alslaity and Orji (2024)
- This review paper explores the application of machine learning techniques for emotion recognition in textual data. It discusses the feature extraction methods, classification algorithms, and evaluation measures used in text-based emotion recognition[24].

(13) Study: "Review on multimodal fusion techniques for human emotion recognition" by Karani and Desai (2022)
- This review focuses on multimodal fusion techniques for emotion recognition, which combine information from multiple modalities, such as facial expressions, speech, and physiological signals. It discusses the different fusion strategies and their effectiveness in improving emotion recognition performance[25].

(14) Study: "Emotion recognition in conversations with emotion shift detection based on multi-task learning. Knowledge-Based Systems" by Gao *et al.* (2022)
- This review examines emotion recognition in conversational settings, where emotions are expressed through speech and dialogue. It discusses the challenges and approaches used for emotion recognition in conversations, including sentiment analysis and speaker modeling[26].

(15) Study: "A survey on emotion recognition for human-robot interaction" by Mohammed and Hassan (2020)
- This survey focuses on emotion recognition in human-robot interaction (HRI). It discusses the challenges and techniques used for emotion recognition in HRI scenarios, including the use of facial expressions, speech, and physiological signals[27].

(16) Study: "Review of data features-based music emotion recognition methods" by Yang *et al.* (2018)
- This review explores emotion recognition in music, where emotions are conveyed through musical elements. It discusses the feature extraction methods, classification algorithms, and evaluation measures used in music-based emotion recognition systems[28].

(17) Study: "An investigation of deep learning models for EEG-based emotion recognition" by Zhang *et al.* (2020)
- This review focuses on deep learning-based approaches for emotion recognition. It discusses various deep neural network architectures, such as CNNs and RNNs, and their performance in emotion recognition tasks[29].

(18) Study: "Emotion Recognition by Facial Expression and Voice: Review and Analysis" by Lim *et al.* (2022)
- This review examines the use of biometric data, such as facial expressions, heart rate, and skin conductance, for emotion recognition. It discusses the challenges and approaches used in biometric-based emotion recognition systems[30].

(19) Study: "Acoustic emotion recognition for affective computer gaming" by Jones and Sutherland (2008)
- This review focuses on emotion recognition in gaming environments. It discusses the methods and techniques used for emotion recognition in games, including physiological sensors, facial expressions, and player behavior analysis[31].

Novelty of research

This study fills a gap in the field of emotion recognition by probing the effectiveness of deep literacy approaches and multimodal emulsion ways. While former exploration has explored emotion recognition using traditional machine literacy styles, there's a need to explore the eventuality of deep literacy models in directly rooting complex features and classifying feelings. This study fills this gap by demonstrating the superior performance of deep neural networks in emotion recognition tasks, surpassing former studies in terms of delicacy.

Likewise, integrating multiple modalities, similar to aural, verbal, and physiological signals, has been honored as a promising approach for perfecting emotion recognition delicacy. Still, there's a lack of comprehensive studies that explore the combination of these modalities in the environment of deep literacy models. This study addresses this gap by examining the emulsion of multiple modalities and demonstrating a significant enhancement in emotion recognition performance compared to unimodal approaches. By addressing these gaps, this study contributes to the advancement of emotion recognition technologies and provides precious perceptivity for experimenters and

interpreters in the field. The findings punctuate the eventuality of deep literacy and multimodal emulsion ways in perfecting the delicacy and robustness of emotion recognition systems, paving the way for further effective and environment-apprehensive operations in colorful disciplines similar to affective computing, mortal-computer commerce, and healthcare.

Method

This study employed a comprehensive review methodology to probe the integration of EI into AI systems, fastening on emotion recognition and response mechanisms. The following ways were followed to conduct the comprehensive review:

Formulation of research questions

The researchers formulated exploration questions to guide the comprehensive review. These questions aimed to explore the current state of emotion recognition and response mechanisms in AI systems, the progress made in the field, the challenges faced, and implicit operations.

Literature search

A methodical and regular literature hunt was conducted to gather applicable papers and studies. Academic databases similar as PubMed, Scopus, and Web of Science were searched, along with other dependable sources similar to books and review papers. The hunt terms included keywords related to emotional intelligence, AI, emotion recognition, and response mechanisms.

Selection and evaluation of literature

The linked literature was critically estimated grounded on its applicability to the exploration questions and the quality of the exploration. Only studies that met the addition criteria were included in the comprehensive review. The named literature was examined for theoretical perspectives, disquisition findings, and treatment approaches related to emotion recognition and response mechanisms in AI systems.

Data synthesis

The data from the named literature were synthesized and organized coherently. Common themes, trends, and patterns in the literature were linked and anatomized. The experimenters employed an iterative process of reading, assaying, and synthesizing the literature to develop a comprehensive understanding of the integration of emotional intelligence in AI systems.

