AI-Enhanced Nutritional Label Extraction and Diabetic Health Assessment

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9th August, 2024

Presentation Outline

- Motivation
- Objectives
- Scope of Project
- Project Applications
- Methodology
- Results
- Results Analysis
- Remaining Tasks
- References

Motivation

- Empower individuals with diabetes to make informed dietary decisions
- Improve blood glucose management through personalized food recommendations
- Leverage advanced technology for accurate glycemic index predictions
- Enhance user quality of life with healthier choices

Objectives

- To develop a mobile app for users to input recent blood sugar levels and medications
- To create a nutritional label scanner to analyze and recommend food suitability based on user profiles

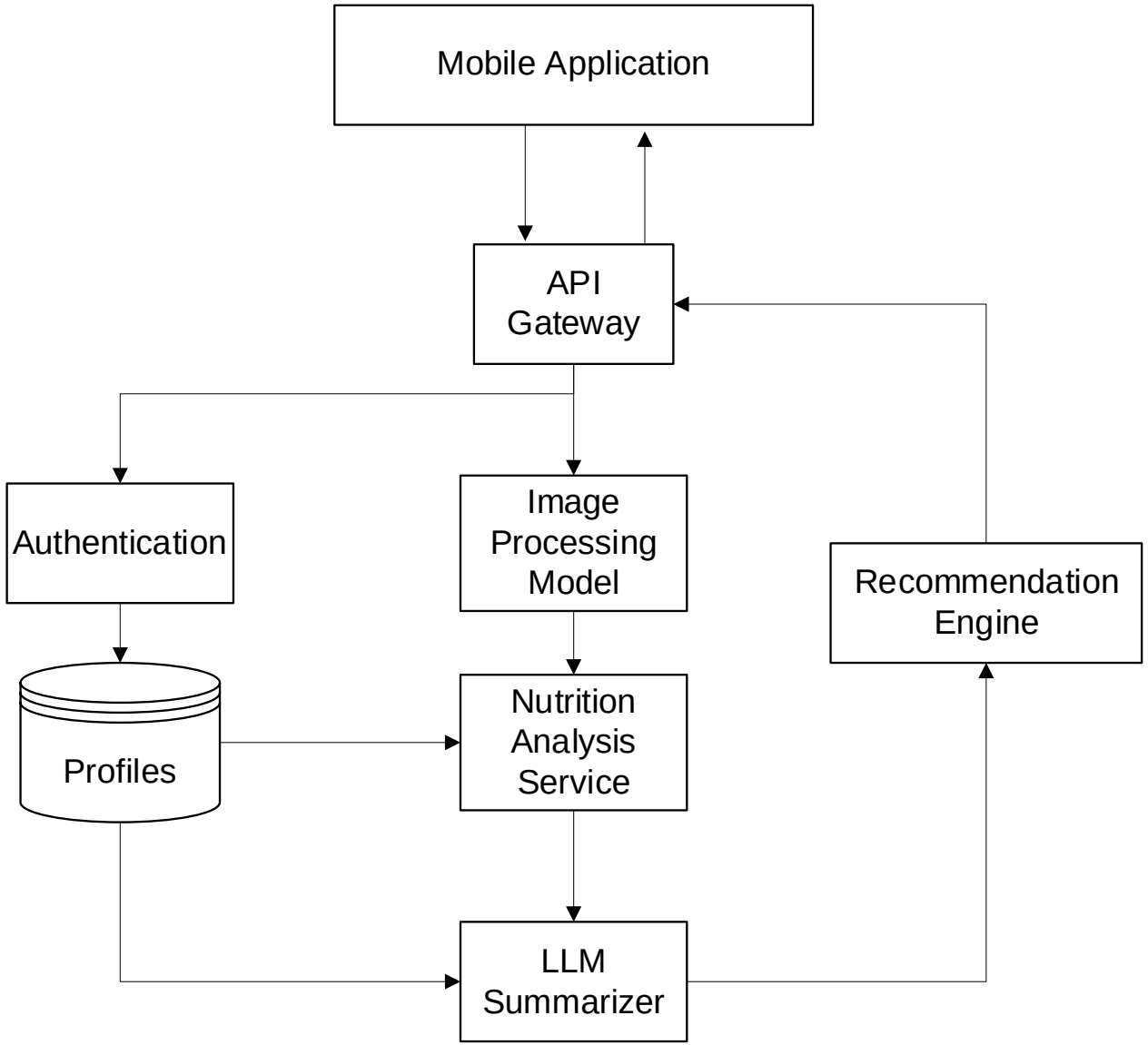
Scope of Project

- Project Capabilities
  - Provides personalized nutritional advice for diabetes management.
  - Simplifies understanding of food labels and nutrition details.
  - Offers a user-friendly platform for health management.
- Project Limitations
  - May not cover all health conditions or restrictions.
  - Dietary advice can vary between regions and cultures.

