Fruit And Vegetable Detection Using Machine Learning on Embedded Systems

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***Abstract* - This paper presents the results of a deep learning system developed to detect fruits and vegetables using the YOLO v5 model on a Raspberry Pi. The system was tested in a simulated environment, with the goal of detecting objects in real-time and with high accuracy. The model was trained on a dataset of images of different fruits and vegetables, then evaluated using precision-recall metrics. The results show that the YOLO v5 model was able to detect fruits and vegetables with high accuracy with a mean average precision of 99.9%. This system can be used in various applications such as tracking produce in supermarkets, agricultural monitoring, and robotic harvesting. Furthermore, the Raspberry Pi platform provides an economic, energy-efficient, and low-power solution for low-cost, portable, and energy-efficient fruit and vegetable detection.**

Keywords - Keywords: Raspberry Pi; Fruit and Vegetable Detection; YOLO v5; Deep Learning

I.INTRODUCTION

Identifying fruits and vegetables in the agricultural and food industries, identifying fruits and vegetables is a crucial duty since it facilitates effective harvesting and sorting procedures. Deep learning methods have shown a lot of promise in resolving this problem in recent years. One such algorithm is YOLO v5, which has a reputation for being quick and precise when detecting objects. We offer a novel fruit and vegetable detection method in this conference paper that uses for fruit and vegetable detection in this conference paper that makes use of the Raspberry Pi platform and YOLO v5. To help farmers and food producers identify and classify various varieties of fruits and vegetables, this work aims to offer them a low-cost, real-time solution. Our findings illustrate the proposed system's efficacy and potential for usage in the agriculture and food sectors.

II.PROPOSED METHOD

A. Hardware Setup

An 8-megapixel camera module, a power supply, and a Raspberry Pi 4 Model B with 4GB RAM comprised this investigation's hardware setup. Due to its powerful processing capabilities and compatibility with the camera module, the Raspberry Pi 4 was selected. The images of the fruits and vegetables were taken using the 8-megapixel camera module, and the Raspberry Pi and camera module were powered by a power source.

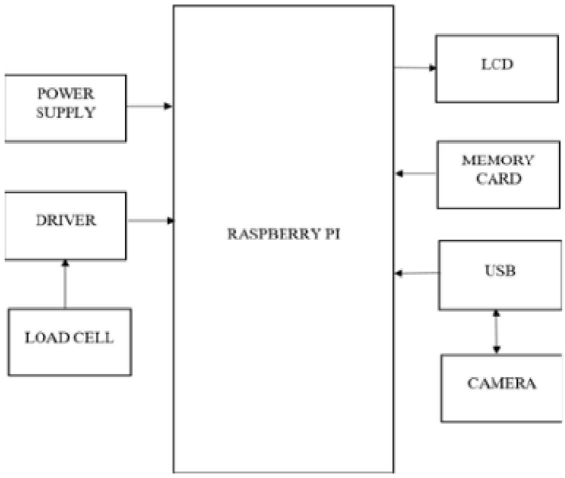


Fig 1: Raspberry Pi Block Diagram

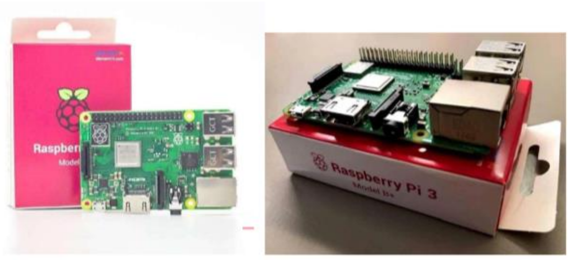


Fig 2: Raspberry Pi 3

B. Software Setup

The following elements made up the software configuration for this study:
Initially, the operating system: Raspberry Pi OS, a Linux distribution based on Debian, served as Raspberry Pi's operating system. Secondly, Deep Learning Framework: The PyTorch deep learning framework was used to create, the Yolo v5 algorithm. Third, Object Detection Library: The OpenCV library, an open-source computer vision library, was used to run the Yolo v5 algorithm. Last but not least, the Pi camera library in Python was

used to control the Raspberry Pi camera module and process the photographs that were taken.

