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S H A P I N G   I N D I A ' S   T E C H S C A P E

Team Members Intro

Title	**Smart Vision + Robotics Challenge**		
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Team Members	1 (Leader)	2	3
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Date of Submission	19^{th} October, 2024		
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Executive Summary

1. **OCR-Based Expiry Date Detection**:
    a. **Objective**: Automate the detection and extraction of expiry dates from product labels.
    b. **Approach**:
        i. Used **YOLOv8n** for identifying the region of interest (ROI) containing the expiry date.
        ii. Applied **EasyOCR** to extract the expiry date text from the ROI.
    c. **Dataset**: **5,000** images of various product labels.
    d. **Hardware**: Training performed on Google Colab T4 GPU.
    e. **Outcome**: Streamlines the quality control process by automatically flagging expired products.

2. **Image Recognition and IR-Based Counting**:
    a. **Objective**: Perform real-time image recognition and object counting.
    b. **Approach**:
        i. Used **YOLOv8n** to identify regions of interest in product images.
        ii. Integrated **EasyOCR** to extract text (e.g., product names or serial numbers) from the identified regions.
        iii. For counting, employed an **IR sensor** and **ESP32** to detect and count objects in real-time.
    c. **Dataset**: **9,000** images used for training.
    d. **Hardware**: Trained on **Google Colab T4 GPU**.
    e. **Outcome**: Provides real-time recognition and counting, suitable for inventory and logistics applications.

3. **Freshness Detection of Produce**:
    a. **Objective**: Classify produce as fresh or rotten using image analysis.
    b. **Approach**:
        i. Implemented a **shallow neural network** for binary classification.
        ii. Used **binary cross-entropy** as the loss function and **sigmoid** for the final layer's activation, Hidden layers used **ReLU** activation.
    c. **Dataset**: Images of fresh and rotten bananas, apples, oranges, mangos, strawberries, potatoes, cucumbers, tomatoes, carrots, okra, and bell peppers.
    d. **Hardware**: Trained on **NVIDIA GeForce GTX 1650 MQ**.
    e. **Outcome**: Generates a **freshness index** in percentage form, improving inventory and supply chain management.

Technical Approach 1: OCR-Based Expiry Date Detection

1. **Object Detection with YOLOv8n**:
    a. **YOLOv8n** was employed for its efficiency in real-time object detection. It divides the input image into a grid, predicting bounding boxes and class probabilities in a single pass. YOLOv8n's ability to detect small, localized regions (such as expiry dates) on product labels made it ideal for this application.
    b. **Training Process**: The model was trained using a custom dataset of 5,000 images, annotated to mark regions where expiry dates are printed. The training process involved data augmentation techniques such as rotation, flipping, and brightness enhancement to improve model generalization.

2. **Text Extraction with EasyOCR**:
    a. After **YOLOv8n** detects the region containing the expiry date, the image is cropped and passed to **EasyOCR** for text extraction.
    b. **Post-Processing**: A regex pattern is applied to the extracted text to ensure it matches common expiry date formats (e.g., DD/MM/YYYY), providing structured data for further use.

Technical Approach 2: Image Recognition and IR-Based Counting

1. **Object Detection with YOLOv8n**:
   a. The YOLOv8n model was used to detect regions of interest (ROI) on product labels, such as product names and batch numbers. YOLOv8n was trained using a dataset of **5,000 images** with varying label orientations, sizes, and conditions to ensure robust object detection.
   b. **Data Augmentation**: Techniques such as flipping, scaling, and brightness adjustments were applied to the training data to improve the model's ability to generalize across different lighting conditions and product types.

2. **Text Extraction with EasyOCR**:
   a. Once YOLOv8n identifies the ROI, **EasyOCR** is used to extract text from the cropped regions. The text extracted typically includes product details such as names, serial numbers, and batch codes.
   b. **Post-Processing**: OCR results are refined using string matching algorithms to correct for minor errors in text extraction, ensuring accurate product identification.

3. **IR-Based Object Counting**:
   a. **IR Sensor**: An infrared sensor was used to detect objects passing through a conveyor system. This sensor triggers the counting mechanism, ensuring that the system can accurately track the number of items in real time.
   b. **ESP32 Microcontroller**: The **ESP32** was employed to process the signals from the IR sensor and maintain an accurate count of the detected objects. It also ensures the data is synchronized with the image recognition system.

Technical Approach 3: Freshness Detection of Produce

1. **Shallow Neural Networks for Binary Classification**:
   a. We developed a shallow neural network for **binary classification** (fresh/rotten) using **ReLU** activations for hidden layers and **sigmoid activation** for the output layer. The model is designed to classify whether a piece of produce is fresh or rotten based on visual cues.
   b. **Loss Function**: We used **binary cross-entropy** as the loss function to calculate the error between the predicted and actual class labels.
2. **Data Augmentation and Training**:
   a. The dataset included images of 11 types of fruits and vegetables. Various augmentation techniques (such as rotation, flipping, and contrast adjustments) were applied to improve model generalization.
   b. **Training Environment**: The model was trained on an **NVIDIA GeForce GTX 1650 MQ**, ensuring efficient processing and high-speed training.

Limitations

- **Lack of Product Catalogue**:
  - The current system extracts expiry dates but cannot associate them with specific brands or products due to the absence of a comprehensive product catalogue.
- **Logo Detection**:
  - The system relies on text within the logo for brand identification. If a brand's logo contains no text, it can be detected but cannot be identified by the current model,
- **IR Sensor Constraints**:
  - The IR sensor may not accurately detect objects that are moving too quickly or those with irregular shapes. Additionally, its counting accuracy decreases with overlapping objects.
- **Dependence on Image of produce Alone**:
  - The system currently relies solely on visual cues from images to detect freshness. It does not take into account other critical factors, such as **temperature**, **humidity**, or **storage conditions**, which can also significantly affect the freshness of produce.

Future Scope:

- **Integration of Logo Recognition**:
  - To overcome the limitation of text-based logos, the system could be enhanced to detect non-textual logos using image recognition techniques, enabling brand identification from logos without text.
- **Catalogue Integration and Fuzzy Matching**:
  - In future versions, we aim to integrate a comprehensive product catalogue. Extracted text can be mapped to the catalogue using **fuzzy matching algorithms** or **approximate string matching** to account for OCR inaccuracies, ensuring accurate brand and product identification.
- **Integration with IoT Sensors**:
  - The freshness detection model could be combined with IoT-based sensors (e.g., for temperature and humidity monitoring) to provide a more accurate assessment of produce freshness, improving the decision-making process for inventory and quality control.
- **Dataset Expansion**:
  - A larger and more diverse dataset would improve the model’s robustness. Incorporating more images across different packaging styles, fonts, and expiry formats will enhance the system’s ability to generalize.

Use Cases Completed

S. No.	Use Case	Weightage
1.	Using OCR to get expiry date details	10%
2.	Image recognition and IR based counting	30%
3.	Detecting freshness of fresh produce	40%

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