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PROJECT TITLE: AI-EBPL-Quality Control in Manufacturing

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# Phase 2: Innovation & Problem Solving

# Title: Smart Freshness Detector for Fruits and Vegetables

### Innovation in Problem Solving

This phase addresses the growing problem of food quality degradation and wastage by introducing an AI-powered freshness monitoring system. The proposed solution integrates computer vision, IoT sensors, and edge computing to provide real-time, reliable, and accessible freshness assessment of fruits and vegetables.

### Core Problems to Solve

1. **Subjective Freshness Assessment**: Human-based judgments of freshness are inconsistent and vary across individuals.  
2. **Environmental Impact on Quality**: Storage conditions like temperature and humidity greatly affect produce lifespan.  
3. **Lack of Real-Time Monitoring**: Existing solutions do not offer instant evaluation at the point of storage, sale, or purchase.  
4**. Food Wastage**: Misjudgment of freshness often leads to premature disposal or overlooked spoilage.

### Innovative Solutions Proposed

1**. AI-Based Visual Freshness Detection**  
**Solution Overview**: A CNN-based image classifier categorizes fruits/vegetables into freshness levels (Fresh, Moderately Fresh, Spoiled).  
**Innovation**: Combines image input with real-time environmental data for enhanced accuracy.  
**Technical Aspects**:  
- Transfer learning using MobileNet.  
- Custom dataset of labeled images across spoilage stages.  
- Lightweight design suitable for edge deployment.  
  
2**. IoT Sensor Integration for Shelf-Life Prediction**  
**Solution Overview**: Real-time monitoring using DHT11 sensor to collect temperature and humidity data.  
**Innovation**: Dynamically estimates shelf life based on environmental readings.  
**Technical Aspects**:  
- Arduino/Raspberry Pi + DHT11.  
- Sensor data parsed via serial communication.  
- Alerts triggered based on spoilage risk thresholds.  
  
3. **Real-Time Dashboard with Alerts**  
**Solution Overview**: A Streamlit app visualizes model predictions and sensor data with a user-friendly interface.  
**Innovation**: Provides color-coded freshness scores and alerts for batch monitoring.  
**Technical Aspects**:  
- Streamlit + Python backend.  
- Image upload and camera input.  
- Optional QR/Barcode-based inventory tracking.  
  
4. **Edge Device Compatibility**  
**Solution Overview**: System deployable on low-cost devices like Raspberry Pi.  
**Innovation**: Enables rural/offline environments to benefit from freshness monitoring.  
**Technical Aspects**:  
- Edge-optimized AI model.  
- Camera module or USB webcam support.  
- Battery-powered operation.

### Implementation Strategy

1. **Dataset Collection & Model Training**  
- Collect and label fruit/vegetable images across freshness stages.  
- Train a CNN model enhanced with sensor data fusion.  
  
2. **Hardware Integration**- Connect DHT11 sensor to microcontroller.  
- Use Python to read, parse, and log environmental data.  
  
3. **App Development**- Build a Streamlit web interface.  
- Integrate AI model and sensor data visualization.  
  
4. **Real-World Testing**  
- Deploy in retail or home storage environments.  
- Compare predictions with actual spoilage outcomes.

### Challenges and Solutions

**Challenge**: Image Quality Variance  
**Solution**: Data augmentation and lighting normalization  
  
**Challenge**: Sensor Inaccuracy  
**Solution:** Calibration using multiple readings and statistical smoothing  
  
**Challenge**: User Interface Complexity  
**Solution**: Simplified UI with visuals and real-time alerts  
  
**Challenge:** Hardware Cost  
**Solution**: Use of affordable components like ESP32, DHT11, and webcams

### Expected Outcomes

1. Reduced Food Waste: Early detection reduces unnecessary disposal.  
2. Improved Quality Assurance: Enables informed decision-making in retail and supply chains.  
3. Accessible Monitoring: Empowers users across different economic sectors.  
4. Scalable Prototype: Adaptable for both household and commercial environments.

### Next Steps

1. Pilot Testing: Small-scale implementation in local shops or homes.  
2. Model Optimization: Improve accuracy using user feedback and real-world data.  
3. Deployment Expansion: Prepare modular kits for use in agricultural markets and cold chains.