NutSure: Nut Detection and Classification Using YOLOv8

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BSCS - 3A

Objectives

1. **Develop an AI-based nut classification system:** Utilize YOLOv8 and convolutional neural networks (CNN) to accurately classify five unshelled nut types (peanut, almond, walnut, cashew, pistachio), overcoming limitations of traditional methods by improving efficiency, consistency, and quality in the food and agriculture industries.

2. **Automate the nut classification process:** Design a scalable, reliable solution capable of analyzing and classifying nuts under various conditions, using preprocessed datasets, advanced machine learning techniques, and real-time implementation potential.

Methodology

Data Collection

- The dataset for NutSure was sourced from two main platforms: Kaggle and Google.
- Kaggle provided **1,000 standalone unshelled nut images** across five classes: almond, cashew, peanut, pistachio, and walnut, with 200 images per class.
- Additionally, **250 clustered unshelled nut images** (50 per class) were manually gathered from Google to finetune the dataset.

Data Pre-processing

1. **Renaming Images:** The **Kaggle dataset was pre-labeled,** while the **Google images required manual labeling**.
    - A **Python script** was developed to automate the renaming process for consistent organization.

Methodology

Data Pre-processing

2. **Data Annotation**: All **1,250 images were annotated using the Python tool labelImg.**
   - Each unshelled nut in the images was bound with bounding boxes and labeled with its corresponding class.
   - This step generated .txt files for each image, containing class numbers and bounding box coordinates, crucial for the machine learning process.

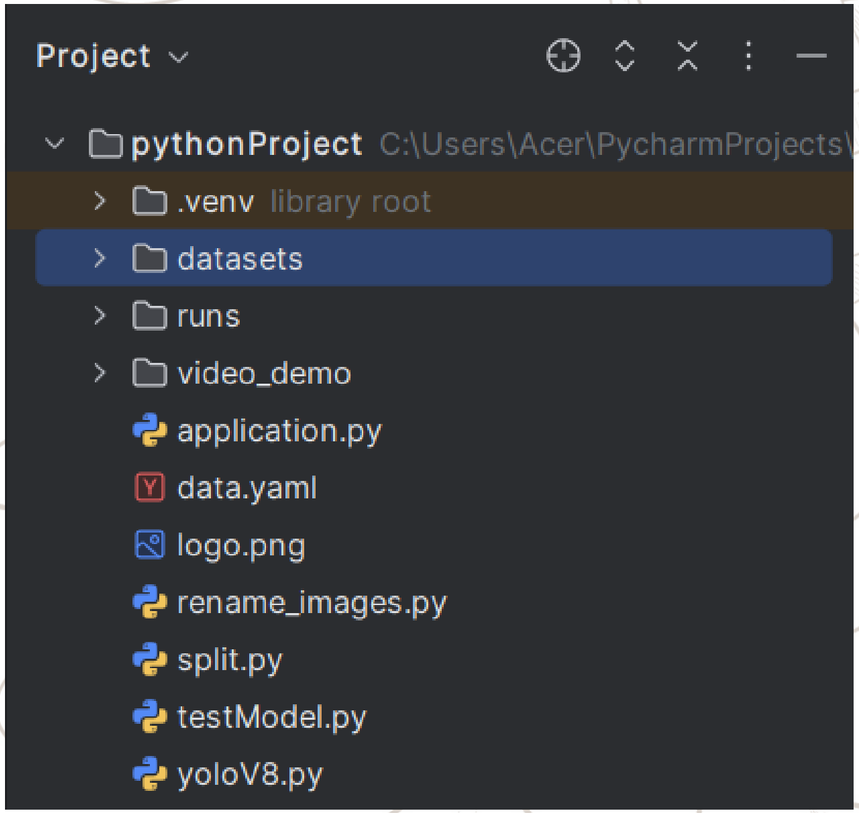
3. **Dataset Splitting:** The dataset was **divided into training (60%), validation (20%), and test (20%) sets**.
   - The Kaggle dataset contributed 600 training images, 200 validation images, and 200 test images.
   - The Google dataset added 150 training images, 50 validation images, and 50 test images, ensuring a balanced distribution for model evaluation.

