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A Robust CNN Framework for Real-Time Facial Emotion Recognition Through Optimized Feature Extraction and Emotion Classification

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Abstract

The significant effects of the COVID-19 pandemic have led to the shutdown of physical classrooms, resulting in a shift toward online teaching methods. To address the challenges posed by the COVID-19 pandemic, 'Distance learning or E-learning' has become increasingly popular in education. To enhance the interactivity of the online learning experience and make it comparable to traditional classroom settings, it is crucial to facilitate active student engagement during online sessions. In this context, the Real-Time Facial Emotion Recognition System in Learning Engagement plays a vital role. The initiative that employs AI, ML, and CNN for tailored education involves the creation of Emotion Recognition systems to assess Learning Engagement. The goal of this research work is to improve online learning experiences by recognizing and reacting to students' emotional states in real-time, thereby ensuring that the educational material captures students' interest.

Keywords: Real-Time Facial Emotion Recognition, CNN, Facial Expression, Online Learning, Interactive Classes, Adaptive Learning

1. Introduction

A key component of human nonverbal communication, facial expressions are essential for expressing feelings, intentions, and responses in social situations. Numerous fields, including psychology, neuroscience, and more recently, artificial intelligence, are involved in the study of facial expressions. Observers can infer an individual's emotional state from their facial expressions, which can include joy, sorrow, rage, fear, surprise, and disgust.

Facial expression analysis refers to a technique used to identify and interpret the emotions conveyed through a person's facial cues. There are numerous types of tools for facial expression analysis, ranging from basic observational methods to advanced computer technologies that employ machine learning models for automatic recognition. One approach to facial expression analysis is the Facial Action Coding System (FACS). The field of facial expression analysis is

rapidly developing and is increasingly sought after, especially in the automotive and educational sectors.

The creation of emotion recognition systems for learning engagement is a research work that makes use of artificial intelligence, machine learning, and convolutional neural networks (CNNs) for individualized education. By recognizing and reacting to students' emotional states in real-time, this initiative seeks to improve online learning experiences and make sure that the instructional material is interesting to students. The creation of emotion recognition systems for learning engagement is a research work that makes use of artificial intelligence, machine learning, and convolutional neural networks (CNNs) for individualized education. By recognizing and reacting to students' emotional states in real-time, this initiative seeks to improve online learning experiences and make sure that the instructional material is interesting to students. Expression identification is a difficult problem, nevertheless, due to the intrinsic unpredictability of face images produced by several factors such as differences in illumination, position, alignment, and occlusions. These issues were covered in a few surveys on facial feature representations for facial recognition and expression analysis.

2. Literature Survey

This research work's primary goal is to watch how students participate in the learning process and then adjust the course to make the sessions more engaging and fascinating. In 2008, academics from North America and Australia performed national surveys on student participation, which is where the term "student engagement" first appeared.[1] The authors define "student involvement" as the time and effort put forth by both students and institutions to promote academic success and the institutions' good name. Much later research reveals that a strong correlation between student involvement, perseverance, and social engagement directly contributes to the success and growth of students. Academic achievement and the quality of instruction are positively impacted by student involvement.

Image Detection: During e-learning, an engagement detection system guarantees that students receive prompt feedback. The conduct of the students during the e-learning session is analyzed by another suggested engagement system. To predict student engagement in e-learning, the suggested unique approach assesses three modalities depending on the student's behavior from the live video broadcasts, including head movement, eye blink count, and facial expression.[6]

One essential and important aspect of human behavior that affects communication is emotion. Accurately analyzing and interpreting the emotional content of facial expressions is necessary for a deeper understanding of human behavior.[5] Even while humans can identify and understand faces and facial emotions with little to no effort, computer systems still have a lot of trouble

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accurately and reliably identifying facial expressions. Analyzing a human face's features and determining its emotional states is a very difficult and complex task. The main obstacles are caused by variations in lighting, shadows, orientation, facial posture, & the irregularity of the human face.

