Deep Learning-based Ingredient Detection for a Recipe Recommendation System

FIGUEROA, JAN ED PAULO | PEÑA, VHAN RANDOLP

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Introduction

Household food waste is the most damaging in terms of environmental and economic impact. Despite food insecurity, approximately one-third of all food produced for human consumption is reported to be wasted.

Problem Statement

- According to the World Wildlife Fund–Philippines (2020), it is estimated that around 2,175 tons of food scraps in greater Metro Manila alone were thrown in the garbage every day in the year 2020, while around 308,000 tons around the country are being considered as food waste.
- In the Philippines, plate waste is closely linked to hunger incidence and threatened food security. Given that plate waste is mostly generated at home, the typical Filipino family generates 66.8g of plate waste each day which is 5.0g more than in 2015.

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The Sustainable Development Goal (SDG) 12.3 specifically targeted and aimed to halve plate waste and decrease food loss by 2030.

Solution

A recipe recommendation system that aims to set out a plan of meals within a specified amount of time in order to optimize the food inventory utilizing deep learning object detection techniques in creating inventory.

Methodology

Data Collection and Preprocessing

It consists of two datasets gathered and preprocessed such as raw ingredient images for object detection and recipe dataset for recipe recommendation.

Deep Learning Object Detection

Using deep learning, three YOLO models were used to be trained using the object detection dataset which will create an inventory record to be a basis on recipe recommendation.

Recipe Recommendation

Using the inventory procured by the object detection model, a recipe recommendation will be generated ensuring optimal use of the entire inventory.

Performance Metrics

Measurement of the performance of the object detection models that will serve as a basis of its accuracy and reliability.

OBJECT DETECTION DATASET

This dataset is composed of images of raw ingredients of a common part of Filipino cuisine. The image datasets used for this research were carefully picked and web-scraped from different web platforms such as Kaggle, OpenCv, RoboFlow, Adobe Stock, and others with 250 images per class.

Label	Class
0	Beef
1	Bitter-Gourd
2	Bottle-Gourd
3	Broccoli
4	Cabbage
5	Carrots
6	Cauliflower
7	Chicken
8	Egg
9	Eggplant
10	Galunggong
11	Garlic
12	Ginger
13	Milkfish
14	Onion
15	Papaya
16	Pork
17	Potato
18	Sayote
19	Tilapia
20	Tomato

RECIPE RECOMMENDATION DATASET

The dataset used for the recipe recommendation system is outsourced from GitHub by Shaan Subbaiah on project, allrecipes-scraper. This project scrapes all recipes available on a famous food-focused online social networking service. This dataset consists of 35,516 entries of 47 columns which includes the following classes:

columns
name
url
category
author
summary
rating
rating_count
review_count
ingredients
directions
prep
cook
total
servings
yield

columns
calories
carbohydrates_g
sugars_g
fat_g
saturated_fat_g
cholesterol_mg
protein_g
dietary_fiber_g
sodium_mg
calories_from_fat
calcium_mg
iron_mg
magnesium_mg
potassium_mg
zinc_mg
phosphorus_mg
vitamin_a_iu_IU
vitamin_b1_mg
vitamin_b2_mg
vitamin_b3_mg
vitamin_b5_mg
vitamin_b6_mg
vitamin_b7_mg
vitamin_b9_mg
vitamin_b12_mg

DATASET PREPROCESSING

OBJECT DETECTION DATASET

- Resizing
- Flipping
- Shearing
- Saturation
- Brightness
- Exposure

RECIPE RECOMMENDATION DATASET

- Conversion of fractions in unicode format
- Modification of quantities based on user desired serving size
- Extraction of crucial information such ingredients and quantities

OBJECT DETECTION MODELS

YOLOv6

YOLOv6 is an object detection model that offers remarkable balance between speed and accuracy, making it a popular choice for real-time applications. It was trained under 142 layers of neural networks consisting 4,235,823 parameters.