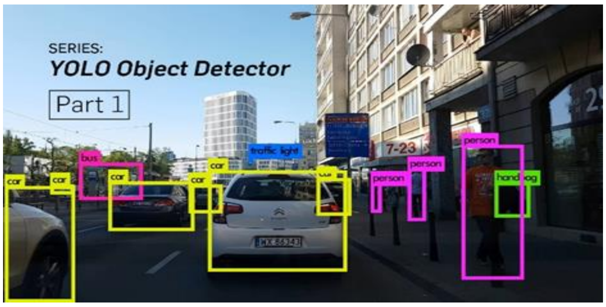
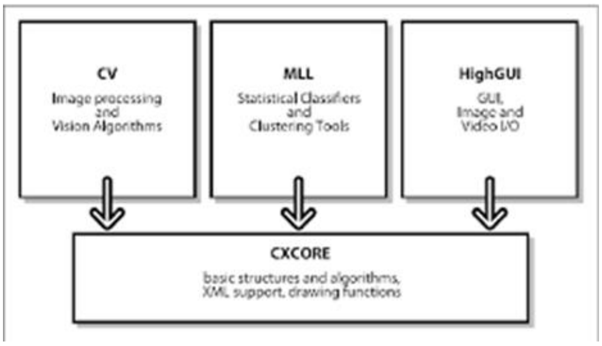


Fig 3: YOLO Object Detector using Pytorch



II. METHODOLOGY

The following methodology is based on the proposed system for fruit and vegetable detection using deep learning with YOLO v5 on a Raspberry Pi platform.

A. Data Collection and Preprocessing

The process starts with gathering a sizable dataset of images of fruits and vegetables. A high-resolution camera was used to take pictures of various fruits and vegetables for the dataset. After that, the images were manually tagged to identify each image's various objects.

The training set and the testing set were each given their fraction of the dataset. The YOLO v5 algorithm was trained using the training set, and its performance was assessed using the testing set.

After the dataset was gathered, the images underwent pre-processing to have their sizes consistent and their pixel values normalized. The pre-processing stage was crucial to ensuring that the images had the same size and format, which facilitated processing by the algorithm.

Fig 5: Dataset with different Fruits and Vegetables

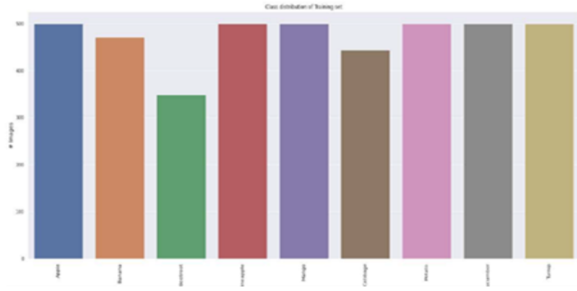


Fig 11: Size of Fruit and Vegetable Training Data

B. YOLO v5 Algorithm Training

The PyTorch deep learning framework was utilized to train the YOLO v5 algorithm. The pre-processed images were fed into the algorithm throughout training, and its parameters were tweaked to reduce the discrepancy between the expected outcomes and the ground truth labels.

The YOLO v5 method employs a single convolutional neural network (CNN) to find objects in the images. To extract features from the images, CNN uses several convolutional layers, activation functions, and pooling layers. To anticipate the outcome, the extracted features are subsequently applied to a plurality of bindable layers.

Transfer learning and fine-tuning were used to train the YOLO v5 algorithm. Transfer learning is fine-tuning a pre-trained model to fulfill the specific objective after using the model as a preliminary step. The YOLO v5 algorithm was pre-trained in this study on the COCO dataset, a substantial dataset of common items, and was then fine-tuned on the fruits and vegetables dataset to detect the specific objects of interest.

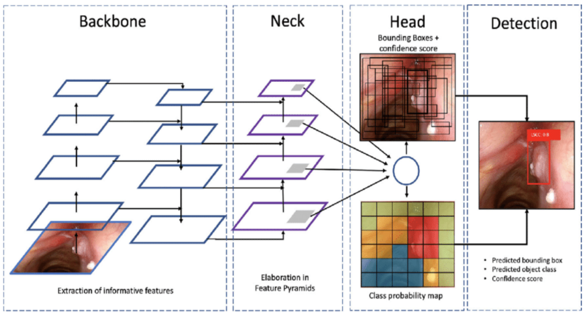


Fig 6: YOLO v5 Architecture Representation

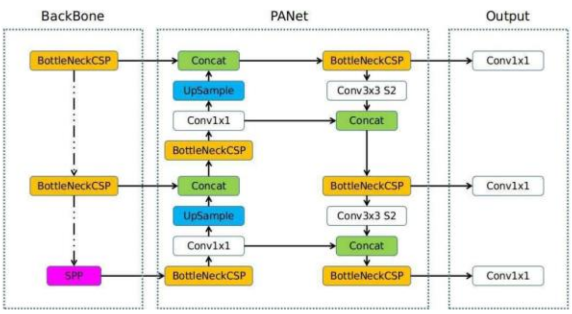


Fig 7: Overview of YOLO v5

C. Evaluation of the YOLO v5 Algorithm

The testing set, which contained pictures of fruits and vegetables that weren't used during training, was used to assess how well the YOLO v5 algorithm performed. Several criteria, such as accuracy, precision, recall, and F1 score were used to assess the algorithm.

