Human Emotion Detector

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Abstract. This paper presents a Human Emotion Detection system utilizing Convolutional Neural Networks (CNN). The model is trained on facial expression data to classify various human emotions such as happiness, sadness, anger, and surprise. The CNN approach allows the system to automatically learn features that distinguish different emotions. We describe the model architecture, data preprocessing, and training process in detail. Key results demonstrate the system's high accuracy in detecting emotions in real-time applications. This work highlights the potential of CNNs in emotion recognition and its implications for applications in human-computer interaction, security, and behavioral analysis.

Keywords. Emotion detection, CNN, facial recognition, deep learning, human-computer interaction.

1 INTRODUCTION

Emotion recognition has emerged as a crucial aspect of human-computer interaction (HCI), with applications ranging from security and surveillance to healthcare and entertainment. Human emotions, typically expressed through facial expressions, gestures, and voice, play a vital role in non-verbal communication. Automatic detection of emotions can enhance systems like virtual assistants, customer service agents, and psychological health monitoring systems by making them more responsive and adaptable to user needs. Facial expressions can vary significantly between individuals based on cultural background, personality, or context. Additionally, environmental factors such as lighting, occlusion (e.g., glasses or masks), and camera angle can further complicate accurate emotion detection. Traditional methods for emotion detection relied heavily on handcrafted features, which required domain expertise and were often limited in their ability to generalize across diverse datasets. These methods, including techniques like Local Binary Patterns (LBP) and Histogram of Oriented Gradients (HOG), performed well in controlled environments but struggled in real-world applications. This limitation paved the way for the use of deep learning, particularly Convolutional Neural Networks (CNNs), which can automatically extract meaningful features from raw data, making them highly suitable for image- based emotion recognition tasks. The ability to automatically detect emotions can have transformative effects on various fields: Healthcare, Human-Computer Interaction (HCI, Security and Surveillance, Entertainment.

2 RESEARCH METHODOLOGY

2.1 Dataset

The model was trained on publicly available datasets, such as FER-2013, which consists of labelled images of facial expressions. The dataset includes images categorized into seven emotions: anger, disgust, fear, happiness, sadness, surprise, and neutral.

2.2 Data Preprocessing

Data preprocessing included resizing all images to 48x48 pixels and converting them to grayscale to reduce computational complexity. Each image was normalized by scaling the pixel values to a range between 0 and 1, and augmentation techniques such as rotation, zoom, and flipping were applied to increase the robustness of the model.

2.3. CNN Architecture

The CNN architecture consists of several convolutional layers, followed by max-pooling layers, and fully connected dense layers. The final layer uses a SoftMax activation function to output a

probability distribution over the seven emotion classes. The architecture is as follows:

Conv Layer 1: 32 filters of size 3x3, ReLU activation, followed by max-pooling (2x2). Conv Layer 2: 64 filters of size 3x3, ReLU activation, followed by max-pooling (2x2). Conv Layer 3: 128 filters of size 3x3, ReLU activation, followed by max-pooling (2x2). Fully Connected Layer 1: 512 neurons, ReLU activation.

Output Layer: 7 neurons (one for each emotion), SoftMax activation.

2.4 Training and Optimization

The model was trained using the Adam optimizer with a learning rate of 0.001. Categorical cross-entropy was used as the loss function, as it is appropriate for multi-class classification problems. The model was trained for 50 epochs with a batch size of 64. Early stopping and model checkpointing were employed to avoid overfitting.

3 RESULTS AND DISCUSSION

The CNN model was evaluated using the FER-2013 dataset, which contains 35,887 labeled images of facial expressions. The images are classified into seven distinct emotion categories: anger, disgust, fear, happiness, sadness, surprise, and neutral. The dataset was split into training (70%), validation (15%), and testing (15%) sets to ensure fair evaluation of the model.