YOLOv8

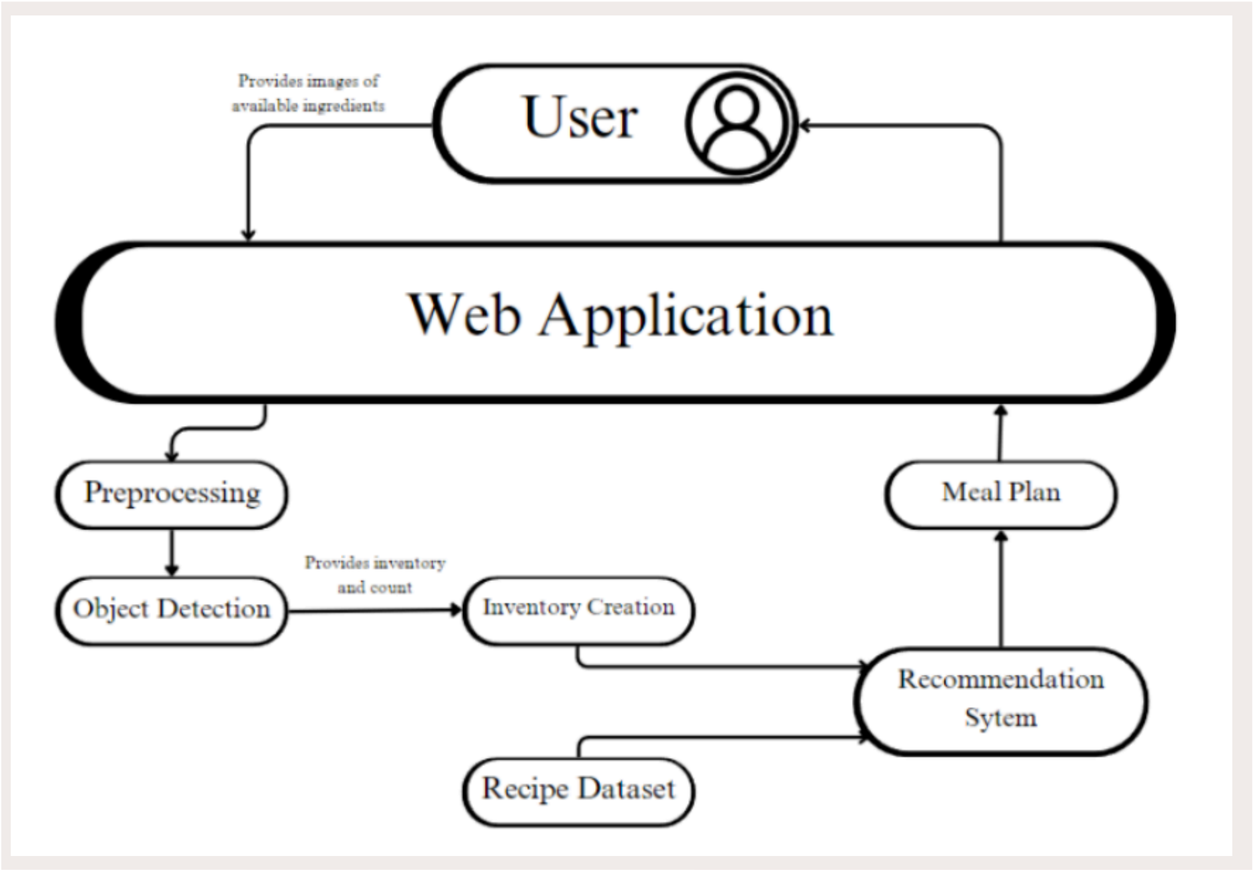
YOLOv8 is built on cutting-edge advancements in deep learning and computer vision, offering unparalleled performance in terms of speed and accuracy. Under this model, the dataset was trained under 261 layers of neural networks consisting 11,798,223 parameters.

YOLOv9

YOLOv9 uses anchor-free detection and sophisticated loss functions like CIoU for improved accuracy and localization. Under this model, the dataset was trained under 618 layers of neural networks consisting 25,548,507 parameters.

RECIPE RECOMMENDATION SYSTEM

A system utilizing Streamlit for the creation of a web application for the users. It generates recipe recommendation that optimizes all available ingredients on the inventory created through ingredient detection.



PERFORMANCE METRICS

Confusion Matrix

a table that compares the predicted labels against the actual labels to visualize and evaluate the performance of an algorithm

Mean Average Precision (mAP)

It takes the average of the precision values for each user, where precision is the proportion of relevant items among the top-K recommended items

Loss

measure the disparity between the predicted and actual bounding boxes.