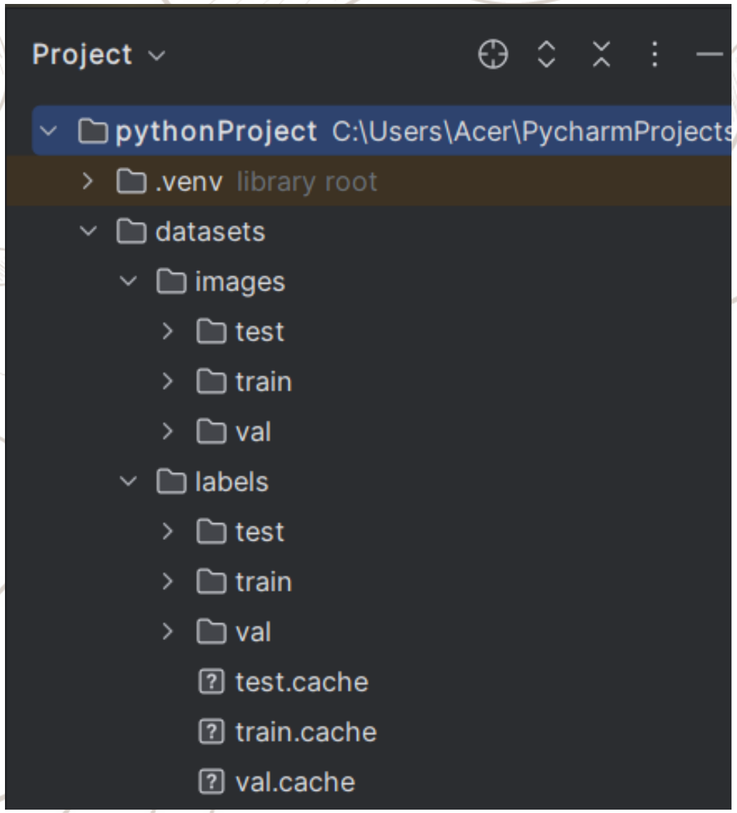
Methodology

Model Training

- The NutSure model was trained **using the YOLOv8** framework in **PyCharm**. YOLOv8 was selected for its **efficiency in object detection** and image classification tasks.
- Initially, the model was trained on the Kaggle dataset, achieving high accuracy for standalone nut images. However, performance issues arose when tested on clustered nut images.
- To address this, the dataset was augmented with the annotated Google images, and the previous model was retrained using the new images. The final model demonstrated improved accuracy and generalization across various conditions.

Methodology

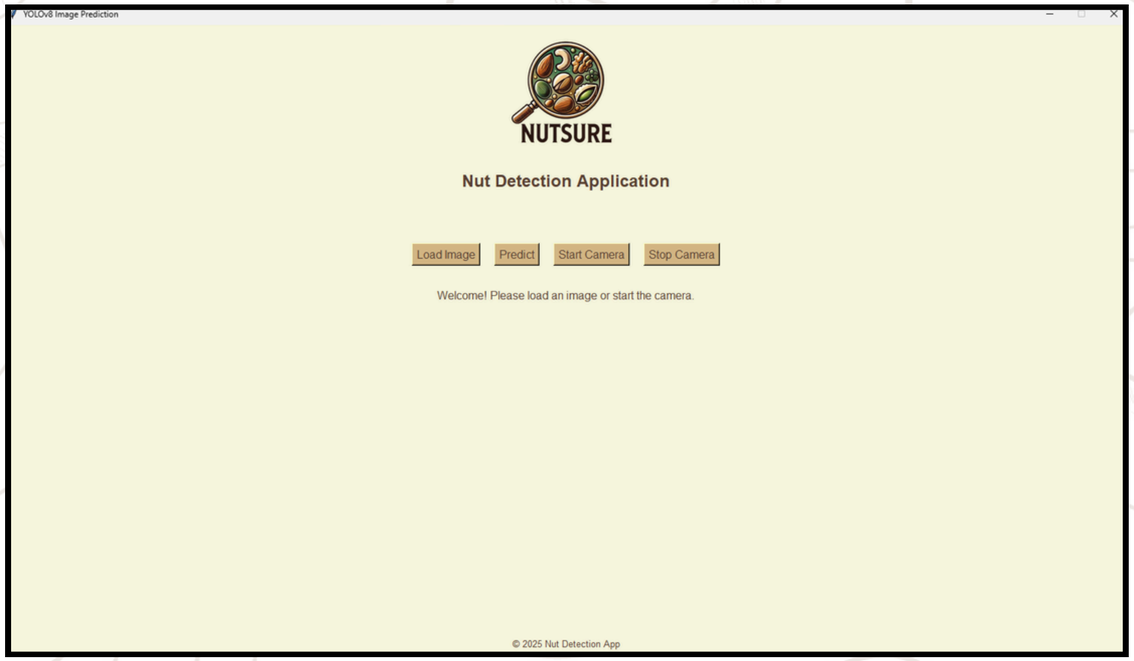




Methodology

Application development

The NutSure application was developed using **Python**, using **OpenCV** for real-time image processing, and **TKinter** for creating the graphical user interface (GUI). The application provides an intuitive interface for users, enabling seamless interaction with the detection and classification features.