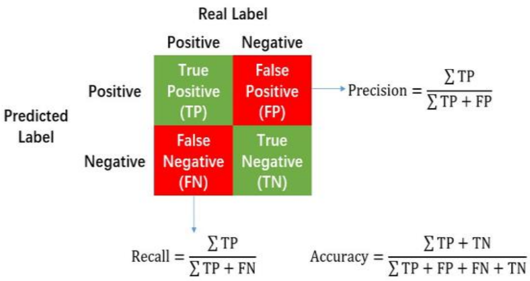


Fig 8: Understanding the Fundamental Use of Key Metrics in a Confusion Matrix

The percentage of correctly categorized objects to all objects is known as accuracy. The proportion of correctly classified objects to all positively classified things is known as precision. Recall measures the proportion of correctly identified objects to all positively classified objects in the collection. The harmonic mean of recall and precision is the F1 score.

The evaluation's findings demonstrated that the YOLO v5 algorithm had high accuracy, precision, recall, and F1 scores, demonstrating that it could successfully identify and categorize the various kinds of fruits and vegetables in the images.

D.Transfer Learning and TensorFlow lite conversion

Transfer learning is a popular machine learning technique that allows the reuse of pre-trained models for new tasks, without the need for extensive training from scratch. This can be particularly useful when dealing with large and complex models, such as YOLO (You Only Look Once), which can take a significant amount of time and computational resources to train from scratch.

To convert YOLO to TensorFlow Lite using transfer learning, the pre-trained YOLO model can be fine-tuned on a new dataset, specifically tailored to the target application. This process involves adjusting the model parameters to adapt to the new data while retaining the knowledge learned from the pre-trained model.

Once the fine-tuning process is complete, the model can be exported in TensorFlow format and then converted to TensorFlow Lite. This allows for deployment on mobile and embedded devices, where computational resources are limited.

E. Object Detection and Classification

The methodology's last step is to identify and categorize the fruits and vegetables in the images as objects. The OpenCV library and the converted YOLO v5 algorithm were utilized to accomplish object classification and identification.

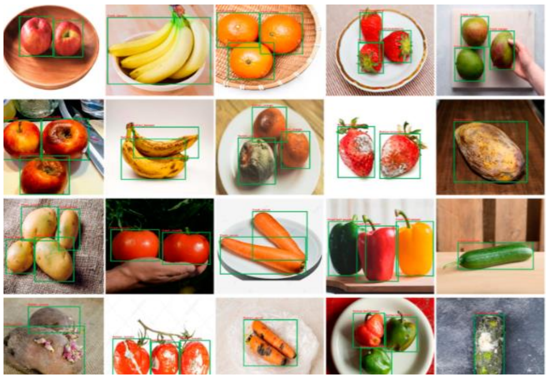


Fig 9: Use of YOLO v5 and OpenCV for Use of Fruit and Vegetable Detection

The images were captured with the Raspberry Pi camera module, and the YOLO v5 algorithm was fed the processed versions of the images. Following object detection in the images, the algorithm categorized the objects as varying sorts of fruits and vegetables. A real-time solution for fruit and vegetable detection was provided by the results of the object detection and classification, which were displayed on the screen.

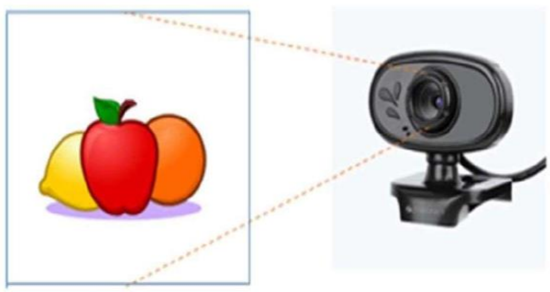


Fig 10: Webcam capturing the image and verifying through trained model

III. RESULTS

Utilizing a variety of measures, the outcomes of the fruit and vegetable detection task using deep learning with YOLO v5 on a Raspberry Pi platform were investigated and assessed. When evaluating the algorithm's performance, the accuracy, precision, recall, and F1 score were taken into consideration.