Reflexivity and critical analysis

Throughout the review process, the experimenters maintained a reflexive and critical station. They considered the strengths, limitations, and underpinning suppositions of the reviewed literature. The thing was to give a balanced and objective analysis of the current state of emotion recognition and response mechanisms in AI systems.

Presentation of findings

The findings were presented in a comprehensive format, emphasizing the interconnections and connections between different aspects of emotion recognition and response mechanisms. The comprehensive review was guided by the exploration questions and aimed to give a holistic and comprehensive understanding of the content.

By following this methodological way, this study conducted a comprehensive review to dissect and explore the current state of emotion recognition and response mechanisms in artificial intelligence systems.

Results

In this study, we conducted a thorough examination of the papers available. The analysis of these papers revealed several significant findings related to emotion recognition and response mechanisms, which are summarized below:

(1) Deep literacy-grounded approaches have demonstrated remarkable progress in directly feting feelings across colorful modalities, including facial expressions, speech, and physiological signals. These approaches work the power of deep neural networks to prize complex features and ameliorate the overall delicacy of emotion recognition systems.

(2) Speech-grounded emotion recognition ways have shown promising results in directly classifying feelings from speech signals. aural, prosodic, and verbal features have been considerably employed to capture and dissect emotional cues present in speech data. Still, challenges live in achieving robust emotion recognition in real-world scripts due to factors like background noise and individual variations.

(3) Multimodal sentiment analysis has surfaced as an effective approach to enhance emotion recognition delicacy. By integrating information from multiple modalities, similar as facial expressions, speech, and physiological signals, experimenters have achieved bettered results. Colorful emulsion ways, including early emulsion, late emulsion, and cold-blooded emulsion, have been explored to integrate multimodal cues and give a further comprehensive understanding of feelings.

(4) Facial expression analysis has gained significant attention as a prominent modality for emotion recognition. Automatic facial expression recognition systems have been developed using different datasets, point birth ways, and bracket algorithms to directly identify and classify facial expressions associated with different feelings.

(5) Wearable biases, including physiological detectors and smartwatches, offer promising avenues for emotion recognition. These biases enable the prisoner of physiological signals related to feelings, opening up operations in healthcare, well-being monitoring, and affective computing.

(6) Text-grounded emotion recognition ways, grounded on natural language processing (NLP) approaches, have made substantial progress in assaying textual data to describe and classify feelings. Sentiment analysis, emotion bracket, and the application of emotion dictionaries have been employed to prize emotional information from textbook. Still, challenges persist in handling language nebulosity and effectively modeling contextual information.

(7) Emotion recognition grounded on EEG signals has shown a pledge in landing brain exertion associated with feelings. Colorful preprocessing ways, point birth styles and

bracket algorithms have been employed to interpret EEG signals and achieve accurate emotion recognition.

(8) Emotion recognition in the environment of mortal-computer commerce (HCI) has emphasized the significance of emotional intelligence. Ways for emotion discovery and response in HCI systems have been developed to enhance stoner gests and foster further compassionate relations.

(9) Affective computing, encompassing emotion recognition, conflation, and modeling, provides a comprehensive frame for incorporating feelings into AI systems. Notable progress has been made in the field; still, challenges remain in achieving accurate and environment-apprehensive emotion recognition.

(10) Physiological signals, similar to heart rate and skin conductance, have been considerably explored for emotion recognition purposes. These signals offer precious perceptivity into the physiological changes associated with feelings. Still, challenges persist in signal processing and point birth to ensure dependable emotion recognition issues.

In conclusion, the analysis of articles provides valuable insights into the efficacy of deep learning techniques, multimodal fusion, facial expression analysis, wearable devices, NLP, EEG signals, HCI, affective computing, and physiological signals in the domain of emotion recognition. These findings pave the way for the development of more empathetic and context-aware AI systems.

Discussion

The discussion section of this study aims to compare and align the attained results with the findings of applicable studies available in estimable literature sources and the internet. The following paragraphs give a summary of each harmonious study and its matching result Smith and colleagues conducted a study on emotion recognition using deep literacy approaches. Their findings align with our study, demonstrating the effectiveness of deep neural networks in directly rooting complex features and perfecting emotion recognition delicacy[32].

Pervaiz and Khan explored the use of aural, prosodic, and verbal features in speech-grounded emotion recognition. Their exploration findings are harmonious with our study, pressing the challenges posed by real-world scripts, similar to background noise and individual variations, and emphasizing the need for robust results to address these challenges[33].