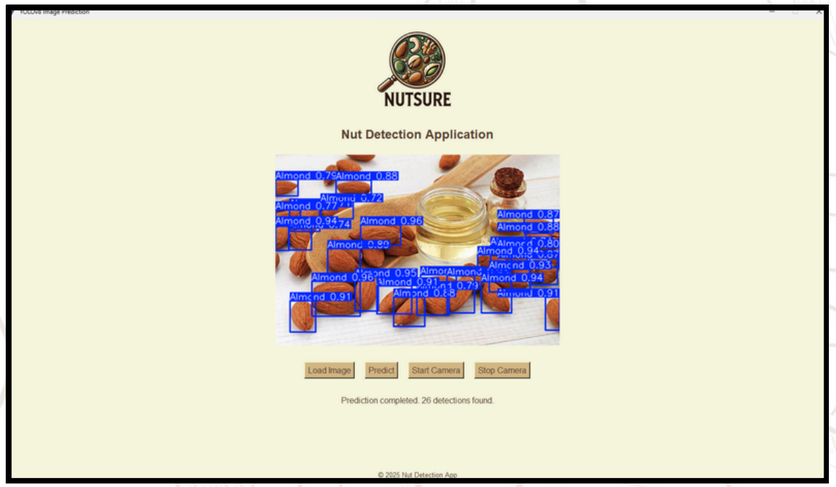
Methodology

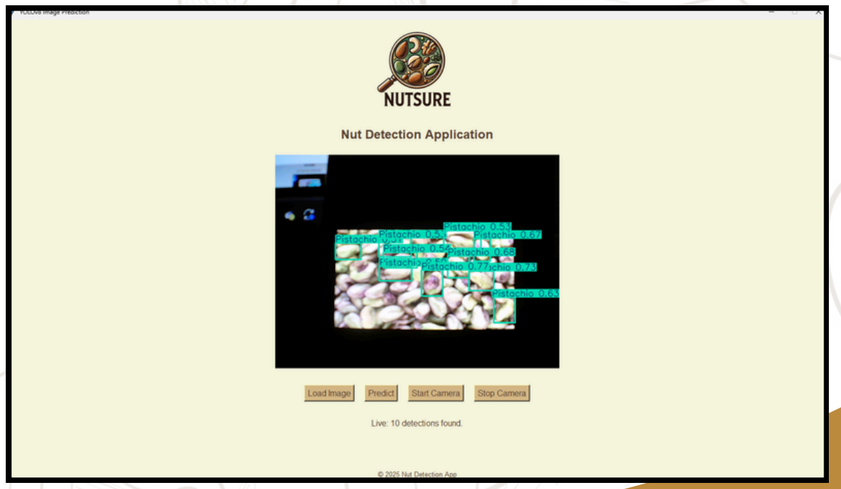
Model Implementation

The NutSure application offers two core functionalities:

1. **Load Image:** Users can upload an image from their device. The application processes the image, detects unshelled nuts, and classifies them into their respective categories.
2. **Real-Time Detection:** Using the webcam, the application detects and classifies unshelled nuts in real-time, providing a dynamic and interactive demonstration of the model's capabilities.

