Human Face Detection

Import Necessary Libraries

Import all fundamental libraries

```
import pandas as pd
import numpy as np
import cv2
from PIL import Image
import os
import torch
```

Data Preprocessing

- **Clean and Handle Annotations:**
  - Load the annotation CSV using pandas.
  - Handle missing values, wrong entries, out-of-bound bounding boxes.
- **Save Cleaned Annotations:**
  - Save the processed CSV for training.
- **Integrate Images with Annotations:**
  - Match each image with its bounding boxes properly.
- **Resize Images:**
  - To prevent GPU memory overflow and speed up training, resize images to a standard size (e.g., 640×640).

Data Augmentation

- **Enhance Dataset:**
  - Apply augmentations like:
    - Horizontal Flip
    - Brightness/Contrast Adjustment
    - Rotation
    - Random Cropping
    - Blurring
- **Normalization:**
  - Scale pixel values to [0, 1] or [-1, 1].

Exploratory Data Analysis (EDA)

- **Visualize Annotations:**
  - Plot sample images with bounding boxes to verify correctness.

- **Analyze Dataset:**
  - Count number of images.
  - Count total faces.
  - Analyze distribution: Faces per image, Image sizes.

Training Preparation

- **Convert CSV to YOLO TXT Format:**
  - Convert bounding box annotations from (x0, y0, x1, y1) to YOLO format: (class, center_x, center_y, width, height).
- **Label Check:**
  - Ensure every image has a corresponding label file (.txt).
- **Dataset Split:**
  - Split data into training and validation sets (e.g., 80%-20%).
- **Create YAML Config File:**
  - Define:
    - Train path
    - Validation path
    - Number of classes
    - Class names

Model Training

- **Initialize YOLOv8 Model:**
  - Load a pretrained YOLOv8n or YOLOv8s model.
- **Pass Data and Parameters:**
  - Batch size, learning rate, epochs, optimizer.
- **Train the Model:**
  - Monitor metrics: Loss, mAP (mean Average Precision), Recall, Precision.

Model Evaluation

- **Performance Metrics:**
  - mAP (IoU@0.5, IoU@0.5:0.95)
  - Precision/Recall curves
- **Testing Predictions:**
  - Run predictions on:
    - New images
    - Videos
    - Webcam live feed

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8. Deployment and Report

- **Deployment:**
  - Build a Streamlit app for demo (upload image/video/webcam).
  - Package the model (.pt file) and code.

Summary in one line:

Clean → Augment → Analyze → Train → Evaluate → Predict → Deploy → Report