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AN INTELLIGENT SUPPORT SYSTEM AND EMOTIONAL STATE TESTS FOR PEOPLE WHO ARE SICK OR RECOVERING

INTELIGENTNY SYSTEM WSPOMAGANIA ORAZ BADANIA STANU EMOCJONALNEGO DLA OSÓB CHORYCH LUB DOCHODZĄCYCH DO ZDROWIA

Abstract

The project aims to develop an intelligent system that has the potential to significantly improve patient care by examining and supporting the emotional state of people with chronic diseases or undergoing rehabilitation. The system will use advanced technologies such as image analysis, natural language processing and understanding (NLP/NLU), and a personal assistant module. Acting as a virtual companion, this module will support the user in everyday tasks such as setting reminders and managing schedules and provide emotional support through interactive conversations. The project also involves the development of an analytical module that automatically generates analyses and reports based on the collected data. A patient-oriented system will be created during the work to collect essential data and support him in rehabilitation. On the other hand, the system will cooperate with a doctor who can make a preliminary diagnosis and develop further treatment based on the patient's data. As feedback, the patient will receive health reports along with their interpretation and treatment recommendations created by the doctor.

Streszczenie

Celem projektu jest opracowanie inteligentnego systemu do badania oraz wspomagania stanu emocjonalnego dla osób z chorobami przewlekłymi lub w trakcie rehabilitacji. System będzie oparty na zaawansowanych technologiach takich jak analiza obrazu, przetwarzanie i rozumienie języka naturalnego (NLP/NLU), oraz module osobistego asystenta, który będzie wspierał użytkownika w codziennych zadaniach. Projekt zakłada również rozwinięcie modułu analitycznego, który automatycznie generuje analizy i raporty na podstawie zebranych danych. W trakcie prac powstanie system ukierunkowany na pacjenta, który będzie zbierać istotne dane i wspomagać go w procesie rehabilitacji. Z drugiej strony system będzie współpracował z lekarzem, który na podstawie danych pacjenta będzie mógł dokonywać wstępnej diagnozy i opracowywać dalszy przebieg leczenia. Jako informacje zwrotne pacjent otrzyma raporty dotyczące zdrowia wraz z ich interpretacją i zaleceniami związanymi z kuracją utworzonymi przez lekarza.

Keywords: *computer vision, natural language processing, natural language understanding, deep learning, transformers*

Słowa kluczowe: *widzenie komputerowe, przetwarzanie języka naturalnego, rozumienie języka naturalnego, głębokie uczenie, transformery*

Introduction

Currently, there are serious concerns about the increase in the number of mental health problems and disorders around the world. Depression has a significant impact on a person with depression, as well as the entire community. Deep learning and artificial intelligence (AI) technologies have recently gained popularity and confidence. They can be helpful in medicine to help doctors identify recovery problems early and predict mental illnesses such as depression and mood disorders and treat them before they cause serious problems.

Emotion analysis through image analysis – the system will use computer vision techniques to determine the user's emotional state while performing specific tasks. This will make it possible to provide feedback on emerging emotions. Thanks to advanced image analysis algorithms, it is possible to recognize emotions such as joy, sadness, stress, or frustration. Feedback on the user's emotional state will allow the user to understand their progress better. Doctors and therapists can adjust therapeutic programs and provide personalized care during medical visits (or in the future by connecting to the patient's account).

Natural language processing (NLP/NLU) – using NLP/NLU algorithms, the system will enable the analysis and understanding of texts, speech, and other information the user enters. The system will understand the context and meaning of the entered data, enabling the generation of personalized recommendations, advice, and reports. The Personal assistant module will have an interactive assistant to support the user in everyday tasks. The assistant will be able to remind you of tasks and work to be performed, remember doctor's visits, and automatically fill out health forms based on the collected data. At the user's request, the assistant will provide information and reports on the user's activities, and current results based on the provided data or create tasks to be performed.