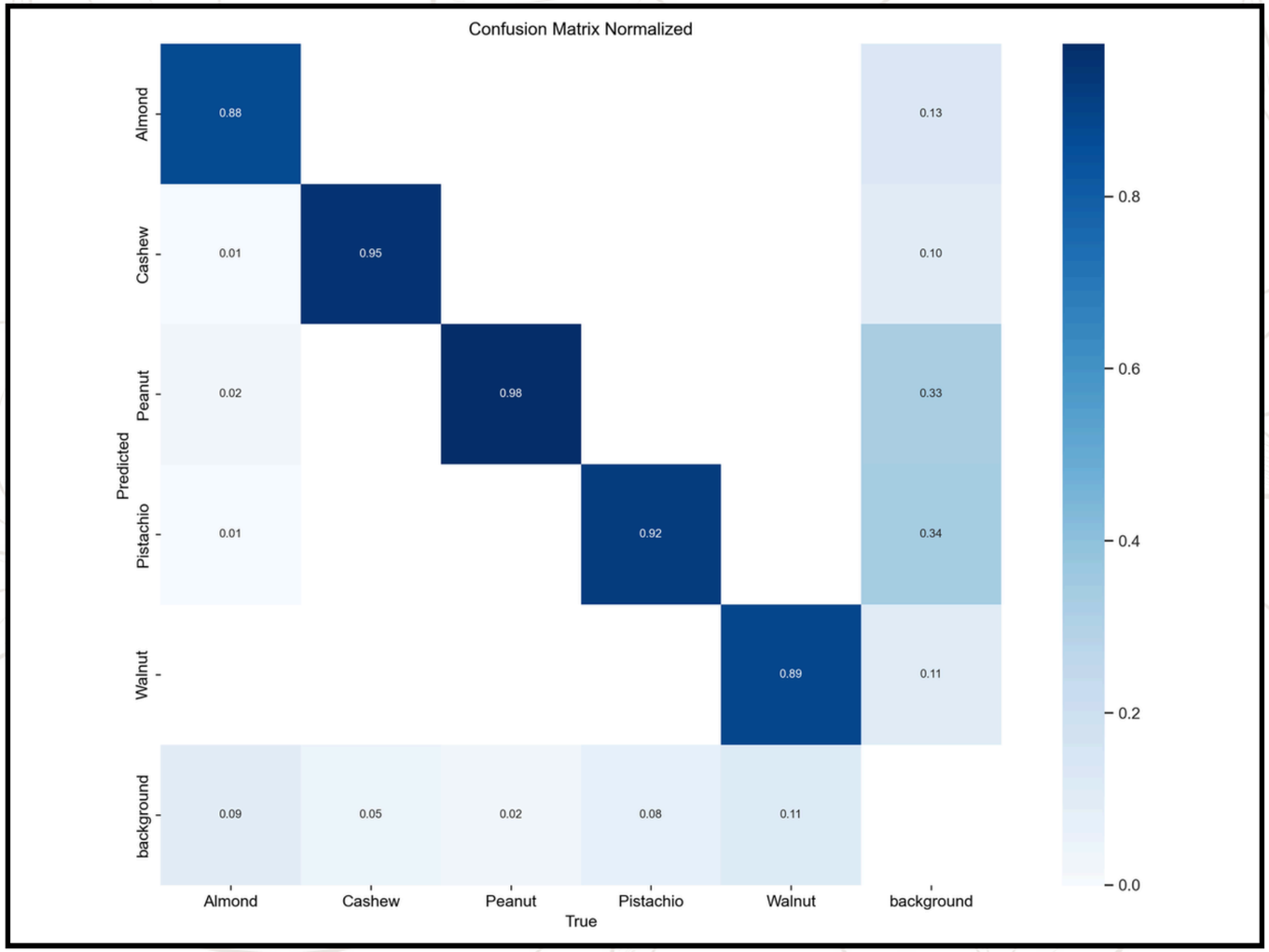
The NutSure application combines the trained YOLOv8 model with an accessible interface, making it a practical tool for nut classification tasks in real-world scenarios.





