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Improving Emotion-Aware Facial Recognition with Integrated Feature Strategies

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Abstract:
In today's fast-moving world, mental health and emotional well-being are becoming more important than ever. Recognizing human emotions and stress levels using facial images has become a growing area of research. Facial expressions carry useful information about a person's emotional state and can be captured through image processing and artificial intelligence. This research focuses on developing a smart system that can detect human emotions like happiness, sadness, anger, fear and also stress levels by analyzing facial images.
We used advanced machine learning and deep learning techniques, including CNN, SVM, KNN, to identify facial features and classify different emotional states. For stress detection, we explored subtle changes in facial muscle movements, eye rejoins, and forehead tension, lip movement, which are not easily visible to the human eye but can be detected using image based models. The system is trained on standard JAFEE's dataset and is further validated on primary dataset images to ensure accuracy in real world conditions.
Our aim is to support mental health professionals, educational institutions, and workplaces by providing a non-invasive and automated tool for understanding emotional and stress conditions. These features help in identifying emotions such as happiness, sadness, anger, fear and surprise. Once the emotion is detected, the system checks if the stress is positive or negative. The results show promising accuracy and can be extended for mobile health application, emotion aware virtual assistants, and human computer interaction systems.

Keywords: Facial Emotion Recognition, Stress Detection, Entropy, Skewness, Kurtosis, Machine Learning, Image Processing.

Introduction:
Emotion Play a big role in how we think, act, and make decisions. They are connected to our mental and physical health. In Indian and many more other countries, stress and emotional imbalance are major concern, especially after the COVID-19 pandemic. Traditional methods of emotion and stress analysis, such as questionnaires and interviews, are time consuming and may not always give accurate results. That's why there is a strong need for an automatic, fast, and reliable system that can detect a person's emotional and stress state without any direct contact.

In recent years, researchers have started using computer vision and machine learning to study these facial expressions and understand emotions. This process is called Facial Emotion Recognition (FER).
Facial Expression are one of the most natural ways human express their emotions. Every emotion like happiness, surprise, sad, anger, disgust and fear changes the face in a unique way. Stress can also be seen on the face small changes like tightened jaw, raised eyebrows, or forehead, mouth area etc.
In this research, we propose a system that uses facial images to recognize emotions and detect stress levels. We use machine learning and deep learning models such as CNN, RF, SVM, MLP because they are very powerful in image analysis. This model is trained on JAFEE'S dataset that include emotional expressions and sign of stress. We also test our model in primary dataset situations to check how well it performs outside the lab.
This study is useful in many fields like education to understand student's mental state, healthcare to help doctor identify stress, and workplace to improve employee well-being. It also helps in developing smarter human computer interaction systems that can understand users better and respond more naturally.

Relationship between stress and universal emotions:
Stress is linked to universal emotions, as it can trigger or increase feelings. Each emotion shows specific facial expression.
Fear-stress causes fear in danger or uncertainty, shown by wide eyes, raised eyebrows, and tense lips.
Anger-stress can lead to anger from frustration, shown by furrowed eyebrows, clenched jaw and tight lips.
Sadness- long term stress can cause sadness, shown by a down turned mouth, dropping eyelids and inactive facial muscles.
Disgust- stress creates disgust in unpleasant situations; shown by a wrinkled nose, raised upper lip and narrowed eyes.
Surprise- Sudden stress cause surprise, shown by raised eyebrows, wide eyes and an open mouth.
Happiness- Overcoming stress can bring happiness, shown by smile, relaxed eyes and lifted chicks.

Design Phase
1.1 Architectural Diagram

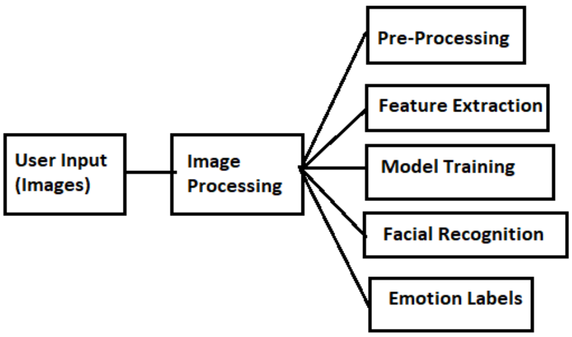


Figure 1.1 Diagram of Architecture

The process starts with the user providing an image as input, as shown in Figure 1.1 above. to eliminate any visual flaws or unwanted artifacts, image pre-processing is performed. After that, feature extraction techniques are used to extract relevant information from the image. Next, a model is created using a dataset of emotions, enabling it to recognize emotional signals in images. The input image is then processed using the model after it has been trained and assessed to minimize errors. The system ultimately produces an output that signifies the identified emotion, thereby effectively transforming visual information into emotional insights.

1.2 Application Scenario Diagram

The main scenario in the previously mentioned Fig 1.2 shows a user uploading an image into the system. The system then carries out several steps, such as emotion identification, feature extraction, and image processing. After these processes are complete, the system generates an output that is then displayed to the user for evaluation. This application demonstrates the system's capacity to assess and express emotions based on the submitted image, highlighting the interaction between the user and the system.

