Computer Vision Engineer Interview Challenge

Background

A retail company wants to implement an advanced in-store analytics system using computer vision technology. The goal is to better understand customer behavior, optimize store layouts, and improve the shopping experience without using facial recognition (for privacy reasons). The system should track customer movements, analyze product interactions, detect queue formation, and provide insights on store operations.

This challenge simulates the real-world complexity of building robust computer vision systems that need to work reliably in varying lighting conditions, with occlusions, and across different store layouts.

Objective

Design and implement a computer vision system that can analyze in-store customer behavior from video feeds while respecting privacy concerns. Your solution should demonstrate proficiency in object detection, tracking, motion analysis, and the ability to extract meaningful insights from visual data.

Dataset Overview

- **Store Videos**: 50 hours of anonymized store footage from 5 different locations
- **Store Layouts**: Floor plans and product placement maps for each location
- **Ground Truth Annotations**: Sample frames with labeled regions of interest and crowd densities
- **Metrics History**: Historical data on store traffic, dwell time, and conversion rates

Scope of Work

1. Customer Detection & Tracking

- Implement privacy-preserving person detection (no facial recognition)
- Develop robust multi-object tracking across video frames
- Handle occlusions and overlapping trajectories
- Address varying lighting conditions and camera angles

2. Behavior Analysis

- Identify customer movement patterns and heat maps
- Detect product interactions and dwell time at displays
- Analyze queue formation and length at checkout areas
- Distinguish between staff and customers

3. Performance Optimization

- Optimize for real-time processing on edge devices
- Implement batch processing for historical analysis
- Balance accuracy and computational efficiency
- Create strategies for handling multiple camera feeds simultaneously

4. Insights Generation

- Extract actionable metrics from visual data
- Develop visualizations of customer flow and store hotspots
- Create anomaly detection for unusual patterns
- Design a dashboard for store management

5. System Integration

- Design an API for integrating with existing retail systems
- Implement data export capabilities for business intelligence tools
- Create an alert system for real-time notifications
- Ensure scalability across multiple store locations

Technical Requirements

- Well-documented CV pipeline with clear module separation
- Efficient implementation suitable for deployment on mid-range hardware
- Appropriate use of pre-trained models and transfer learning
- Privacy-preserving design that avoids identifying individuals
- Consideration of edge cases (store crowding, unusual lighting, etc.)

Evaluation Criteria

Your solution will be evaluated based on:

- Accuracy of detection and tracking in challenging conditions
- System performance and computational efficiency
- Quality of insights generated from visual data
- Privacy-conscious approach to computer vision
- Code quality, documentation, and reproducibility

Discussion Questions

- How would your system handle previously unseen store layouts?
- What measures have you taken to ensure customer privacy?

- How would you adapt your system for nighttime operation or low lighting?
- What are the main limitations of your current approach?
- How would you measure the business impact of your computer vision system?

Deliverables

- Complete code repository with setup instructions
- Technical documentation explaining your approach and algorithms
- Performance analysis across different store scenarios
- Integration guide for deployment in production environments
- Brief presentation (5-10 slides) summarizing your solution

Final Notes

This challenge assesses your ability to build practical computer vision systems that solve real business problems while addressing common challenges like privacy, varying environmental conditions, and computational constraints. Focus on creating a solution that balances technical sophistication with practical implementation concerns.