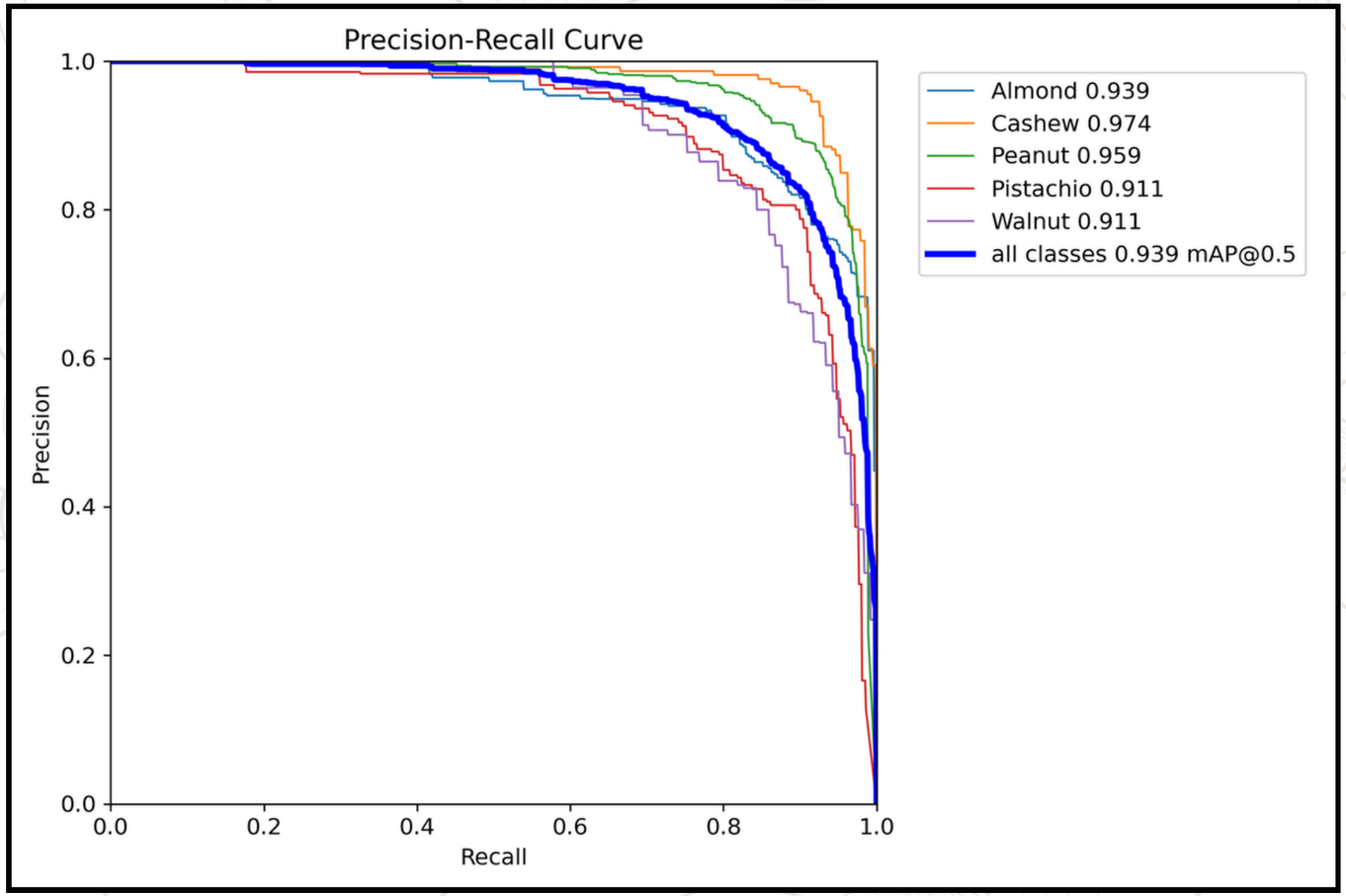
Result

- **Model Accuracy:** Achieved an overall accuracy of **92.1%** on the combined Kaggle and Google dataset.
- The model performs well in classifying Cashew, Peanut, and Walnut, with high accuracy for these classes.
- There are notable misclassifications for Almond and Pistachio, which are often confused with the background.
- The background class occasionally gets misclassified as certain nuts.



