**Face Recognition Using HOG and Landmark Analysis**

**Introduction**

Face detection and recognition is a crucial task in computer vision since it is used in many real-time applications like surveillance systems.

There are several techniques used for face detection. These are -but not limited to- face detection with HOG (Histogram Oriented Gradients) and face landmarks.

In recent years, neural networks have made it much easier to carry out this task by providing a very high accuracy with a trade-off with performance (It requires a lot of processing power).

**Problem definition**

Face detection is the process of detecting the presence of faces inside images as well as drawing a bounding box around the detected faces inside a picture or a video stream, while face recognition is the process of recognizing faces based on the facial features of the detected face. Both tasks are really challenging and require a lot of computation power. There are also some problems that make the detection and recognition task harder which are lighting conditions, pose, facial expressions, and occlusions. Also, the main problem of facial detection and recognition lies in the demand for high accuracy and robustly identifying faces and associating them with the corresponding labels.

**Importance**

HOG for Face Detection: -

Histogram of Oriented Gradients is a popular feature extraction method that characterizes local object appearance and shape using local gradient orientations.

HOG provides a concise representation of facial structure and texture, allowing effective discrimination between faces and non-facial regions. When combined with a neural network-based classifier, HOG features can enable accurate and efficient face detection. HOG captures both global and local facial information, making it resilient to variations in pose and illumination.

Facial Landmarks for Face Detection and Recognition: -

Facial landmarks are key points or features on a face, such as the corners of the eyes, nose, and mouth. These landmarks play a crucial role in aligning faces to a consistent coordinate system, enabling accurate detection and recognition. Neural networks trained to detect facial landmarks can precisely localize facial structures, aiding in face alignment, pose estimation, and subsequent feature extraction. By utilizing facial landmarks, the face detection and recognition systems can handle variations in face appearance caused by different facial expressions, orientations, and illuminations.

Neural Networks for Face Detection and Recognition:

The power of neural networks lies in their ability to learn complex patterns and representations from large amounts of data. When integrated with HOG and landmark-based techniques, neural networks can exploit the hierarchical nature of facial features, extracting discriminative representations for robust face detection and recognition. Neural networks enable end-to-end learning, allowing the system to adapt and generalize well to unseen faces.

**Methods & Algorithms**

**Hog Algorithm**

The HOG algorithm follows a series of steps to extract features from an input image:

1. Image Preprocessing
2. Gradient Computation
3. Image Division into Cells
4. Histogram Calculation
5. Block Normalization
6. Feature Vector

