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Fruit recognition and classification based on image processing and raspberry pi

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ABSTRACT :

Accurate classification of fruit maturity is crucial for small-scale farmers, as it directly impacts market value and post-harvest quality. Traditionally, farmers rely on manual evaluation through visual observation, a repetitive and error-prone process. According to FAMA, six maturity indexes are used to assess fruit ripeness.

This study presents an automated system for identifying the maturity of mangoes using image processing techniques. A Raspberry Pi, a compact yet powerful computing device, is employed to execute the image processing algorithm. The system analyzes fruit size and applies K-means clustering to classify mango color, enabling a more consistent and efficient maturity assessment. By reducing human error and streamlining the classification process, this approach offers a practical solution for small-scale farmers seeking improved accuracy in fruit maturity evaluation.

Keywords: Raspberry Pi, Leverages, Computer vision, Machine Learning.

I. INTRODUCTION

Indian farmers have access to a diverse range of crops. There are numerous environmental infections that have a negative impact on crops and the soil where fruit is grown, reducing crop productivity. A number of diseases are visible through the leaves of fruits and crops. The disease is easy to spot due to the fruit's colourful patterns and dots. The previous method of identifying fruit diseases relied on direct eye observation while keeping in mind the distinct group of diseases based on climate, season, and so on. These methods were both time-consuming and inaccurate. Nowadays, diagnosing fruit 978-1-6654-5499-5/22/$31.00 ©2022 IEEE Kolkata, India. neerajrjd@gmail.com Niraj Kumar Div. of Research and Inno., Uttaranchal University, Dehradun, Uttarkhand, India nirajunisci2k@gmail.com illnesses entails a variety of lab tests, competent personnel, well-stocked labs, and so on. These items are difficult to obtain, particularly in remote locations. The technique I've presented allows for the automatic identification of cultures. In general, the leaves of a diseased fruit serve as the fruit's primary indicator of disease. The disease-related dots on the leaves are usually visible. However, if the fruit is infected with a lot of diseases, it will have disease spots all over it [1]–[3]. Insects in their larval stage are classified as "fruit miners." They feed on the upper and lower parts of the fruit. Because of the large number of insects present in the fruits, they are severely harmed. On a single apple, maggots can number up to six. As a result, it has the potential to seriously harm the fruit. It has the potential to limit fruit growth, resulting in lower yields. Image processing is used to detect fruit freshness and illness by changing the colour, texture, and shape of the fruit. Fruit quality can be improved by controlling the image processing quality [4], [5].