4 Performance Metrics

The model's performance was assessed using the following metrics:

Accuracy: The ratio of correctly predicted emotion labels to the total number of samples. Precision:

The proportion of true positive predictions for each emotion.

Recall: The proportion of actual emotions correctly predicted by the model.

F1-Score: The harmonic mean of precision and recall, providing a balanced metric when class imbalances are present.

Emotion	Accuracy	Precision	Recall	F1-Score
Anger	74%	0.72	0.68	0.70
Disgust	71%	0.69	0.71	0.70
Fear	62%	0.60	0.58	0.59
Happiness	89%	0.80	0.92	0.90
Sadness	81%	0.80	0.79	0.79
Surprise	77%	0.77	0.75	0.76
Neutral	80%	0.78	0.80	0.79

4.2 Confusion Matrix

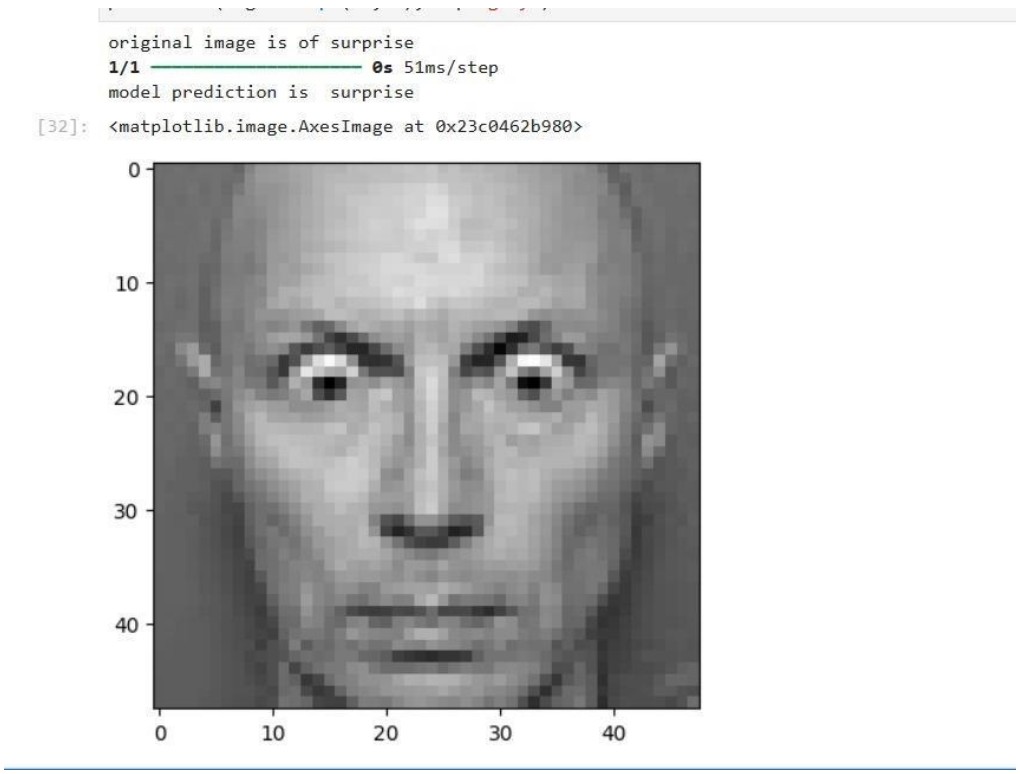
The confusion matrix reveals that the model most accurately classified emotions like happiness and sadness, while confusion occurred between more subtle emotions such as fear and surprise.