Engagement Analysis: A vital factor in creating intelligent instructional interfaces is engagement, which is a crucial indicator of the caliber of the learning process. In order to react effectively, any such interface needs to be able to identify the amount of engagement; unfortunately, there isn't much data available to use as a learning resource, and obtaining additional data is costly and challenging.[10] I discovered that the engagement model performs better than methods that use histogram of directed gradients and efficient deep learning architectures that we use for the first time to engagement recognition. E-learning system technological advancements give students new chances to strengthen their academic progress and increase educational accessibility. An area that is becoming increasingly significant in intelligent e-learning systems is facial expression recognition [4]. Supporting students' emotional side during learning tasks, however, is difficult and necessitates emotional intelligence. To demonstrate the significance of facial expression identification in e-learning systems, a brief review is given. The three primary processes of convolutional neural network-based facial expression identification and its use in e-learning systems are preprocessing, feature extraction, and classification.

Emotion Analysis: Without knowing a student's emotional reaction, teachers find it difficult to assess their level of participation in class. Basic human emotions including happiness, anger, sadness, surprise, and neutrality are the focus of the facial expression recognition databases currently in use. Since psychological and educational research has demonstrated that there are distinctions between academic emotions and basic human emotions, these feelings are inappropriate for learning. A distinct dataset must be created for the study on academic feelings. Four relevant academic emotions have been compiled into a dataset. Both handcrafted and deep learning methods are used to do empirical analysis on the dataset [9]. These four emotions are boredom, hope, anxiety, and joy or enjoyment. Using computer vision techniques, we examine the students' eye look, head posture, and facial expressions to determine their level of involvement or attention. Machine learning algorithms are then used to make a conclusion [12]. We have gathered two facets of student behavior data—face data (using adaptive weighted Local Gray Code Patterns for facial expression identification) and mouse interaction—to increase the precision of learning engagement detection [13].

3.. Literature Survey

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This research work's primary goal is to monitor students' participation in the learning process and adjust the course design to make the sessions more captivating and engaging. 1. Enhance Learning Personalization 2. Boost Teacher Effectiveness 3. Improve Real-Time Engagement Analysis.

The necessity to improve educational experiences by accommodating learners' emotional states is the driving force behind the implementation of a real-time facial emotion identification system for learning engagement utilizing CNN. The effectiveness of teaching strategies and the learning environment can be greatly increased by identifying and reacting to students' emotions in real time.

1. Personalized Learning
2. Immediate Feedback and Adjustment
3. Improved Learning Outcomes

4. Methodology

Implementing a Real-Time Facial Emotion Recognition System in educational settings involves a detailed methodology that spans several phases, from initial planning and development to deployment and evaluation. Here's an outline of the methodology that could be used:

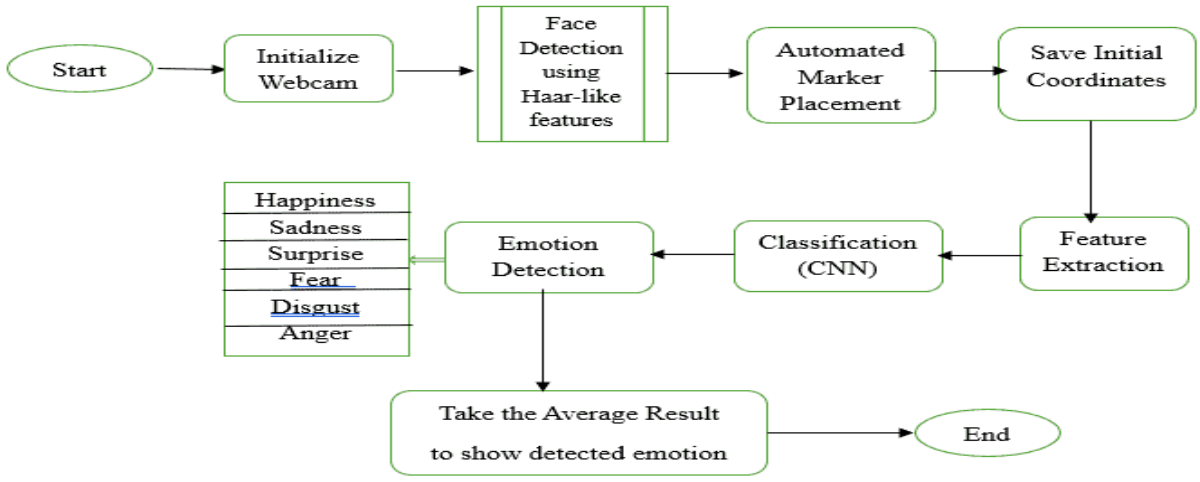

Figure 1. Facial Recognition Model

Phase 1: Planning and Design:

Needs Assessment: To determine the precise requirements and expectations for the FER system, poll and hold focus groups with educators, students, and administrators. Determine the main ways that emotion recognition can enhance teaching methods and student learning.

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Technology Selection: Assess several software programs and emotion recognition technologies that are appropriate for the classroom. Select devices with sufficient processing power and cameras that can facilitate real-time analysis. Ethics and Privacy Considerations: Create privacy policies to safeguard student information. Obtain the required consents and approvals from the relevant parties, making sure that the data protection and education laws are followed.

In the above block diagram figure1, the process of a Real-Time Facial Emotion Recognition Model is given as follows: The model will start up by opening the camera for real-time recognition after the code has been executed. The Haar-Cascade model will then be used to perform face detection, and once the face has been captured, the feature extraction stage will be handled. The CNN model is used in the first and last rounds of classification, after which the emotions—happiness, sadness, surprise, fear, disgust, and anger—are identified based on the faces.

Phase 2: Development and Testing:

System Development: Create or modify the FER software to satisfy certain learning objectives. If required, integrate the FER system with already-existing educational technology platforms. Pilot Testing: To improve the system based on actual use, run pilot tests in a few chosen classrooms. To find any problems or areas that need work, get input from both teachers and students. Instruction and Adjustment: To make sure the algorithm can correctly identify a broad range of emotions across various demographics, train it is using a variety of datasets. Adjust the system's calibration to work well in classrooms with different lighting and spatial arrangements.

Phase 3: Deployment

Full-Scale Implementation: Include the FER system in everyday teaching activities and roll it out throughout classrooms. Verify that every piece of software and hardware is installed and operating as it should. Teacher and Staff Training: To acquaint teachers and educational staff with the system, hold thorough training sessions. Offer continuing assistance to resolve any technical problems or inquiries arising.

Phase 4: Monitoring and Evaluation

Constant Monitoring: Keep an eye on the system's functionality and the precision of emotion recognition. To evaluate the effectiveness of the FER system, gather and examine data on educational results and student participation. Feedback Loop: Put in place a way for instructors and students to share their thoughts about the system and voice any issues they may have. Make incremental changes to the technology and how it is used in the classroom by using feedback.

Impact Assessment: To ascertain how well the system is enhancing learning results, emotional intelligence, and student involvement, conduct official reviews. Adapt instructional tactics in light of the knowledge gathered from data analysis.

Phase 5: Refinement and Scaling

System Refinement: Adjust and improve the FER system considering evaluation findings and user input. Improve the user experience and interface to guarantee minimal disruption during instruction and ease of usage. Scaling: Increase the number of classrooms or other institutions where the implementation is being used. To encourage greater adoption, disseminate research results and best practices to the larger educational community.

This thorough approach guarantees that a Real-Time Facial Emotion Recognition System is implemented in a way that is efficient, moral, and improves the learning environment. To effortlessly incorporate technology into educational environments and continuously enhance it based on user feedback and technical improvements, a cyclical process of assessment, development, implementation, and refinement is required.