Project Application

- Personalized Health Profiles
  - ➢Create profiles with blood sugar, medications, recommendations
- Nutritional Label Scanner
  - ➢Uses YOLO & OCR to extract nutritional information from labels
- Machine Learning-Driven Recommendation
  - ➢Analyzes data to generate personalized dietary recommendations
- User Empowerment
  - ➢Provides insights and tools for informed health decisions

Methodology - [1] (System Architecture)

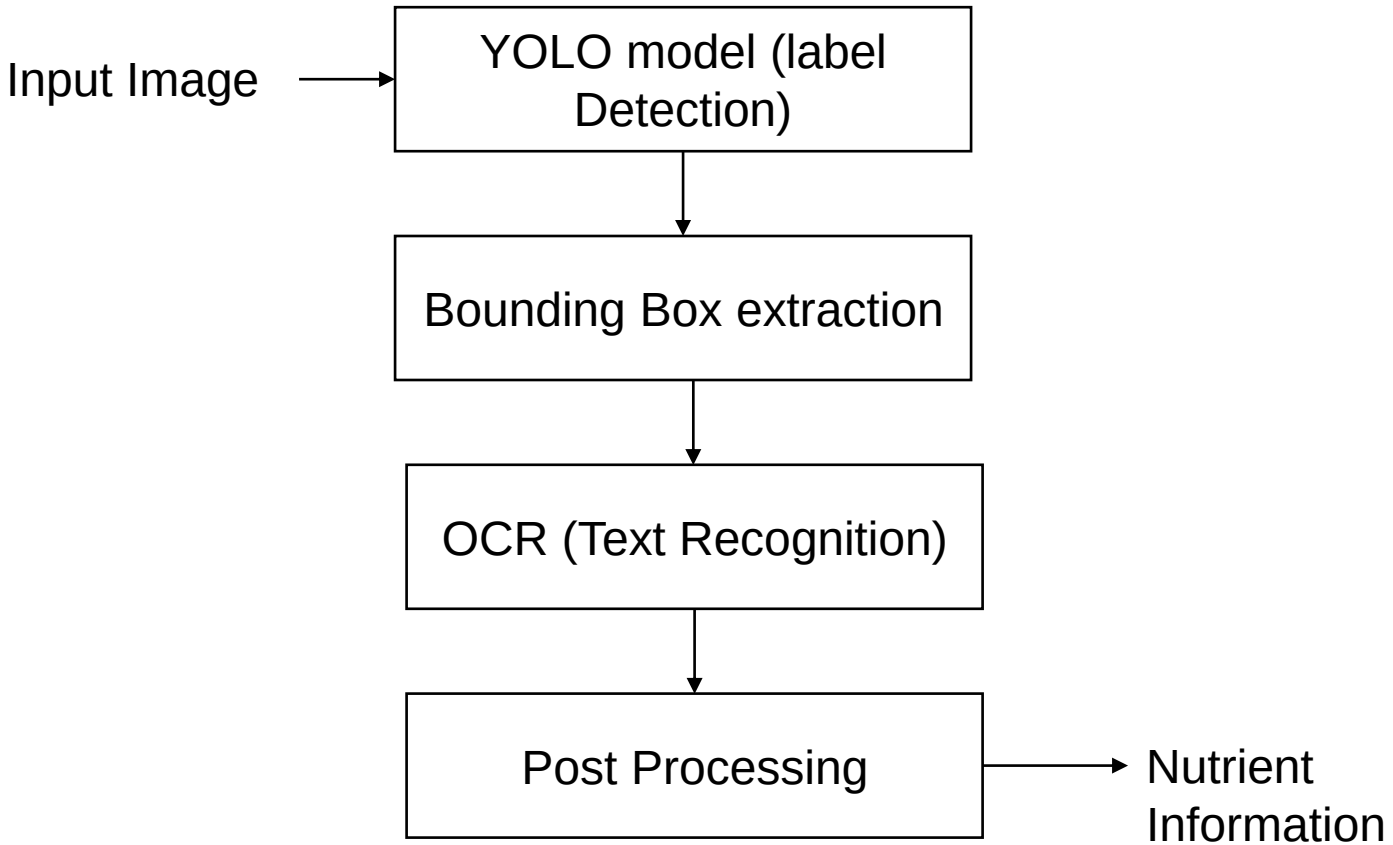


Methodology - [2]
(Mobile Application)

