FACE DETECTION IN COLOR IMAGES USING HOG–LBP FEATURES AND SVM CLASSIFIER

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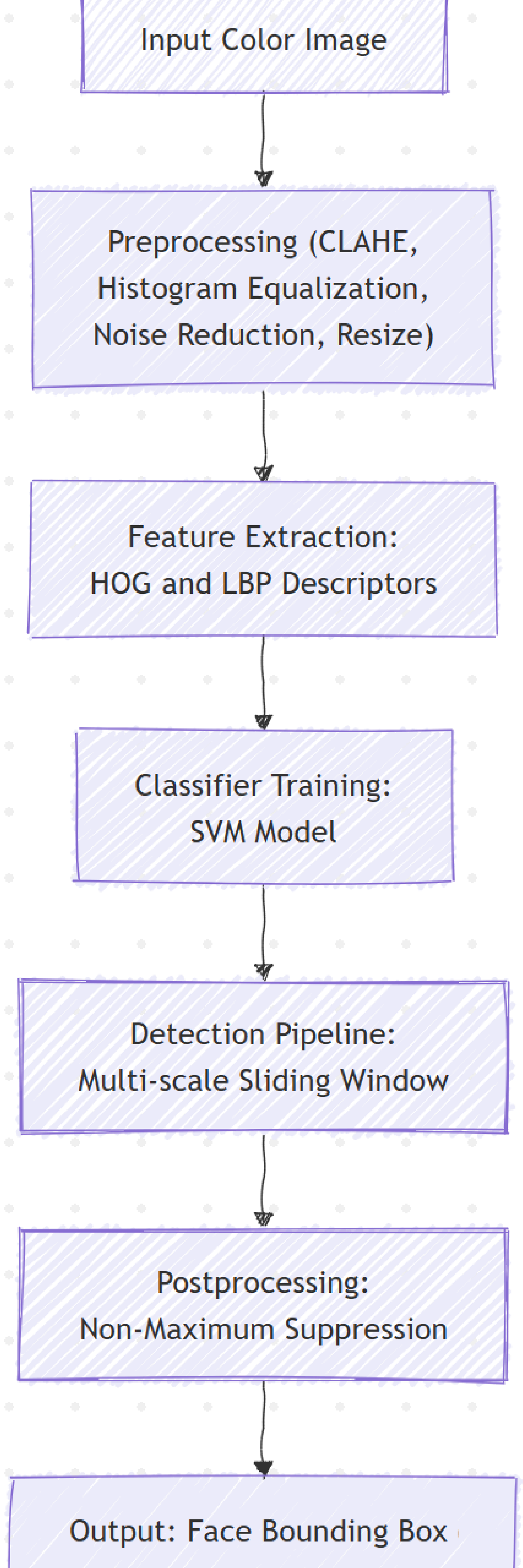
SOLUTION OVERVIEW

The proposed approach is a hybrid, feature-based face detection system built using classical computer vision methods. The design combines two complementary feature extraction techniques: the **Histogram of Oriented Gradients (HOG)**, which captures the overall shape and edge structure of a face, and the **Local Binary Patterns (LBP)**, which describe fine texture variations. These features are concatenated to form a robust feature vector that represents each image patch.
A **Support Vector Machine (SVM)** classifier is trained using these feature vectors, with positive samples taken from known face regions and negative samples from non-face areas. During detection, the trained SVM evaluates sliding windows at multiple image scales to determine whether each region contains a face. Finally, overlapping detections are refined using Non-Maximum Suppression (NMS) to produce a single bounding box per face.



SYSTEM BLOCK DIAGRAM

The overall system is organized into five main stages: preprocessing, feature extraction, classifier training, detection, and postprocessing. The process begins with input color images that are normalized and filtered to reduce the impact of illumination and noise. From these images, discriminative features are extracted and combined into a unified representation. The SVM classifier is then trained on labeled examples of faces and non-faces. During detection, the trained model scans the image at multiple scales using a sliding window approach to predict face regions. Finally, Non-Maximum Suppression merges overlapping detections and the resulting rectangles are drawn over the detected faces.

IMPLEMENTATION FLOW

The face detection pipeline begins by collecting and organizing a dataset of color images together with their face bounding box annotations. Input images undergo preprocessing, including illumination normalization (using CLAHE or histogram equalization), noise reduction, and resizing to standardize all patches and reduce the impact of lighting and noise.

For the feature extraction stage, a multi-scale sliding window is applied across each preprocessed image. For every window, Histogram of Oriented Gradients (HOG) descriptors are computed to capture edge and shape information, while Local Binary Patterns (LBP) are extracted to describe local texture variations. The HOG and LBP features are concatenated to form a robust and comprehensive feature vector that summarizes the content of each patch.

Training data is then assembled by labeling patches overlapping the annotated face regions as positive samples and selecting negative samples from non-face regions or external images. The extracted feature vectors and their labels are used to train a Support Vector Machine (SVM) classifier that distinguishes between face and non-face patterns.

In the detection phase, the trained SVM evaluates feature vectors from new image patches sampled by the sliding window across different scales. Patches classified as containing faces are recorded as detection candidates.

To address duplicate and closely positioned detections, Non-Maximum Suppression is applied to the set of bounding boxes, ensuring that only the most confident detection remains in overlapping regions. Finally, the resulting bounding boxes are drawn on the original color image, marking all detected face regions.