Precision and recall

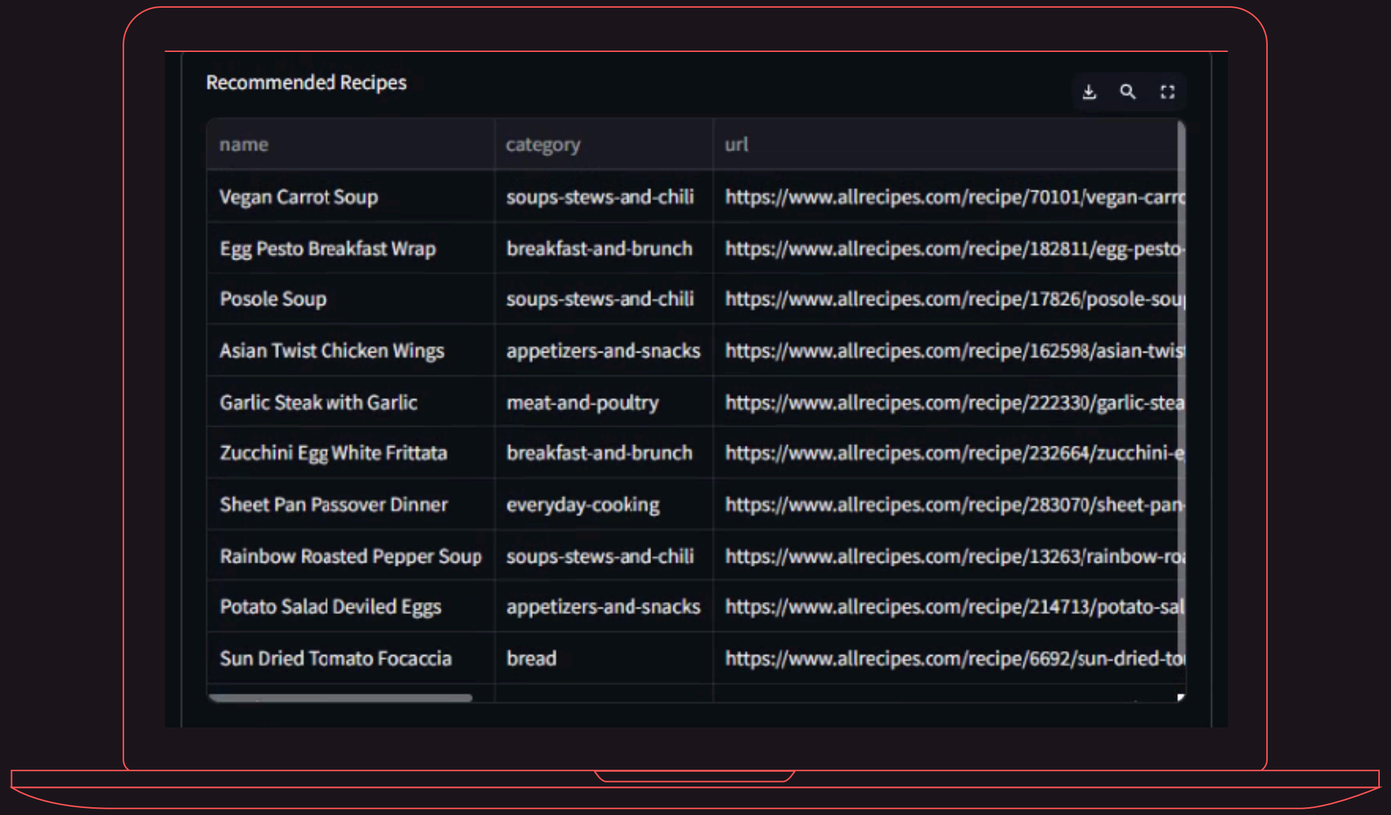
provides a balanced understanding of a model's performance in object detection, highlighting both its accuracy in predictions and its ability to detect all relevant objects

RESULTS AND DISCUSSION

	Precision	Recall	maP50	maP50-95
YOLOv6	**82.30%**	**76.09%**	**81.64%**	**71.95%**
YOLOv8	**81.25%**	**78.59%**	**82.63%**	**75.19%**
YOLOv9	**91.96%**	**91.53%**	**95.40%**	**77.92%**

Overall, the YOLOv9 model performs the best for the object detection providing a great balance between the precision and recall with values of 91% for both of them. It also produce an accurate prediction due to the high percentage with maP values with 95% in maP50 and almost 78% percent in maP50-95.

Recipe Recommendation System



The recipes are generated by adjusting ingredient quantities based on the desired serving size and calculating the percentage of inventory used for each recipe. The recipes were evaluated to ensure they could be made with the current inventory using a knapsack-like approach before adding them to the output.

Conclusion

This research shows the potential to reduce the food waste by integrating deep learning techniques for ingredient detection into recipe recommendation. This system provides recipe recommendation that utilizes all available ingredients from object detection results that helps in managing food inventory better and minimizes food waste. Future work may involve weight/volume estimation for other ingredients while improving object detection models' performance.


Thank
you!