Analytical module – the project involves the development of an analytical module that, based on the collected data, generates reports and analyzes regarding, among others, medical results, emotional states, tasks performed, or costs incurred for pharmaceuticals. Thanks to this, the user can better understand the obtained test results and progress in the rehabilitation process. Microservices architecture – the system will be built based on the microservices architecture, which will allow for the independence of individual

modules and easy implementation and improvement of the solution in the future. Advanced technologies used in the project will enable the creation of a comprehensive system that integrates various aspects of the user's everyday life, health care, psychological support, and data analysis. Thanks to this, users will have easier access to information regarding their health condition and the course of the recovery process.

Research Methodology

Emotions are essential in our lives, influencing our thoughts, behavior, and well-being. Negative emotions such as sadness, anxiety, and anger can significantly impact our functioning and quality of life. There are many different ways to deal with difficult emotions, such as therapy, medication, and support groups. In recent years, there has been increasing interest in intelligent support systems (ISS), which can help people deal with emotions. This study aims to develop and evaluate an ISS to identify and support individuals' emotional states. The study will seek to determine the accuracy of the ISS in identifying emotions, assess its effectiveness in providing support, and examine the impact of the ISS on individuals' well-being.

Participants in the study will be adults aged 18 to 65 who experience negative emotions such as sadness, anxiety, or anger. Participants will be recruited through advertisements, social media, and online recruitment. Study participants will be invited to participate in a research laboratory. After obtaining consent from participants, they will be asked to complete a questionnaire assessing their emotional state. Participants will then be able to use the ISS for 20 minutes. During this time, the ISS software will monitor their emotional state using a webcam and microphone. After completing the ISS session, participants will again complete a questionnaire assessing their emotional state.

The data will be analyzed using appropriate statistical methods. The accuracy of the ISS in identifying emotions will be assessed using metrics such as sensitivity and specificity. The effectiveness of the ISS in providing support will be evaluated by comparing the results of pre-and post-session questionnaires with the ISS. The impact of the ISS on individuals' well-being will be assessed

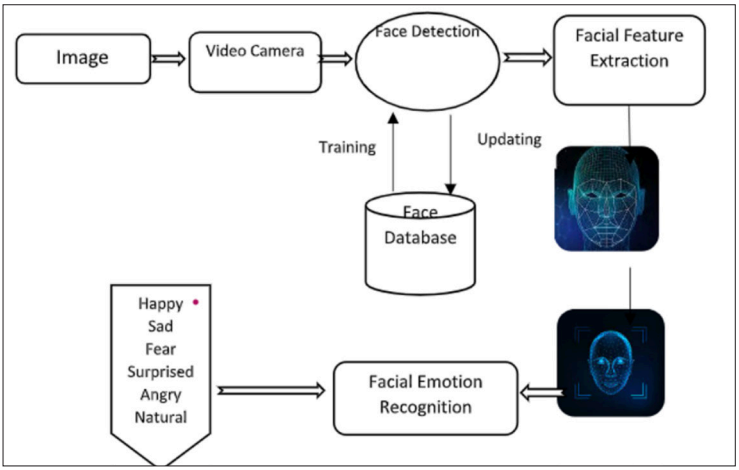
using a longitudinal analysis. All research procedures will be consistent with the principles of research ethics. Informed consent will be obtained from participants, and their confidentiality will be ensured.

The study is expected to demonstrate that ISS can accurately identify and effectively support people's emotional states. The use of ISS is also likely to lead to improved well-being of individuals in the long term. The results of this study may have important implications for the development of new technologies supporting coping with emotions. ISS can be a valuable tool for people who experience negative emotions and need support. It should be noted that this study is a pilot study and involves a relatively small group of participants. Further research with more participants must generalize the results to a broader population.