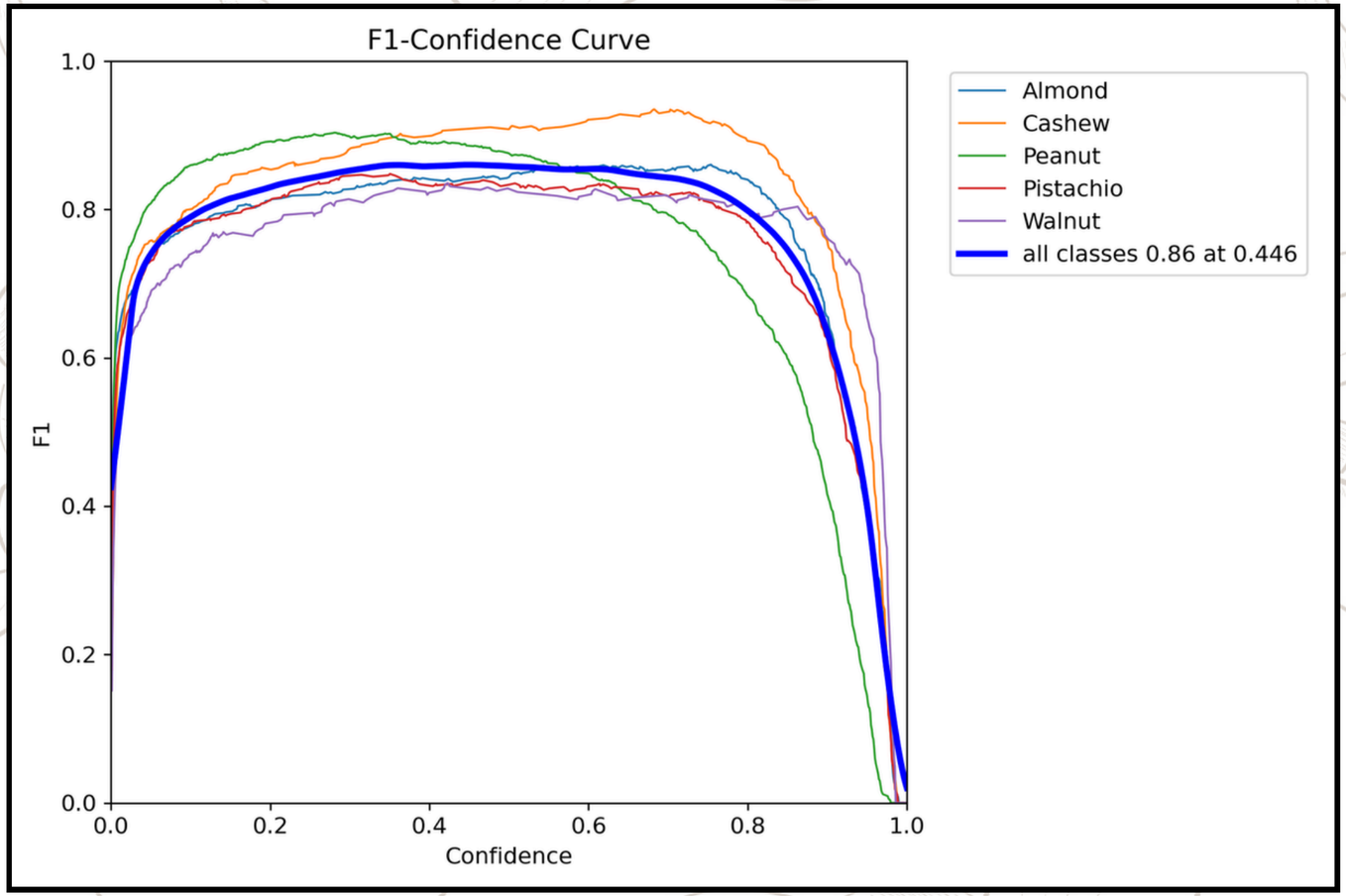
Result

- The model attained a mean Average Precision (mAP@0.5) of **93.9%**, with Cashew performing the best at **97.4%** mAP, followed by Peanut (**95.9%**), while Pistachio (**91.1%**) and Walnut (**88.2%**) were slightly lower.



