2026 Volume: 02 Issue: 03 www.ijrpa.com ISSN 2456-9995 Research Article

International Journal Research Publication

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# AI-BASED PAIN LEVEL ESTIMATION FROM FACIAL EXPRESSIONS USING SMART TRIAGE

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**Article Received: 26 January 2026**
**Article Revised: 15 February 2026**
**Published on: 07 March 2026**

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DOI: https://doi-doi.org/101555/ijrpa.1292

## ABSTRACT

This project presents an AI-Based Pain Level Estimation system that automatically predicts pain intensity from facial expressions using deep learning techniques. The system utilizes a Convolutional Neural Network (CNN) to extract spatial facial features and a Long Short-Term Memory (LSTM) network to analyze temporal variations in video frames. It predicts pain intensity on a numerical scale from 1 to 5 and displays the result in real time through a Streamlit- based web application. The proposed solution provides a non-invasive, objective, and efficient approach to support smart triage and healthcare monitoring.

## 1. INTRODUCTION

Pain assessment is an essential part of healthcare, as it helps doctors determine the severity of a patient's condition and provide appropriate treatment. Traditional pain evaluation methods rely on self- reporting scales, which are subjective and may not be suitable for patients who cannot communicate effectively, such as infants, elderly individuals, or unconscious patients. This highlights the need for an objective and automated pain assessment system. This project proposes an AI-Based Pain Level Estimation system that predicts pain intensity from facial expressions using deep learning. A CNN model extracts facial features, and an LSTM network analyzes temporal changes in video frames. The system predicts pain intensity on a numerical scale from 1 to 5 and displays the result in real time through a web-based application. The proposed solution aims to support smart triage and improve accuracy in pain evaluation

## 2. Literature Review:

Earlier studies used facial action units and traditional machine learning for pain detection. Later, CNN-based models improved accuracy by extracting deep facial features. Recent research combines CNN and LSTM to capture both spatial and temporal information from video sequences. However, many existing systems lack real-time deployment and practical healthcare integration. The proposed project implements a real-time CNN–LSTM model for numerical pain intensity prediction (1–5 scale).

## 3. Problem Statement:

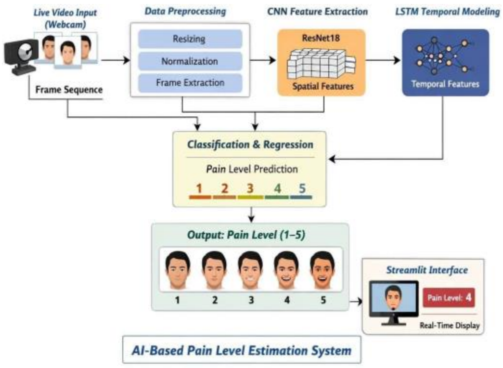
In healthcare environments, pain assessment is primarily based on self- reporting by patients or manual observation by medical staff. There is a need for an automated, objective and real time system that can analyze facial expressions to estimate pain intensity accurately.

Therefore, this project aims to develop an AI-based system using CNN and LSTM models to predict pain intensity levels (1–5 scale) from facial expressions captured through live video for smart triage support.

## 4. Methodology:

The dataset includes patient vital signs such as respiratory rate, oxygen saturation, blood pressure, heart rate, body temperature, consciousness level, and oxygen support, which are preprocessed by handling missing values, encoding categorical features, and scaling data using StandardScaler, after which a Random Forest Classifier is trained using a train–test split to predict patient health risk levels along with their associated probabilities.

## 5. Architecture:



## 6. Modules:

- Data Collection And

Pre-Processing

- Model selection and training
- Evaluation Model
- Experimental setup
- Results and analysis

### 6.1 Data Collection

The dataset is organized subject-wise, allowing the model to learn variations across different individuals. Since the proposed system uses temporal modeling, individual images were grouped into sequences of 16 consecutive frames to simulate real-time facial expression changes. Each condition was mapped to a numerical pain intensity level ranging from 1 to 5. Additionally, mild augmentation techniques were applied to generate intermediate pain levels where necessary to ensure better class distribution. The dataset was carefully structured to support multi-class classification and temporal sequence learning.

### 6.2 Model Selection and Training

A hybrid deep learning architecture combining Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) networks was selected for this project. The model was trained using Cross-Entropy loss and optimized using the Adam optimizer with a learning rate of 0.0001. The dataset was divided into training (80%) and validation (20%) sets, and the model was trained for multiple epochs until convergence was achieved.

### 6.3 Model Evaluation

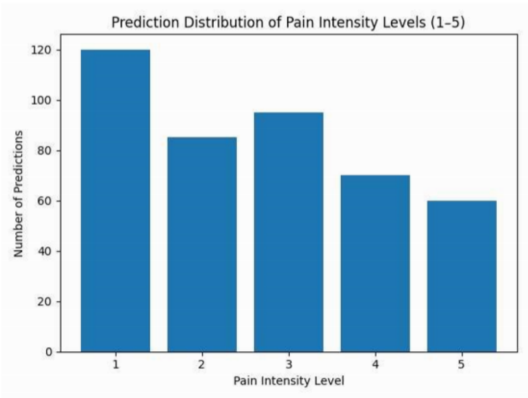
The model was evaluated using several performance metrics to ensure robustness and generalization. Training and validation loss were monitored to observe learning behavior and detect overfitting. Accuracy was calculated to measure overall prediction correctness across all five pain classes.

### 6.4 Experimental Setup

The experimental setup was implemented using Python with the PyTorch deep learning framework. The training environment included GPU acceleration (if available) to speed up computations. All input images were resized to 224×224 pixels and normalized to a range of 0–1 before being converted into PyTorch tensors. The sequence length was fixed at 16 frames for temporal modeling. Batch size, learning rate, and number of epochs were carefully selected to balance training speed and performance.

### 6.5 RESULTS AND ANALYSIS

The proposed system uses a CNN–LSTM model to detect and estimate pain intensity from facial expressions. The model was trained on a Kaggle facial expression dataset after applying preprocessing techniques such as image resizing and normalization. The system predicts pain levels on a scale of 1–5. Performance was evaluated using accuracy, precision, recall, and F1-score, and results showed that the model can effectively classify different pain levels. Real-time testing using a Streamlit interface and webcam confirmed that the application can predict pain intensity quickly and accurately, making it useful for smart healthcare and patient monitoring systems.




## 7. CONCLUSION:

This project provides an automated and objective approach for assessing pain intensity using facial expressions. By integrating a CNN for spatial feature extraction and an LSTM for temporal analysis, the system effectively captures dynamic facial patterns associated with pain. The model predicts pain intensity on a numerical scale from 1 to 5 and delivers real-time results through a user-friendly Streamlit web application. This solution reduces dependency on subjective self- reporting methods and supports smart triage applications in healthcare settings.

## FUTURE SCOPE:

The project can be further enhanced by incorporating a larger and more diverse dataset to improve model generalization across different ethnicities, lighting conditions, and camera angles. Integration with hospital management systems can enable automated patient monitoring and triage prioritization

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