II. Flow Chart

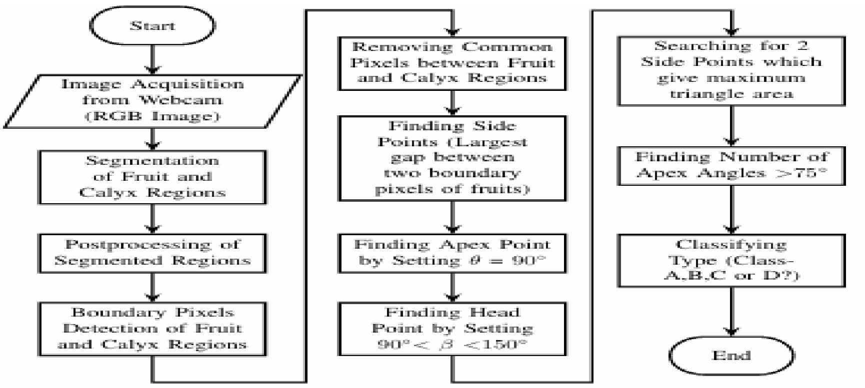

Fig 1. Flow Chart of Proposed Algorithm

III. LITERATURE SURVEY

1. Automated vegetables monitoring system by et al Dr. Nita M. Thakare, S. S. Kale, G. S. Lakhotiya, J. P. Gahukar, A. Y. Kawade, V. K. Thakre - focused on using IoT and computer vision to automate vegetable monitoring, helping to reduce human error in classification and sorting.
2. Deep Residual Learning for Image Recognition by et al Kaiming He, Xiangyu Zhang, Shaoqing Ren, Jian Sun Introduced ResNet - introduced deep learning model that mitigates vanishing gradients in deep CNNs, significantly improving image classification accuracy.
3. Background Prior-Based Salient Object Detection via Deep Reconstruction Residual by et al J. Han, D. Zhang, X. Hu, L. Guo, J. Ren, F. Wu -Proposed a deep residual network for detecting salient objects using background priors and reconstruction errors, improving detection robustness.
4. Automatic Fruit Grading and Classification System Using Computer Vision by et al Seema, A. Kumar, G. S. Gill – Reviewed various fruit classification techniques using computer vision, highlighting challenges such as varying shapes, textures, and lighting conditions.
5. Review of Fruit Grading Systems for Quality Inspection by et al R. S. Lakshmi, B. Kanchanadevi – conducted a survey of various fruit grading systems, focusing on manual vs automated methods, and emphasizing the need for vision-based, real-time systems.
6. Representation and Preprocessing Techniques for Illumination Invariant 3D Face Recognition by et al N. M. Thakare, V. M. Thakare – Discussed preprocessing techniques to improve recognition under varying lighting, relevant to real-time image classification in embedded vision systems.

IV. METHODOLOGY

Automated Fruit Detection System Objective

1. Automated Fruit Identification
   - Develop a system that can automatically detect and classify various fruit types with high accuracy.
   - Reduce manual sorting efforts and enhance operational efficiency.
2. Quality Evaluation
   - Implement a mechanism to assess fruit quality by distinguishing between ripe, unripe, and damaged fruits.
   - Ensure that only premium-quality fruits are selected for distribution.
3. Quantity Estimation
   - Provide real-time fruit count for inventory tracking and yield forecasting.
   - Assist farmers and distributors in managing stock efficiently.
4. Real-time Monitoring
   - Enable continuous tracking of fruit detection and quality assessment.
   - Support large-scale agricultural operations with instant data insights.

Proposed Methodology

Hardware Setup

1. Raspberry Pi as the Processing Unit
   - Acts as the core computing device for image analysis and machine learning.
   - Affordable, compact, and capable of handling real-time processing.
   - Facilitates seamless integration with cameras and sensors for efficient fruit detection.
2. Camera Module for Image Capture
   - High-resolution imaging ensures clear and detailed fruit identification.
   - Compact design allows flexible placement for optimal image acquisition.
   - Energy-efficient operation supports continuous monitoring in resource-limited environments.
   - Adjustable settings (focus, exposure, white balance) enhance adaptability to different lighting conditions.
3. Real-time Imaging and Processing
   - Enables instant fruit detection and classification.
   - Supports live streaming for immediate decision-making in sorting and grading.
4. Hardware Integration

- Connect and synchronize Raspberry Pi, cameras, lighting systems, sensors, and conveyor belts.
- Ensure smooth data flow between components for efficient operation.

Software Implementation

1. Image Processing & Machine Learning
   - Develop algorithms to extract features from fruit images.
   - Train models to classify fruits based on color, texture, and shape.
   - Implement deep learning techniques for enhanced accuracy.
2. User Interface Development
   - Create an intuitive dashboard for monitoring fruit detection results.
   - Provide mobile and web-based access for remote tracking.
3. Conveyor System Integration
   - Automate fruit movement using conveyor belts.
   - Utilize sensors to regulate speed and direction for optimized processing.

Testing & Calibration

1. Dataset Preparation
   - Collect diverse fruit images for model training.
   - Ensure balanced representation of different fruit types and quality levels.
2. Model Training & Validation
   - Train the system using labeled datasets to improve classification accuracy.
   - Validate performance using unseen data to prevent overfitting.
3. System Optimization
   - Fine-tune hardware and software components for maximum efficiency.
   - Adjust lighting, camera angles, and processing parameters to enhance detection accuracy.

Maintenance & Upkeep

1. Hardware Maintenance
   - Regularly inspect and clean cameras, sensors, and conveyor belts.
   - Ensure Raspberry Pi and other components function optimally.
2. Software Updates
   - Continuously improve detection algorithms for better accuracy.
   - Update the user interface for enhanced usability.