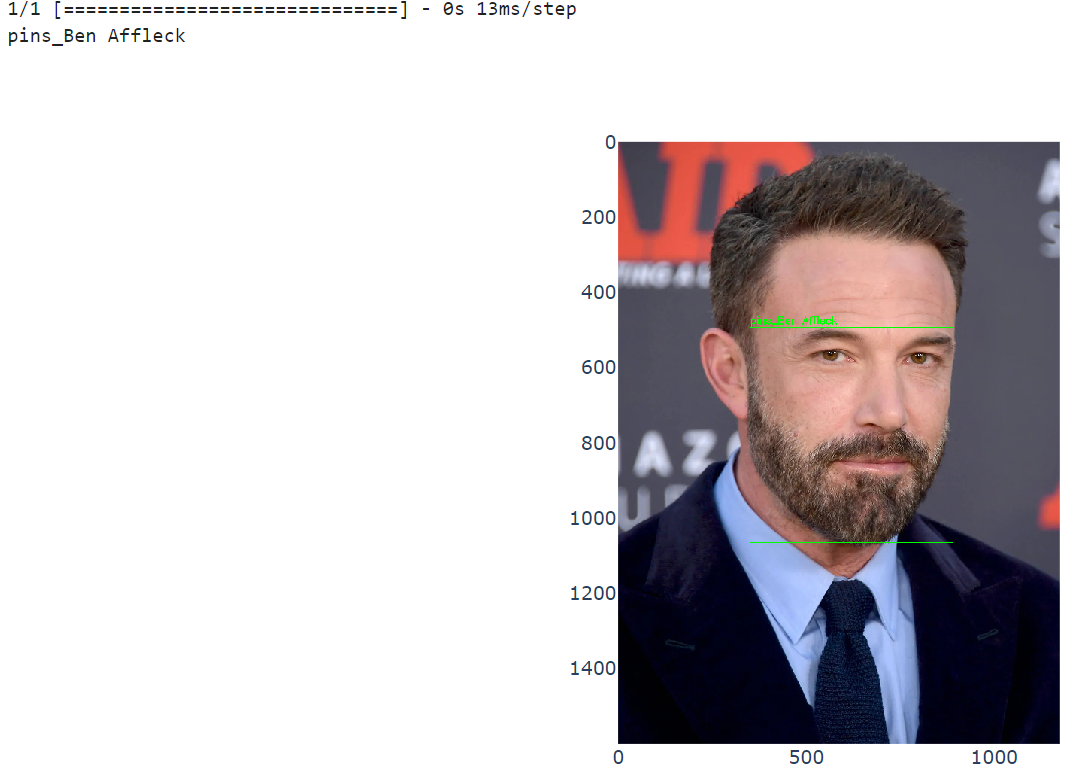
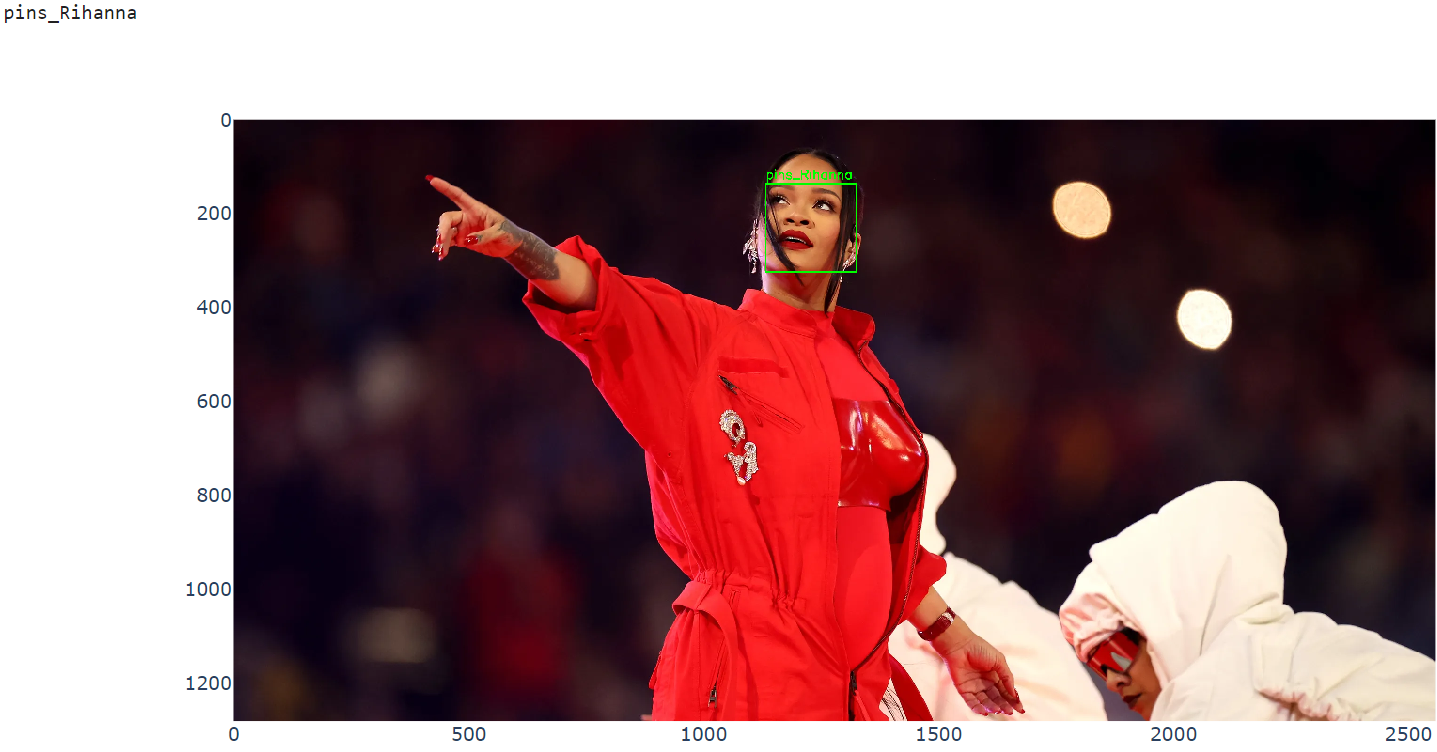
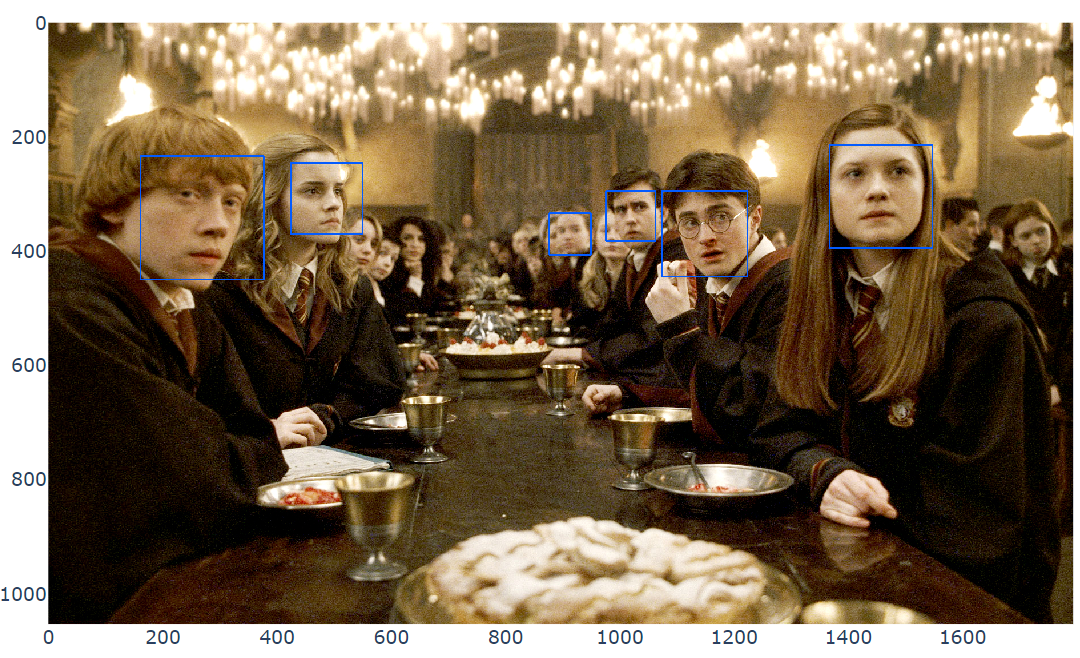
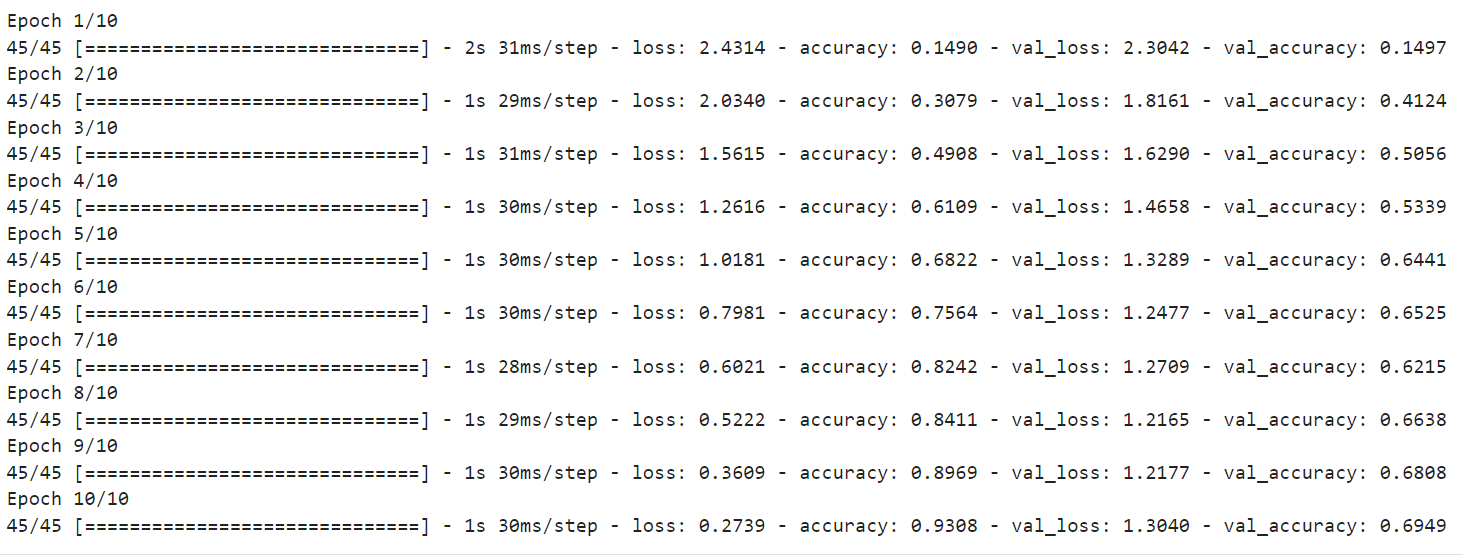
**Landmarks**

The landmarks generated by the dlib library in Python refer to a set of 68 specific points on a face. These landmarks are commonly used for facial analysis tasks, including face alignment, and pose estimation.

The dlib library provides a pre-trained facial landmark detection model, which is based on a shape predictor trained using a large dataset of annotated facial landmarks. When applied to an input image or face region, the dlib model predicts the coordinates of these 68 landmarks, providing detailed information about the spatial positioning of various facial structures.

The 68 facial landmarks generated by the dlib library typically include:

* Outer Eye Points: These landmarks capture the outer corners and edges of the eyes, such as the corners of the eyebrows, the outer corners of the eyes, and points along the upper and lower eyelids.
* Inner Eye Points: These landmarks mark the inner corners and edges of the eyes, including the tear ducts and points along the inner eyelids.
* Nose Points: These landmarks correspond to the bridge, tip, and base of the nose, as well as points along the sides and nostrils.
* Mouth Points: These landmarks indicate the corners of the mouth, points along the upper and lower lips, and points along the contour of the mouth.
* Jaw Points: These landmarks capture the outline of the jaw, including the chin, jawline, and points along the sides of the face.

**Results**