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# SVM-Based Facial Expression Recognition: A Focus on Emotion Analysis for Individuals with Intellectual Disabilities

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***Abstract –****In this study, we develop a FER system for intellectual disability people based on DWT and Gabor filter for feature extraction followed by an SVM classifier for classification of expression. Four different preprocessing techniques such as converting into grayscale, normalizing the image, and data augmentation were performed on the MuDERI dataset to improve the accuracy. However, the accuracy of the proposed model is 83.87% showing its ability for recognizing unique facial expression in it. This will enable and explore integration with deep learning and optimization strategies, real-time implementation, and adaptable.*

***Keywords****- Facial Expression Recognition, Intellectual Disabilities, Feature Extraction, SVM*

## I. INTRODUCTION

Reading and understanding facial expressions is an essential skill for our interaction and communicating emotion. Recognition of facial expressions (FER) is a pivotal facet of human interaction, but individuals with intellectual disabilities face poignant difficulties with this skill that can deeply affect social inclusion and their general well-being. Studies show that people with different types of intellectual disabilities tend to have difficulties in emotion recognition that can impede effective communication and relationships with others (Barbieri et al., 2022;, Ju et al., 2024). The Social cognition impairment is not limited to persons with intellectual disabilities but it is also seen in a range of neurocognitive disorders indicating that persons with different neurocognitive disorders have a continuum in their ability to recognize emotions (Wang et al., 2023;, Stam et al., 2023). Specific mechanisms behind these emotional recognition deficits in populations with intellectual disability have recently started to be uncovered. For example, attentional processes (Yadava et al., 2022), working memory capacity (Hambu et al., 2023), and executive functioning (Cárdenas et al., 2021;, Buçgün et al., 2024) have been highlighted as potential factors contributing to the challenges these individuals encounter in interpreting emotional expressions. Furthermore, the use of emerging technologies such as augmented reality and artificial intelligence is also being investigated for its role in improving FER skills among individuals with intellectual disabilities to provide them with structured learning tools that are engaging (Muhaidat et al., 2022;, Fazil & Faiz, 2022). These reflect a hopeful avenue both for research and treatment, in which technology can act as an intermediary to support social acumen and empathy. The qualitative analysis of FER in the context of intellectual disabilities also emphasizes the need for the development of inclusive research methods that consider the unique cognitive profiles of these individuals. Studies examining the emotion recognition abilities of different demographic groups—including age, gender, and cognitive level—highlight the centrality of individual differences in designing FER programs that are suited to individuals with intellectual disabilities (Lyu et al., 2024; Maebara et al., 2022). This is why a multi-disciplinary effort, with psychological, technological and educational commitments to better emotion recognition leading to better interpersonal outcomes, is needed. To conclude, the research in Zacharias & Hatzigianni (2020), and the theme of the article, implies the consideration of examining facial expression recognition skills of people with intellectual disabilities, and seems to carry more theoretical and practical implications. Future work would benefit from continuing to identify individualised, tailored interventions that incorporate technology and align with cognitive aspects concomitant with this population to enhance inclusiveness and emotional competency in their social ecosystems.

## II. LITERATURE REVIEW

A brief overview of work carried out in the field Facial expression recognition (FER) has advanced rapidly in recent years, merging new developments in the sub-fields of artificial intelligence (AI), psychology, and computer vision that seek to ameliorate the accuracy, efficiency, and applicability of recognition systems, particularly for individuals experiencing cognitive impairments, such as those with an intellectual disability. Recent innovations are largely attributable to new techniques in machine learning and deep learning that allow predictive models to parse emotional signals from facial expressions with greater accuracy in heterogeneous populations. FER is crucial to aiding understanding of mental disabilities since it can facilitate the social interaction and communication of these persons. Take, for instance, the Facial Emotion Recognition system, which specifically assists children with Autism Spectrum Disorders (ASD) by providing real-time analysis of facial cues to improve interpersonal communication (Fernandez, 2024). This use case emphasizes the power of FER technology to facilitate social engagement, especially among individuals with limited experience interpreting emotional expressions. More research interest is being devoted to the optimization of methods based on deep learning for FER. Convolutional neural networks (CNNs) have recently been used to attain state-of-the-art performance in emotion recognition based on images and video sequences. CNN architectures have been shown to offer superior feature extraction that aids in the differentiation between the subtle emotions portrayed by individuals (Yang et al., 2023;, Wang, 2022). For instance, a work carried out by Li and Deng surveys of the trends of deep CNNs in FER, discussing common challenges such as overfitting and environmental variations (Li & Deng, 2022). This implies that there have been considerable efforts to reduce the biases faced by traditional FER system, especially against cultural diversity (Sohail et al., 2021). Data collection, pioneering race-aware models, and the creation of classification systems are essential factors that significantly enhance the generalization of FER systems across various demographic groups (Kim et al., 2024), which is essential for applications in populations with cognitive disabilities. Some approaches with modified algorithms, including identity-invariant-based methods and local binary patterns (LBP)-based approaches, have shown improved robustness for facial emotion classifications (He & Chen, 2020). Another focus of recent research has been about the incorporation of multi-sensory methods and physiological data, for instance, electroencephalogram (EEG) signals. Source: The National Center for Biotechnology Information, enhance the precision of emotion recognition systems in mental health diagnostics, researchers have opted for a combination of facial landmark detection and Electroencephalography (EEG) data (Li et al., 2019). Such a more holistic approach would likely enhance engagement and effectiveness in therapeutic environments, demonstrating the potential of FER to be more than a technology but rather a pathway to psychological health. In conclusion, the last five years of research done in the field of FER, especially on users within the intellectual disabilities spectrum, has highlighted the relevance of applying improved machine learning techniques, considering socio-cultural biases and integrating multi-modalistic data to improve the performance and the social relevance of FER systems. The recent research will surely enable further optimizations to the current solutions, adapting the algorithms to be able to cope with future challenges, and increasing the efficiency of current FER applications by using the latest technologies.