Emotion Recognition Systems Research

A study titled Deep Care: Smart Depression Counseling System through Emotion Recognition and Opinion Mining using Deep Learning indicates that facial expressions help detect patients' emotions and are further used to recognize depression in patients (Alrowais et al., 2023). The facial muscles and landmarks generated by the Media Pipe library (Ohri et al., 2023) are helpful for emotion detection. They are divided into four stages: image pre-processing, extraction features, face detection, and emotion detection. In this study, five universal emotions were considered, i.e., happy, sad, neutral, angry, and surprised, and the YALE facial expression database was used to classify the emotions (Alsemawi et al., 2023). Gaussian filtering was used to filter unwanted image features and noise if objects were not extracted. Human Facial Coding System [FACS] was used to transform facial features, i.e., eyebrows, lips, jawline, and other facial landmarks, to convert them into emotions and detect depression in patients (Khattak et al., 2022).

Figure 1. *System do rozpoznawania emocji*



The flowchart shown in Figure 1 is divided into four steps, which are as follows:

- Image Preprocessing: Focuses on enhancing image data by suppressing unwanted distortions or improving visual properties necessary for subsequent processing and analysis tasks.
- Feature Extraction: The goal of feature extraction is to minimize the number of features in a dataset by developing new ones from existing ones (and then discarding the original features).
- Face Detection: A deep learning model matches facial features in the training data for testing and identifies the face in the video stream or input image.
- Emotion Classification: Emotions are classified into six basic categories using a Bayesian classifier, extracting facial features and displaying emotions on the monitor.

The project mentioned above aims to create a depression detection system for students and patients by combining two popular approaches: Opinion Mining and Emotion Detection. All users can access it 24 hours a day, seven days a week, sitting at home and checking their health status through the created online portal (Figure 2).

Figure 2. *System architecture*

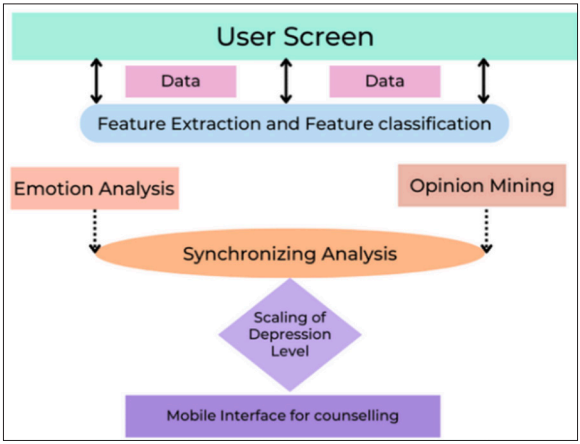
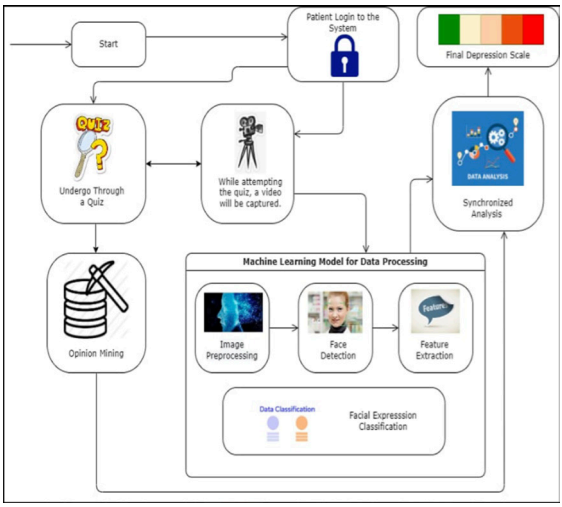


Figure 3 explains the operation of Deep Care, an intelligent human guidance system with depression created using the MERN stack. The entire project is initially built in ReactJS, including all pages, user quizzes, and dashboards. All user information is then stored in Mongo dB, an unstructured database.