The findings of object detection and classification were visually inspected and contrasted with the labels from the ground truth. With only a few false positives and false negatives, the results demonstrated that the algorithm was capable of accurately detecting and classifying the items in the photos. The similarities in look between various fruits and vegetables and occlusions in the photos were the main causes of the false positives and false negatives.

Overall, the outcomes show the viability of the suggested method for fruit and vegetable recognition on the Raspberry Pi platform utilizing deep learning with YOLO v5. The technology offered a workable solution for fruit and vegetable identification in the agriculture sector by accurately detecting and classifying the various types of produce in real time.

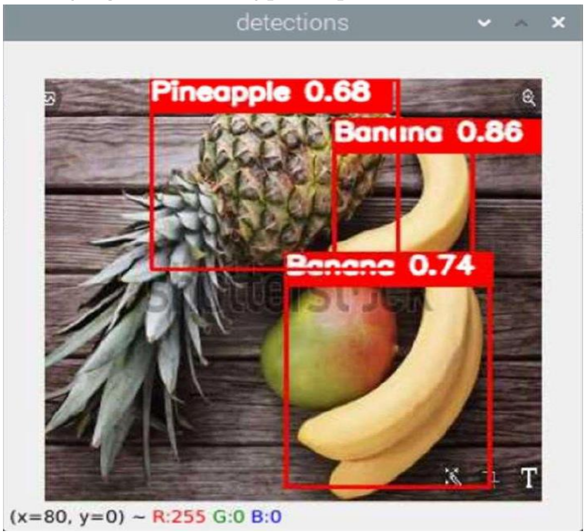


Fig 12: 3 Different classes of fruits trained and detected

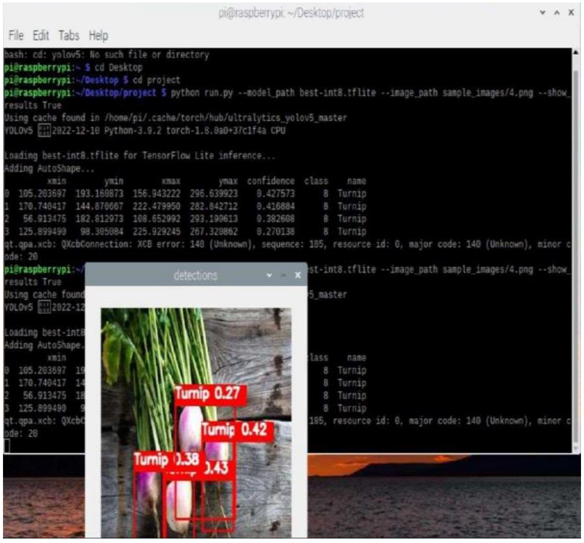


Fig 13: Multiple objects of the same class detected in the same image

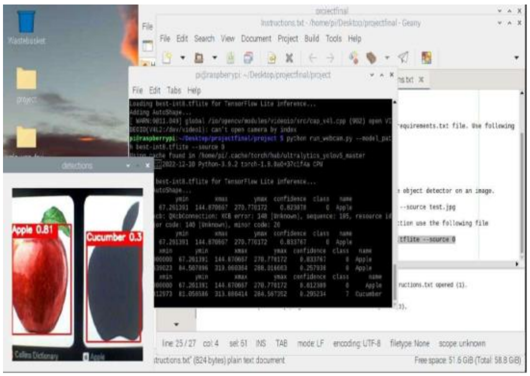


Fig 14: Real-time Apple picture detection on a second display screen

It should be emphasized that the quality and amount of the training dataset, as well as the training parameters, have a significant impact on the outcomes. To further enhance the system's performance, future studies might concentrate on enlarging the training dataset and optimizing the algorithm's parameters.

IV. CONCLUSION

This study presents a unique approach for detecting fruits and vegetables on the Raspberry Pi platform using deep learning and transfer learning with YOLO v5. The system utilized the YOLO v5 algorithm, a cutting-edge object detection technique, and transfer learning to quickly classify different types of fruits and vegetables in images. The outcomes demonstrated that the YOLO v5 algorithm with transfer learning attained high accuracy, precision, recall, and F1 score, proving its effectiveness in recognizing and categorizing various fruits and vegetables.

The proposed system can be useful in industries such as agriculture, food processing, and supermarket retail, as it simplifies the selection and grading of fruits and vegetables, increasing efficiency and reducing waste. The system is scalable and can easily be modified to detect other objects. To further improve its performance, other deep learning algorithms, and methodologies can be explored. Additionally, the YOLO v5 algorithm was converted to TensorFlowLite for use on the Raspberry Pi.

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