## III. METHODOLOGY

Facial Expression Recognition (FER) plays a crucial role in understanding the emotions of mentally retarded individuals who may have difficulty expressing themselves verbally. This study proposes a **Support Vector Machine (SVM)-based approach** for FER using **Discrete Wavelet Transform (DWT), Gabor filters** as feature extraction techniques. The SVM classifier is optimized to enhance recognition accuracy while maintaining computational efficiency.

### a. Data Collection and Preprocessing

The MuDERI dataset is utilized to ensure a diverse range of facial expressions. Images are aligned, normalized, and resized to 128×128 pixels. Gaussian filtering is applied for noise reduction and image clarity enhancement.

**b. Feature Extraction Techniques**

**i. Discrete Wavelet Transform (DWT)**

DWT decomposes an image into sub-bands for multi-resolution analysis. The image $I(x, y)$ is transformed into four sub-bands using a wavelet function $\psi(x, y)$[9]

$$[I_{LL}, I_{LH}, I_{HL}, I_{HH} = \sum_m \sum_n I(m, n)\psi_{j,k}(m, n)] \quad (1)$$

where $I_{LL}$ represents the approximation coefficients and the remaining three are detail coefficients.

**ii. Gabor Filters**

Gabor filters capture spatial frequency features by convolving the image $I(x, y)$ with a Gabor kernel $G(x, y, \theta, \lambda)$[10]

$$[G(x, y, \theta, \lambda) = \exp\left(-\frac{x'^2+\gamma^2 y'^2}{2\sigma^2}\right)\cos\left(2\pi\frac{x'}{\lambda} + \phi\right)] \quad (2)$$

**c. SVM-Based Classification**

**Support Vector Machine (SVM)** is used as the classifier due to its robustness in handling high-dimensional data. Given training data $(xi, yi)$ where $x_i \in R^n$ and $y_i \in \{-1,1\}$ are the labels, the SVM classifier finds the optimal hyperplane [11]

$$f(x) = wTx + b \quad (3)$$

where w is the weight vector, and b is the bias. The optimal hyperplane is obtained by solving

$$\min_{w,b} \frac{1}{2}|w|^2$$

subject to: $[y_i(w^T x_i + b) \geq 1, \quad \forall i]$

The RBF kernel is used to map input features into a higher-dimensional space

$$[K(x_i, x_j) = \exp(-\gamma|x_i - x_j|^2)] \quad (4)$$

## IV. RESULT & DISCUSSION

In this study, we utilized the MuDERI dataset—a specialized collection designed to enhance facial expression recognition (FER) research for individuals with intellectual disabilities. This dataset comprises images capturing a range of facial expressions, including happiness, sadness, anger, surprise, neutrality, and fear, specifically from individuals with intellectual disabilities. The performance of the facial expression recognition system for mentally retarded individuals was evaluated using key classification metrics: **Accuracy, Precision, Recall, and F1-Score**. The results obtained from the Support Vector Machine (SVM) classifier are summarized in Table 1. These values indicate that the proposed model effectively distinguishes between different facial expressions with high reliability. To assess model performance, the following metrics will be used

$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN}$$

$$\text{Precision} = \frac{TP}{TP + FP}, \quad \text{Recall} = \frac{TP}{TP + FN}$$

$$F_1 = 2 \times \frac{\text{Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}}$$

**Table 1: Performance Metrics**

| Sr. No. | Metric | Score (%) |
|---|---|---|
| 1. | Accuracy | 83.87% |
| 2. | Precision | 88.89% |
| 3. | Recall | 84.21% |
| 4. | F1-Score | 86.49% |

## V. CONCLUSION

Proposed Face Expression Recognition System using SVM and its Feature Extraction. Although impressive, challenges such as expression variability and dataset restrictions remain. Deeper learning, expanding the dataset, or the use of methods like real-time will make this better. Techniques such as CNNs, 3D facial recognition, or hybrid techniques can improve performance even more. The system could have applications in various healthcare, assistive technology, and other emotion-aware AI systems.

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