Figure 3. *Data flow workflow diagram*



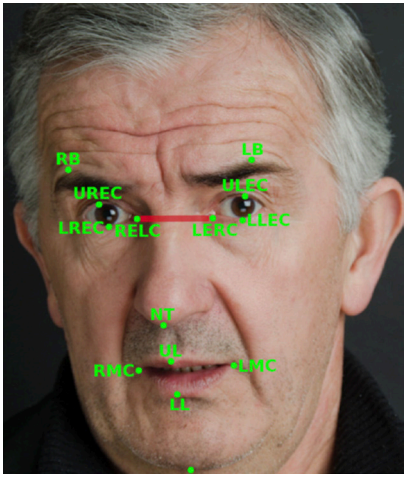
Textual analysis of emotions is a semi-method that is traceable and controllable, which can help diagnose ailments. This is a key tool in the fight against depression because it enables you to identify happy and sad moments without visiting a psychologist, allowing you to act immediately when necessary. It is possible to recognize, assess, and prevent depression using facial expressions (image and video processing). Several deep learning techniques, including image preprocessing, feature extraction, and classification algorithms, are synchronized with the questionnaire (Maciura et al., 2023).

Patients diagnosed with schizophrenia and healthy controls interacted with Tina, a virtual conversational agent, who guided them through a short set of structured tasks. At the same time, their speech and facial expressions were streamed in real-time to a back-end analytics module. Trained raters on validated clinical scales simultaneously assessed patients. Research is ongoing on the use of correlation analysis between extracted indices and standardized clinical scales to assess schizophrenia symptoms and how such speech and facial biomarkers may provide further insight into schizophrenia symptomatology. Growing levels of depression, anxiety, and suicide have heightened the need for telehealth-based mental health assessments and remote patient monitoring (RPM) systems to alleviate the pressure on mental health professionals and improve their efficiency. Multimodal dialogue systems (MDS) that deliver on-demand structured interviews offer a scalable and economical answer to this demand.

Research in the publication entitled A multimodal dialogue approach to mental state characterization in clinically depressed, anxious, and suicidal populations demonstrated that the multimodal dialogue system (MDS) is a feasible, scalable, and interpretable solution for remote patient monitoring (RPM) in real-world clinical depression, anxiety, and suicidal populations (Alsemawi et al., 2023). The novelty of this study is that it examines features from multiple zones – speech, language, and facial behavior – to simultaneously analyze and characterize three mental disorders – depression, anxiety, and suicide risk. An interesting finding was that different modalities were most effective in distinguishing controls from cases for each disorder considered: speech for depression, facial for anxiety, and text/language for suicide. The combination of features from different modalities extracted during a short, standardized MDS interview generally improved the discriminative ability of machine learning models to characterize mental states

in all three disorders. Moreover, both healthy participants and people with mental disorders indicated acceptance of technology (Maj et al., 2022).

Figure 4. *Illustration of the 14 facial landmarks used to calculate facial features*



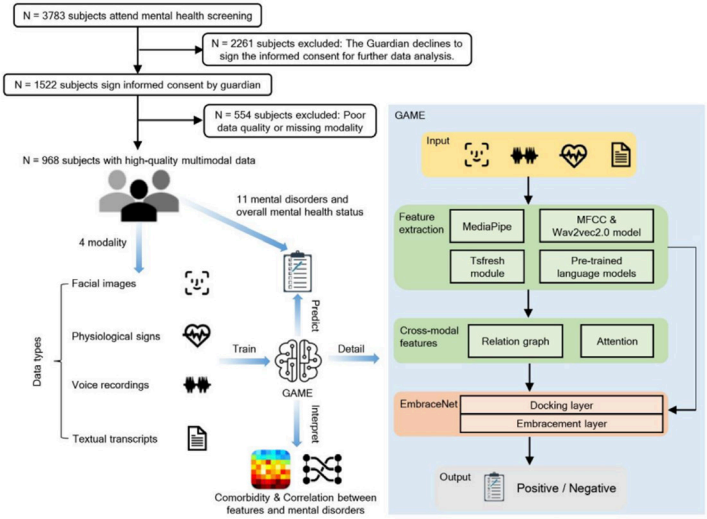
For user feedback, two forms of data collection were used: a qualitative questionnaire (likes/pros, cons/disadvantages, and improvements) and a five-question survey with Likert-scale responses (Mumu et al., 2022), shown below.

