AI-Based Facial Recognition, People Counting, and Gender Classification Using Edge Devices

Background

With the increasing need for intelligent surveillance, smart infrastructure management, and automated monitoring systems, organizations are shifting toward **AI-driven vision-based analytics** capable of operating in real-time environments. Traditional surveillance systems primarily rely on manual monitoring, which is resource-intensive, error-prone, and inefficient for large-scale deployments.

Advancements in **Computer Vision and Edge Artificial Intelligence (Edge AI)** now enable automated detection and analysis of human presence directly on edge devices such as embedded systems, smart cameras, or low-power computing platforms without relying heavily on cloud infrastructure.

AI-powered edge systems can perform tasks such as:

- Facial recognition for identity verification
- Real-time people counting
- Gender classification
- Occupancy monitoring
- Crowd analytics and behavioral insights

Processing data locally on edge devices ensures:

- Reduced latency
- Improved privacy protection
- Lower bandwidth consumption
- Continuous operation even without internet connectivity

However, deploying reliable AI systems in real-world environments presents several challenges including varying lighting conditions, occlusions, crowd density, computational limitations of edge hardware, and ethical considerations related to privacy and bias.

At present, there is limited standardized implementation addressing:

1. Accurate real-time facial recognition and demographic classification on resource-constrained edge devices.
2. Efficient people-counting mechanisms capable of handling crowded and dynamic environments.
3. Optimization of AI models to balance accuracy, speed, and power consumption on edge hardware.
4. Privacy-preserving analytics that minimize storage or transmission of sensitive biometric data.

Objective of the Exercise

The objective of this problem is to:

● Develop an AI-based system capable of detecting and recognizing human faces in real time using edge devices.

● Implement automated people counting mechanisms for monitoring occupancy and crowd density.

● Perform gender classification using computer vision techniques while maintaining acceptable accuracy levels.

● Design optimized AI models suitable for deployment on low-power edge computing platforms.

● Ensure minimal dependency on cloud infrastructure through on-device inference.

Expected Outcome

The problem-solving team is expected to:

● Develop a working prototype capable of real-time face detection and recognition.

● Demonstrate accurate people counting under classroom, public, or surveillance-like environments.

● Implement gender classification integrated with detection pipelines.

● Optimize model performance for edge deployment considering latency and hardware constraints.

● Provide system architecture including:

- Data acquisition
- Model training
- Edge deployment
- Real-time inference pipeline

● Address ethical considerations such as privacy protection, bias mitigation, and responsible AI usage.