IV. RESULTS AND ANALYSIS

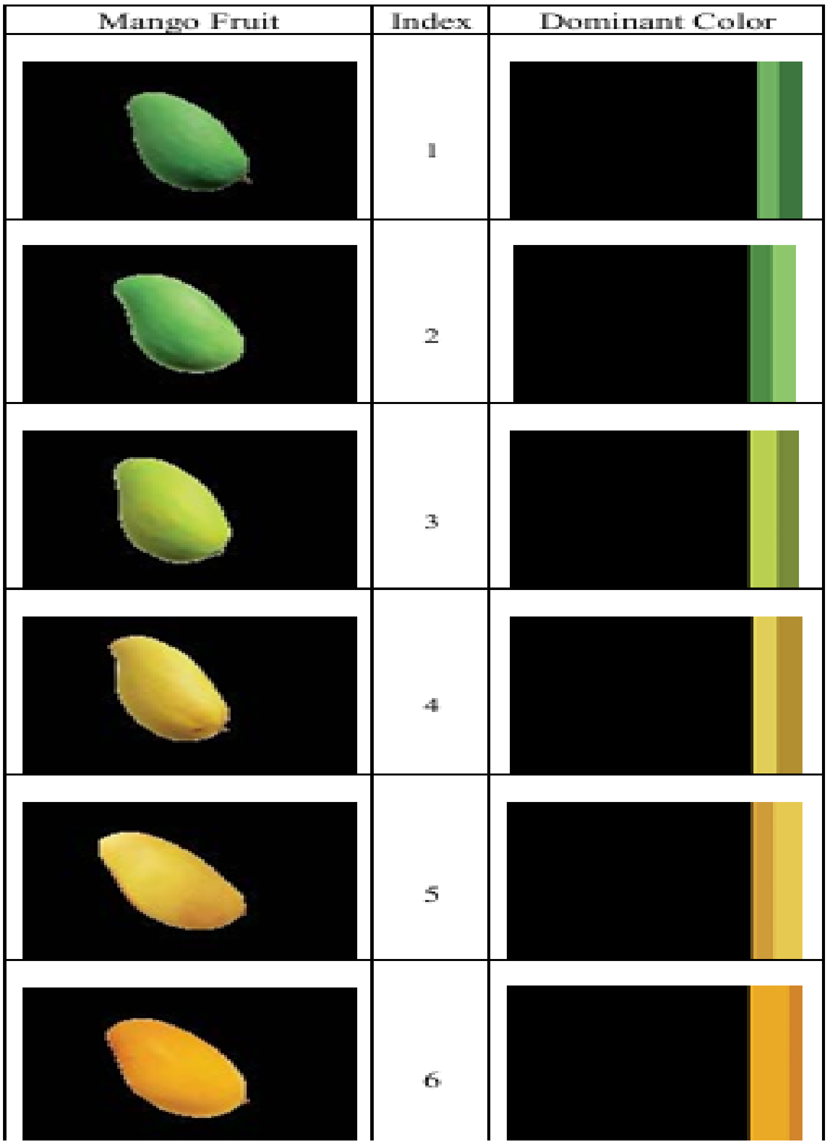

Figure 2 : The three most dominant color of the for each of the mango.

A Raspberry Pi system is used to analyze mango maturity levels by processing images displayed on a laptop monitor via an Ethernet connection, utilizing the TightVNCViewer application. Mango images with varying maturity stages are sourced from FAMA-related websites and articles.

To determine mango maturity, k-means clustering is employed to identify the dominant color in each image. Each maturity index corresponds to a specific dominant color, which serves as a reference for comparison. The background is represented in black, while the foreground highlights the fruit itself.

A reference mango image is compared against the dataset using a color histogram, which helps match the closest maturity index. If the reference mango belongs to the same dataset, its similarity value is 0.00. A similarity score below 0.40 indicates a close match, while values above or equal to 0.40 suggest a significant difference from the reference mango, regardless of color sorting.

V. CONCLUSION

Enhancing fruit categorization with advanced Raspberry Pi models significantly boosts image processing speed and accuracy. This improvement plays a crucial role in detecting fruit freshness and identifying diseases early, leading to increased farm productivity. By automating the assessment of fruit quality, this approach ensures that only fresh and healthy produce reaches consumers, reducing waste and improving food safety. The integration of such technology in agriculture streamlines operations and supports sustainable farming practices.

VI. REFERENCES :

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