Figure 5. *Survey after the job interview*

Przedmiot	Pytania w ankiecie
Pytania w skali Likerta: 1 = najbardziej negatywne do 5 = najbardziej pozytywne	
1.	Jakie to uczucie wyrazić swoje emocje związane z nadzieją, tajemnicami, złością, strachem i emocjonalnym bólem wirtualnemu asystentowi?
2.	Jak szczere byłeś w swoich odpowiedziach na wirtualną asystentkę?
3.	Jak komfortowo czułeś się w swoich odpowiedziach na wirtualną asystentkę?
4.	Jakie wrażenie wywarł na tobie wirtualny asystent pod względem wyglądu i głosu?
5.	Jakie wrażenie wywarł na Tobie wirtualny asystent pod względem tempa rozmowy kwalifikacyjnej, w tym przerw i pauz ze strony wirtualnego asystenta, oraz czasu na odpowiedź?
Pytania otwarte:	
6.	Co Ci się podobało w Tinie?
7.	Co ci się nie podobało w Tinie?
8.	Co można poprawić dzięki temu doświadczeniu?

Rapid identification of mental disorders in adolescents is a global public health challenge. Detecting abnormalities in a single factor is difficult due to its complex and subtle nature. Furthermore, generalized multimodal computer-assisted screening (CAS) systems with interactive robots for adolescent mental disorders are not available (Misra et al., 2016). Here, an Android application with chat recording implemented on a portable robot was designed to screen 3,783 middle school students and construct a multimodal screening dataset, including facial images, physiological symptoms, voice recordings, and text transcripts. During the research, a GAME (Generalized Model with Attention and Multimodal EmbraceNet) model was developed with an attention mechanism that integrates cross-modal features into the model (Choi & Lee, 2019). GAME assesses the mental state of adolescents with high accuracy (73.34%-92.77%) and F1-Score (71.32%-91.06%). Each modality was found to contribute to screening for mental disorders and comorbidities dynamically, demonstrating the feasibility and explainability of the model. This study provides a system capable of acquiring multimodal information and constructs a generalized multimodal integration algorithm with novel attention mechanisms for early screening of adolescent mental disorders (Pena et al., 2023).

Figure 6. *Data processing pipeline and GAME structure*

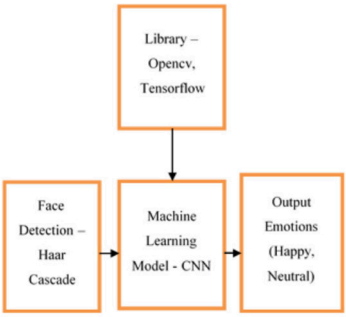


Expressing emotions is an essential aspect of human life. Expression represents the perception of incidents, interpersonal interactions, decision-making, and intelligence. Emotions express a person's psychophysiological and psychological state. A person's emotional state has a significant impact on mental health, which is the cause of depression in many people. Recognizing and classifying these emotions is possible through various modalities, i.e., electroencephalography (EEG), gestures, facial expressions, speech patterns, etc. (Sepúlveda et al., 2021). In certain circumstances, people may hold back or be unable to express their true feelings. A person with a mental or physical disability may not be able to express their true feelings during treatment in the hospital. An automated way of collecting human emotions using a computer-aided diagnostics (CAD) tool plays a vital role in such a situation. It can play a lively role, e.g., in national defense when training soldiers in simulated environments. Such tools can be used to assess mental conditions in combat situations. There is an urgent need to remove the stigma associated with depression and mental health so that the detection of mental disorders can be carried out on social networks, which can help in destigmatizing them. Tests can be performed using various artificial intelligence and machine learning algorithms to detect emotional imbalances in multiple scenarios. As technology advances, various AI-based approaches are evolving to make machines emotionally intelligent to detect emotions in humans (Steppan et al., 2023). Text-based emotion recognition, such as sentiment analysis of tweets and posts on various social media platforms, can help detect a user's mood and emotions, as well as help predict a user's suicidal thoughts and prevent suicide by warning users or their loved ones (Bharti et al., 2022). Various machine learning algorithms, such as Naive-Bayes, Support Vector Machines (SVM), etc., can be used for this purpose, and the results can be evaluated using a confusion matrix. An algorithm that works well will have a high precision score and help correctly predict emotions, which may be positive or negative.