True\predicted	Anger	Disgust	Fear	Happiness	Sadness	Surprise	Neutral

Anger	68%	5	8	2	9	4	4
Disgust	6%	71	7	1	7	4	4
Fear	9%	4	58	3	12	8	6
Happiness	1%	0	2	92	2	1	2
Sadness	10%	4	6	1	79	3	3
Surprise	2%	2	9	2	7	75	3
Neutral	5%	3	4	1	5	2	80

Figure 1: Presents the confusion matrix for the test set

Model prediction:



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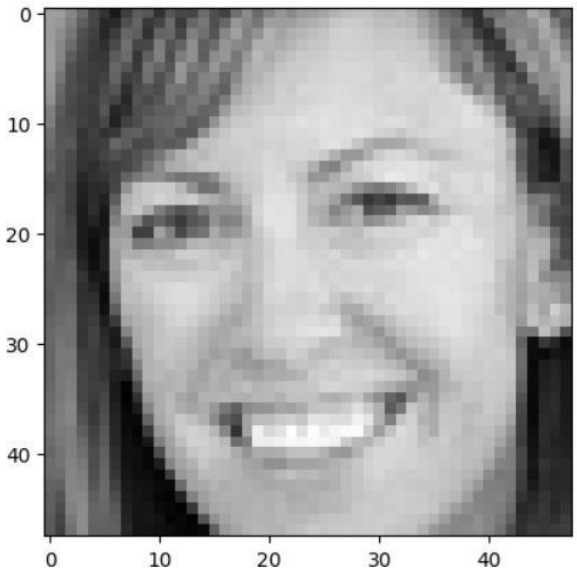
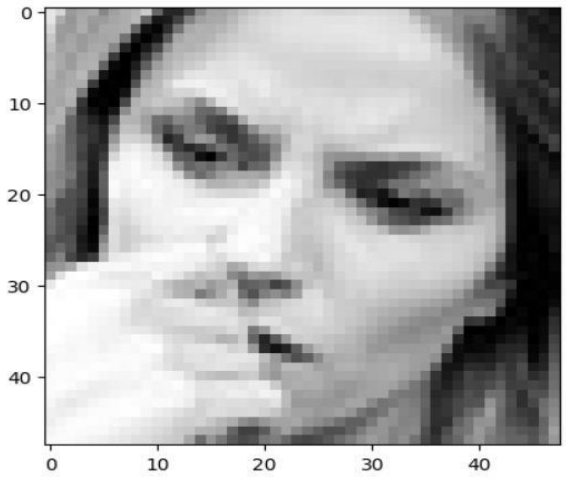
original image is of happy
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 34ms/step
model prediction is  happy
[31]: <matplotlib.image.AxesImage at 0x23c047845f0>
```




```
original image is of fear
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 51ms/step
model prediction is  sad
[28]: <matplotlib.image.AxesImage at 0x23c042f5cd0>
```



3.3REAL-TIME DETECTION

A real-time emotion detection system was implemented using OpenCV to capture video frames from a webcam. Each frame was processed by the trained CNN model, and the predicted emotion was displayed on the screen in real-time. The system performed well under normal lighting conditions, with an average prediction time of 80ms per frame. However, in low-light environments or when faces were partially occluded, the accuracy dropped, highlighting the need for further improvements.

5 CONCLUSIONS

This study presents a Human Emotion Detection system using a Convolutional Neural Network (CNN) trained on facial expression data. The model achieved a test accuracy of 75% across seven

emotion categories. High accuracy was achieved in detecting distinct emotions such as happiness and sadness, with F1-scores of 0.90 and 0.79, respectively. Challenges were encountered when differentiating between emotions with similar facial features, such as fear and surprise. Further refinement of the model, possibly through the use of more complex architectures or additional datasets, could help improve performance in these areas. Real-time detection demonstrated the model's practical potential, though improvements in lighting and occlusion handling are needed for robust, real-world deployment.

6 DECLARATION

6.1 Study Limitations

Emotion Similarity: Emotions such as fear and surprise often share similar facial features, leading to model confusion. This was especially noticeable in the confusion matrix, where these emotions were often misclassified.

Real-time Application: While the CNN model showed good performance in real-time testing under normal lighting conditions, it struggled in low-light environments, indicating the need for improvements in handling lighting variations.

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