5. Results & Discussion

The entire dataset is divided between training and testing sections in an 80:20 ratio. While 7178, or 20%, of the photos are in the testing dataset, 28709 images are in the training dataset. The model performs better on the used dataset because the accuracy of the testing dataset is higher than that of the training dataset, which appears to be overfitting as shown in table1.

Real challenges include occlusion, light conditions, and facial orientation that affect feature extraction. High testing accuracy, according to evaluation metrics, shows how well this model detects users' shifting moods as shown in figure 2. However, from a real-time practical standpoint, improving training features by using balanced, varied datasets that represent a range of user moods, such as happiness, sadness, fear, and surprise. In addition to these, data augmentation or dropout will be necessary to detect users' more nuanced emotions.

Table 1. Evaluation Metrics

Dataset	No. of Images (Percentage)	Accuracy (%)
Training Dataset	28,709 (80%)	64.88%
Testing Dataset	7,178 (20%)	76.42%

6. Conclusion

An approach to identifying the category of facial expressions is proposed by this research work. Numerous applications, including pain management, video surveillance, security, and human-computer interaction, benefit from the detection and extraction of facial expressions from facial images. The goal of this research work was to create a facial expression recognition system

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that would enhance the advanced feature extraction and classification in facial expression recognition while implementing computer vision. Seven distinct facial expressions of various individuals' photos from the dataset have been examined in this research work. This research work uses the fer-2013 face database to identify more facial expressions.

According to the experiment results database fer2013 dataset, our suggested approach has produced better results than usual. Recognizing facial expressions is a really difficult task. For significant applications, further work should be done to enhance classification performance. My future research will concentrate on enhancing the system's functionality and creating more appropriate classifications that could be useful in a variety of real-world applications.

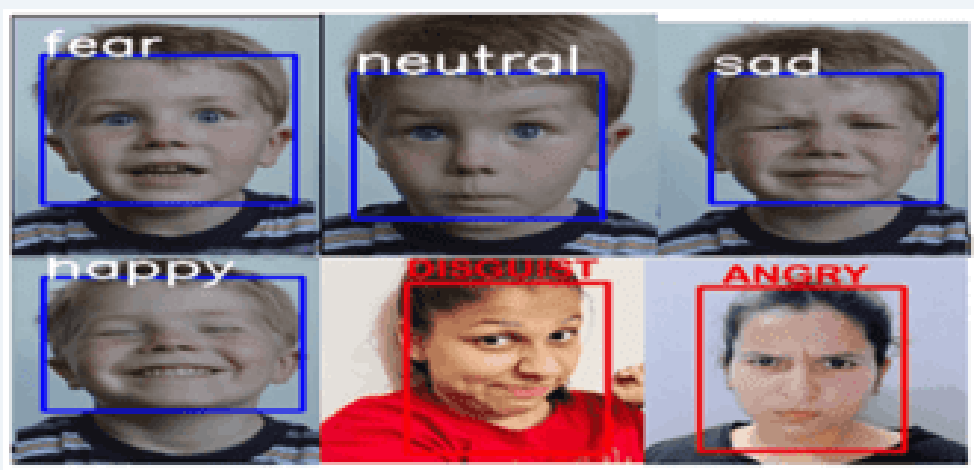

Figure 2. Models Mood extraction

Feature Enhancement

Over the last ten years, facial expression recognition technology has advanced significantly. Undoubtedly, the emphasis has moved from recognizing contrived expressions to recognizing spontaneous ones. Significant performance increases can be achieved in our system, along with promising outcomes under face registration errors, fast processing time, and high correct recognition rate (CRR). The system may work with an image feed and is completely automated. It can identify impromptu communication. Our technique can be applied to digital cameras, which only take pictures when the subject grins. Any way that a person expresses himself can be recognized by security systems.

When someone enters a room in a home, they can adjust the lights and television to their preferences. The device allows doctors to gauge a deaf patient's level of pain or disease. Our

technology can be used to identify and monitor a user's mental condition, as well as to see customer comments at shopping centers and mini marts to improve business, etc.

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