Emotion Recognition Systems Research

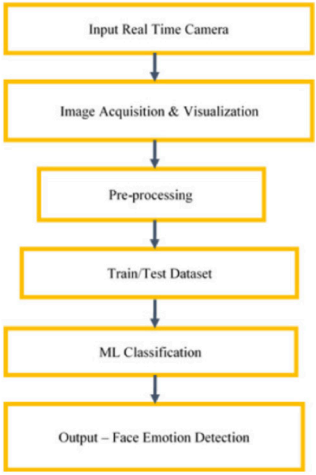
These captured facial emotions are further analyzed to estimate the patient's depression level. The analysis proposed in this article in AI therapy leads to a new generation of treatments for patients with stress or depression. The system architecture of the project is shown in Figure 7.

Figure 7. *The proposed architecture of a system using CNN*



The dataset is used to train a neural network model. The pre-processing stage includes image visualization. The Panda's Python library is used for data analysis.

Figure 8. *Proposed methodology*

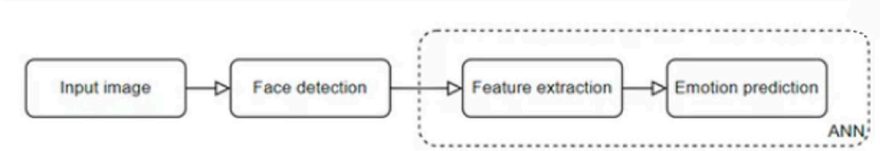


Facial emotion detection is one of the emerging concepts in machine learning technologies. Artificial intelligence influences the human lifestyle (H. Ma & Wang, 2021)The proposed AI therapy in this research article has a wide range of applications. AI therapy can be used in smart cars to detect the driver's facial expressions and inform him when he feels drowsy. The proposed AI therapy creates a wide scope for the future of medical science. Emotion detection can be used to monitor stress and anxiety in elderly people and patients regularly.

A tutoring system that can autonomously detect the presence of academic emotions in a student, i.e., frustration and boredom, could result in better learning outcomes by keeping students motivated. In the study entitled Deep Learning of Facial Embeddings and Facial Landmark Points (Wu & Ji, 2019) for the detection of academic emotions assessed the use of deep learning FaceNet through facial embeddings and landmark points to detect academic emotions in a publicly available dataset – DAiSEE (Santoni et al., 2023), which was annotated with descriptions of emotional states of engagement, boredom, frustration, and confusion. In addition to the spatial dimensions, the temporal dimensions of facial videos were modeled to improve detection accuracy. The processing workflow for the FaceNet (Xu et al., 2021) is embedding model is similar to the facial landmark model, except that the MTCNN library (Azamy et al., 2023) is used for face detection and cropping (instead of dlib). Facial landmark extraction is replaced by facial embedding extraction using the FaceNet model.