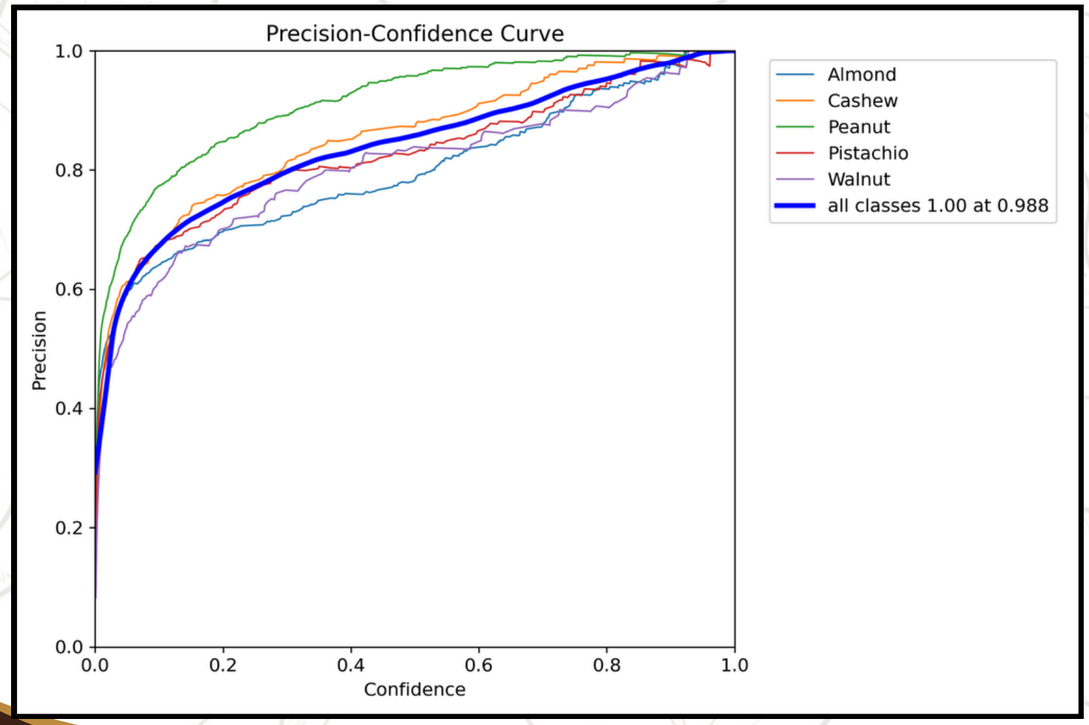
Result

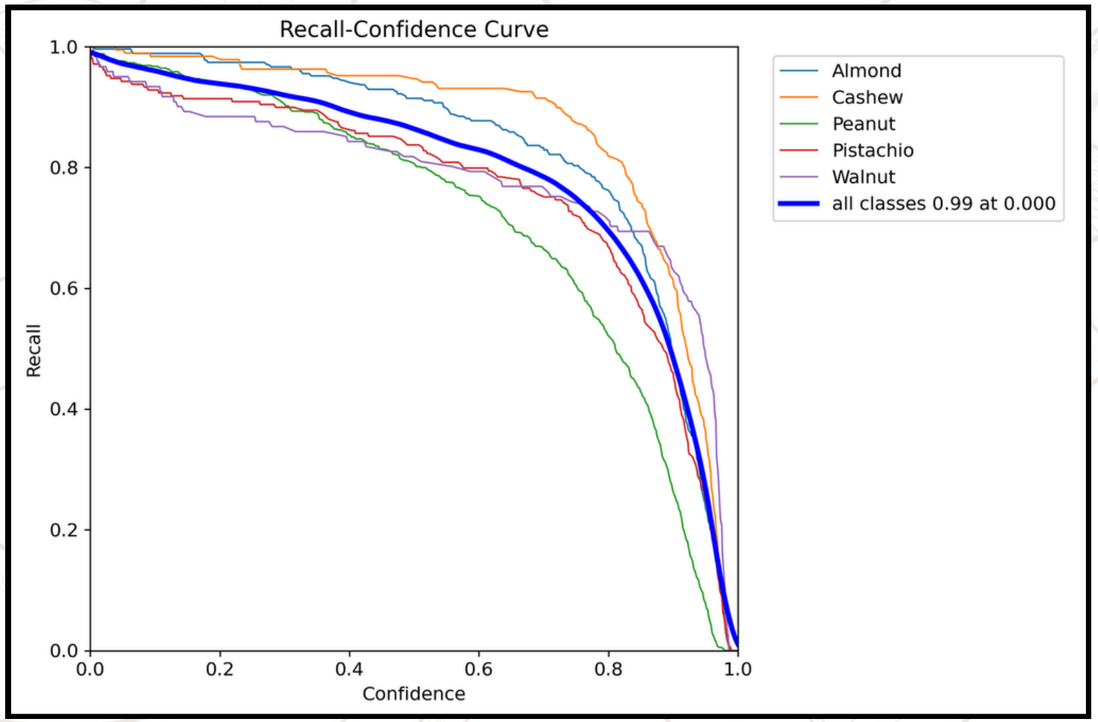
- The highest F1 score was **86%** at a confidence threshold of **44.6%**, showing a good balance between precision and recall.