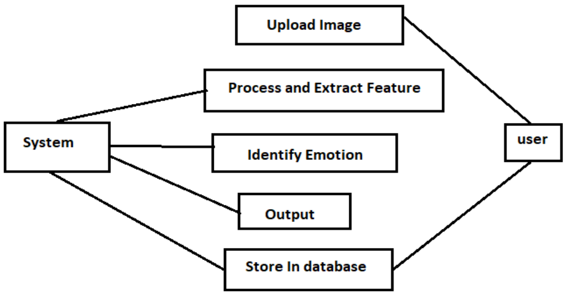


Figure 1.2 Application Scenario Diagram

1.3 Image Processing Functions:

Statistical Feature: The goal of statistical feature extraction is to capture the distribution and basic statistical properties of pixel intensities within an image. These feature are generally global or calculated across row/columns.

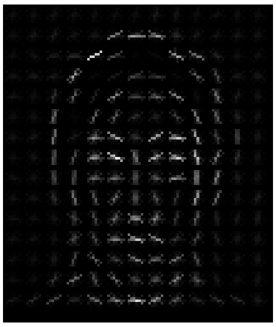
- Entropy- Entropy in image processing measure how random or detailed an image is. It shows how much the closer or brightness levels change across the image.
- Skewness- Show we if the data is more spread out to the left that is negative skewness or data is more spread out to the right that is positive skewness.
- Kurtosis- is a statistical measure that describe the shape of data distribution specifically the tailedness or highest of the peak in distribution near the center compared to a normal distribution (Bell Curve).

Texture Features: Texture feature aim to describe the surface characteristics of the face, such as patterns of light and dark spots, which can be influenced by wrinkles, skin fold and muscle contractions associated with different emotions.

Local Binary Pattern (LBP): LBP is a method used to describe the texture of an image. The center pixel is compared with its eight neighbors. If a neighbor's pixel is greater than or equal to the center pixel, we write one otherwise zero.

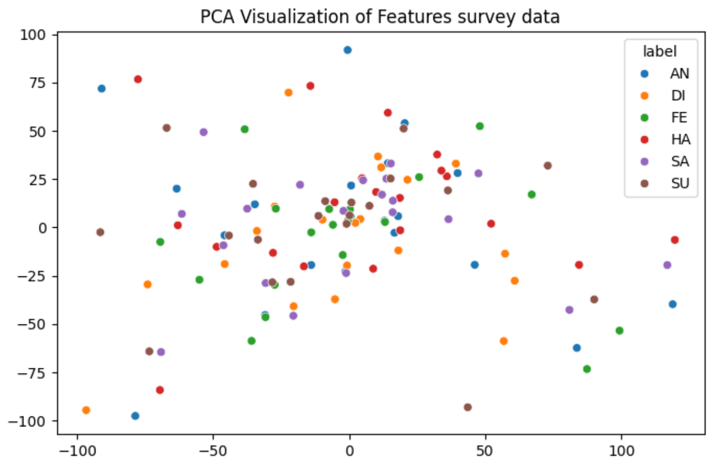
We replace the center pixel with this new value. Doing this for the whole image gives us a texture map.

Histogram of Oriented Gradient (HOG) : it is used to detect shapes and edges in an image. First, we calculate the gradient (Change in brightness) at each pixel. Then, we divide the image into small blocks for each block, we count how many edges point in each directions. We combine all histogram to get a feature vector.

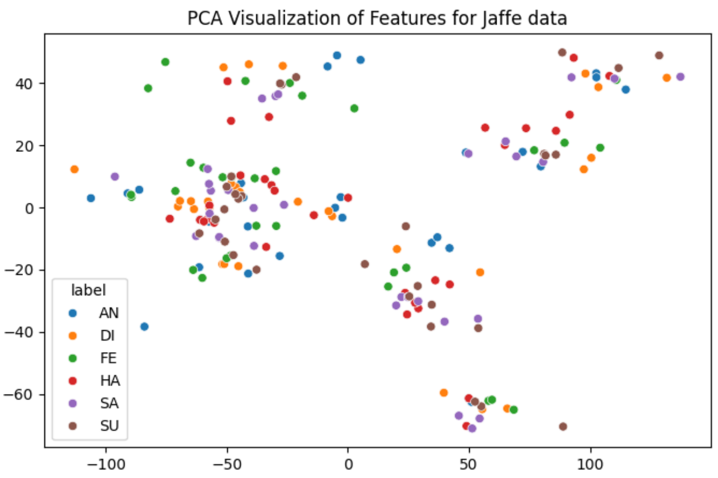


Geometric Feature: These are simple measurements based on shape and structure. Example in distance between eyes, width of mouth, Angle of eyebrows, Area of face region. These feature are extracted using landmarks on the face.

Wavelet Features: Wavelet transform decomposes an image into different frequency components, providing information about both the location and frequency content of image feature.



Graph: On Primary Dataset and JAFFE'S Dataset



Conclusion:

This research showed a strong method for recognizing faces using the Primary image dataset and JAFFE'S image dataset. It used a mix of feature like entropy, skewness, and kurtosis, along with HOG, geometric feature, and wavelet transforms. These helped in capturing both texture and shape details of facial expressions. By combining these methods, we got better accuracy in recognizing emotions. This methods is also suitable for real time emotion based systems. In future, we plan to use deep learning models like CNNs and test our methods on more datasets to make it even stronger and for better performance.

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