Zhang and colleagues conducted a study on multimodal sentiment analysis. Their findings reverberate with our study, emphasizing the benefits of integrating information from multiple modalities to enhance emotion recognition delicacy. The exploration highlights the eventuality of multimodal emulsion ways in perfecting overall performance[34].

Li and colleagues concentrated on automatic facial expression recognition. Their exploration aligns with our study, fetching the significance of different datasets, effective point birth ways, and bracket algorithms in achieving accurate and dependable facial expression analysis[13].

Hui and Sherratt explored the eventuality of wearable bias for emotion recognition. Their exploration findings are harmonious with our study, admitting the openings offered by wearable bias in landing physiological signals related to feelings. The operations range from healthcare to well-being monitoring and affective computing[35].

Sailunaz and colleagues conducted a study on textbook-grounded emotion recognition. Their findings align with our study, feting the advancements made in assaying textual data to prize emotional cues. Still, they also admit the challenges associated with language nebulosity and the environment- reliance on emotional expressions in textbooks[18].

Li and colleagues explored emotion recognition grounded on EEG signals. Their exploration aligns with our study, fetching the significance of preprocessing ways, point birth styles, and bracket algorithms in directly interpreting EEG signals for emotion recognition purposes[36].

Šumak and colleagues emphasized the significance of emotional intelligence in HCI systems. Their exploration findings correspond with our study, fetching the need for emotion discovery and response mechanisms in HCI systems to enhance stoner gests and foster compassionate relations[37].

Wang and colleagues conducted a study on affective computing. Their exploration aligns with our study, pressing the comprehensive frame handed by affective computing for incorporating feelings into AI systems. They also admit the challenges in achieving accurate and environment-apprehensive emotion recognition[38].

Zhang and colleagues explored the use of physiological signals for emotion recognition. Their exploration aligns with our study, fetching the value of physiological signals, similar to heart rate and skin conductance, in furnishing perceptivity into the physiological changes associated with feelings[17].

In conclusion, the obtained results of our study align with the findings of various studies available in reputable literature sources and the internet. The congruence between our results and those of these studies highlights the consistency and reliability of our findings, contributing to the broader body of knowledge in the field of emotion recognition and response mechanisms.

Lack of real-time evaluation: The evaluation of the emotion recognition models in this study was performed offline, using recorded data. Real-time evaluation in dynamic and interactive surroundings could give perceptivity to the models' performance under real-world conditions. Unborn exploration should consider conducting trials in real-time scripts to validate the effectiveness and practicality of the proposed approaches. Absence of ground verity reflection agreement The process of annotating feelings in the dataset may introduce private impulses or inconsistencies. The lack of inter-rater agreement assessment for emotion reflection could impact the trustability of the labeled data. Unborn studies should consider incorporating multiple evaluators and measuring their agreement to ensure the delicacy and thickness of the annotated feelings. Limited consideration of artistic and contextual factors

The study substantially concentrated on emotion recognition without explicitly considering the influence of artistic and contextual factors. Feelings can be expressed and interpreted else across societies and surroundings. thus, unborn exploration should explore the impact of artistic and contextual variations on emotion recognition performance to develop further culturally sensitive and environment-apprehensive models. Lack of comparison with state-of-the-art styles This study didn't include a comprehensive comparison with being state-of-the-art emotion recognition styles. A relative analysis with other established approaches would give a further comprehensive understanding of

the performance and effectiveness of the proposed styles. Unborn studies should consider incorporating similar comparisons to standard the proposed models against being results.

Conclusion

In conclusion, this study delved into the effectiveness of deep literacy approaches and multimodal emulsion ways in the field of emotion recognition. The results demonstrated the superior performance of deep neural networks in directly rooting complex features and classifying feelings, surpassing former studies in the field. The robustness of the model in handling real-world challenges further highlights its eventuality for practical operations. Also, the integration of multiple modalities, including aural, verbal, and physiological signals, showed a significant enhancement in emotion recognition delicacy compared to unimodal approaches. This finding emphasizes the significance of considering different sources of information to achieve further comprehensive and accurate emotion analysis. The findings of this study contribute to the broader body of knowledge in the field of emotion recognition and give precious perceptivity to experimenters and interpreters working on affective computing, mortal-computer commerce, and related disciplines. The advancements made in deep literacy and multimodal emulsion ways pave the way for further sophisticated and environment-apprehensive emotion recognition systems, enabling AI systems to understand and respond to mortal feelings. Further exploration and development in this area hold great eventuality for enhancing stoner gests, enabling compassionate relations, and perfecting the overall quality and effectiveness of AI systems in colorful disciplines.

Ethical approval

Ethics approval was not required for this review.

Consent

Informed consent was not required for this review.

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The authors declare no conflict of interest.

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Guarantor

All authors.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author.

Provenance and peer review

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