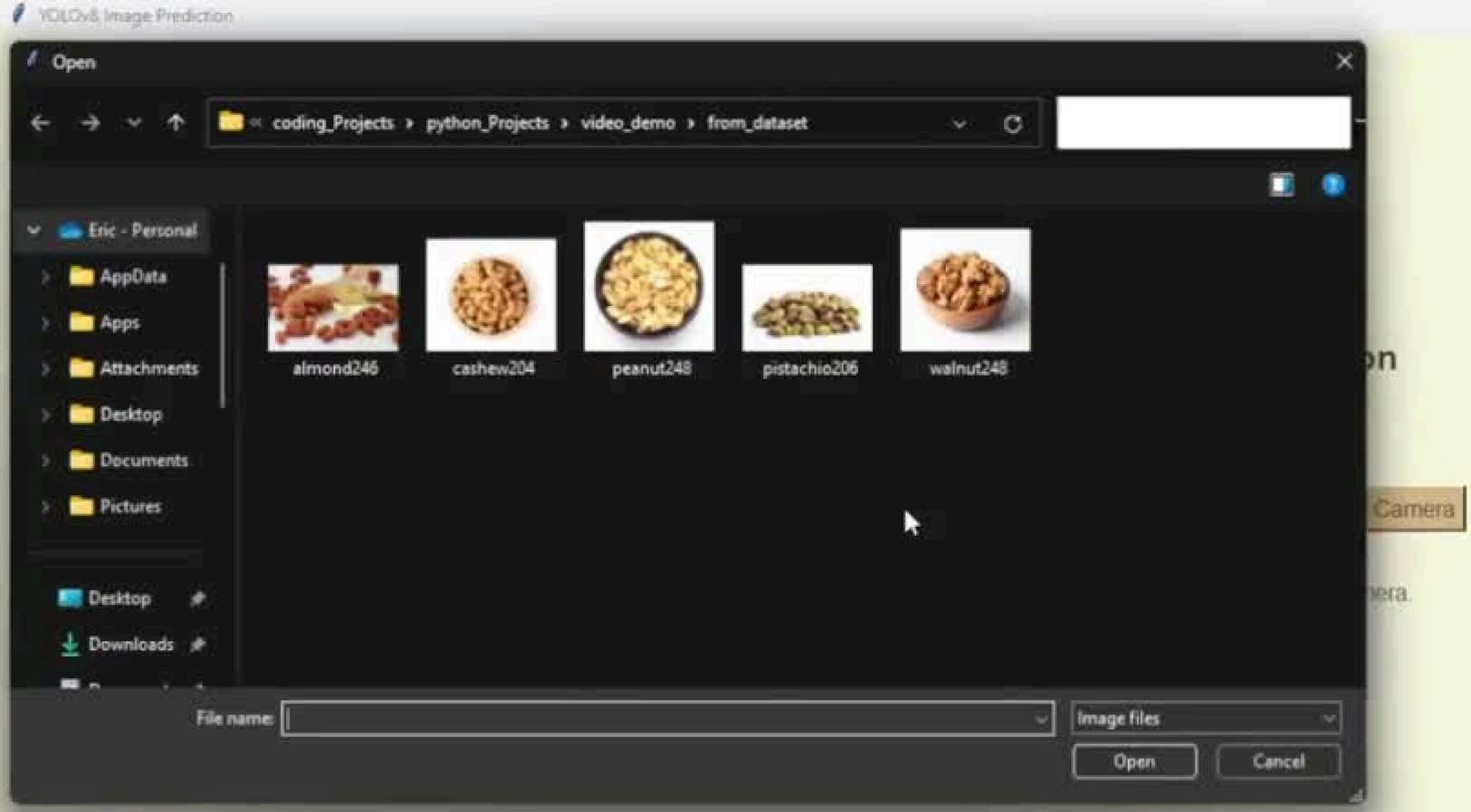


Result

- Precision reached **100% at a 98.8% confidence threshold**, and recall achieved **99% at a 0% confidence threshold**, demonstrating the model's ability to minimize false positives while identifying nearly all relevant instances.






YOLOv8 Image Prediction
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VIDEO DEMO

Conclusion

The NutSure project utilized deep learning, CNN, and YOLOv8 to address the need for efficient and accurate nut classification in the food and agricultural industry. Achieving a validation accuracy of 94% and a testing accuracy of 92.1%, the system demonstrates its effectiveness in classifying almonds, cashews, peanuts, pistachios, and walnuts, paving the way for improved quality control and automation in food processing.

Recommendations

- Incorporate more clustered shelled and unshelled nut images into the dataset to improve prediction accuracy.
- Introduce background or negative classes to distinguish nuts from irrelevant objects.
- Add features to detect fresh or damaged nuts for enhanced quality control.

Thank You