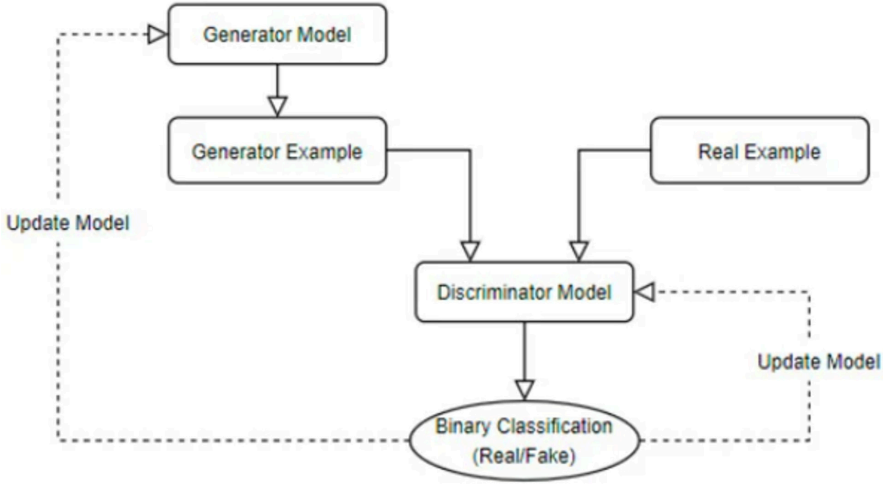
New trends in facial emotion recognition using image analysis performed by neural networks. It also revealed the available datasets currently being used to recognize emotions based on facial expressions and micro-expressions and the use of various deep-learning models in solving this problem. Several studies conducted in FER (Ko, 2018) are analyzed, and open issues and future trends are addressed. The publication validates architectures based on convolutional neural networks (CNN) compared to other neural network architectures, i.e., recurrent neural networks or generative adversarial networks, highlighting each architecture's key elements and performance and the advantages and limitations of the proposed models in the analyzed articles.

Figure 9. *Main components of an ANN-based facial emotion recognition system*



Generative adversarial networks (GANs) are also used in FER systems and in the development of any deep neural networks that move towards higher simulation of human cognitive tasks (F. Ma et al., 2022). Scientists are looking at the potential of generative adversarial networks to increase the power of neural networks and their ability to *think* in a human way. For example, in computer vision, a GAN not only tries to recreate images from training data but also trains itself to generate new images that are as realistic as possible.

Figure 10. *Architektura GAN*



Conclusions

Ongoing mental health problems can cause disorders as well as mortality. The increasing demand for psychiatric treatment and limited healthcare resources around the world demonstrate the need for an innovative framework solution. Artificial Intelligence (AI), Big Data Science, 5G, and Information Communications have proven that technology (ICT) can bring about many significant improvements and could be a potential way to develop such a framework. AI can be a very effective tool in helping the healthcare sector provide more effective services to patients with mental health issues through emotion analysis. The ability to process and identify facial emotions is essential to an individual's social interaction. Certain mental disorders may limit an individual's ability to recognize emotions in facial expressions. This problem can be addressed using computational techniques to develop learning environments for diagnosing, assessing, and training facial emotion recognition.

Nonverbal emotional expression plays a vital role in building and sustaining interpersonal relationships, as correctly identifying and categorizing facial expressions is among the most common and effective nonverbal communication abilities. Accurately interpreting emotional facial expressions and aligning with a similar emotional state are essential to feeling empathy. However, not everyone is equally skilled at interpreting subtle facial emotions, particularly individuals with psychopathic and alexithymic traits. Both alexithymia and psychopathy are linked to emotional processing difficulties stemming from challenges in recognizing facial emotions. Although these traits are interconnected, research in this field is limited, and its results remain controversial. Alexithymic and psychopathic traits are distinct constructs yet closely related. Both are connected to facial emotion processing issues that signal empathy deficits, but the mechanisms behind these deficits are poorly understood. The current research on deficits in facial emotion categorization linked to psychopathic and alexithymic traits may lay the groundwork for preventative and intervention measures to aid those with these personality traits in better recognizing facial emotions.

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