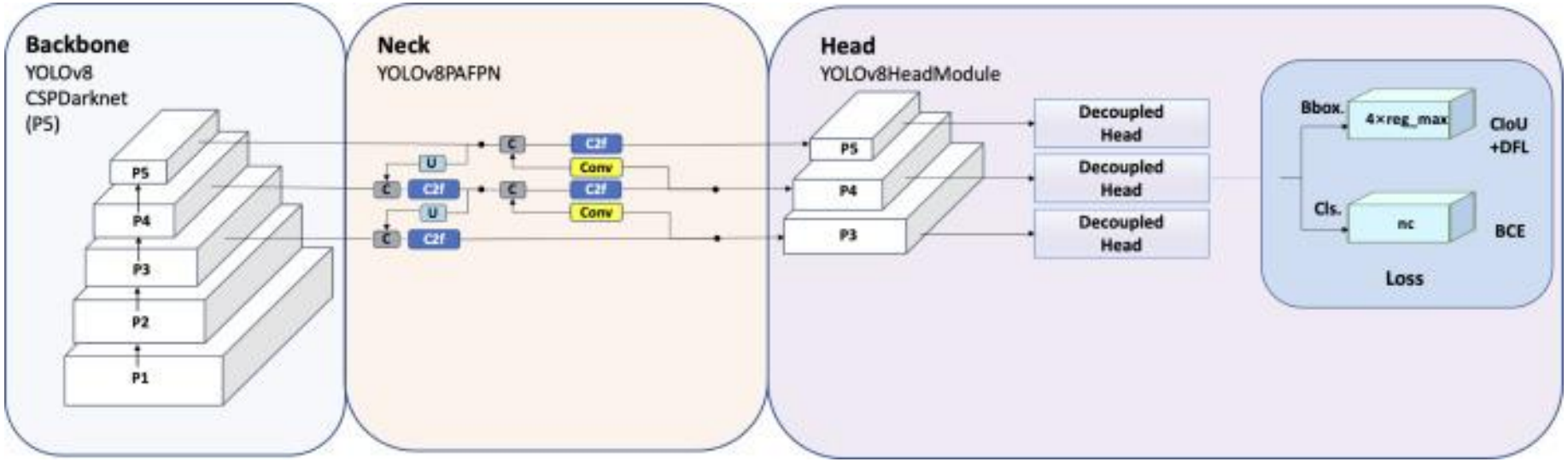
- Purpose
  - User-friendly interface for personalized diabetic profiles
  - Input health data and scan food items easily
  - Receive personalized dietary recommendations in real-time

- Development method
  - Using cross-platform frameworks for compatibility, like Flutter or React Native
  - Integrate user authentication for secure login, data storage
  - Communicate with backend APIs for nutritional analysis display

Methodology - [3]
(Image Processing Model)



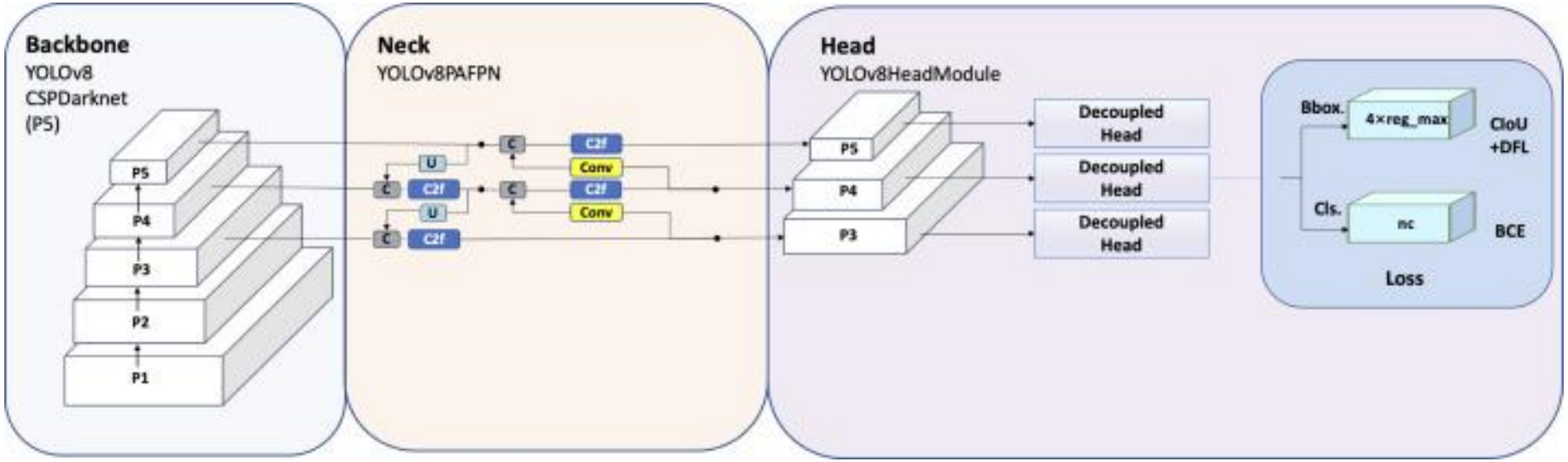
Methodology - [4]
(YOLOv8 for Nutritional Label Detection)



Backbone: YOLOv8 CSPDarknet

- Convolutional layers extract rich features from image.
- CSP connections enhance efficiency and gradient flow.
- Feature maps progress through stages P1-P5.
- Detecting nutritional label region on food packaging.

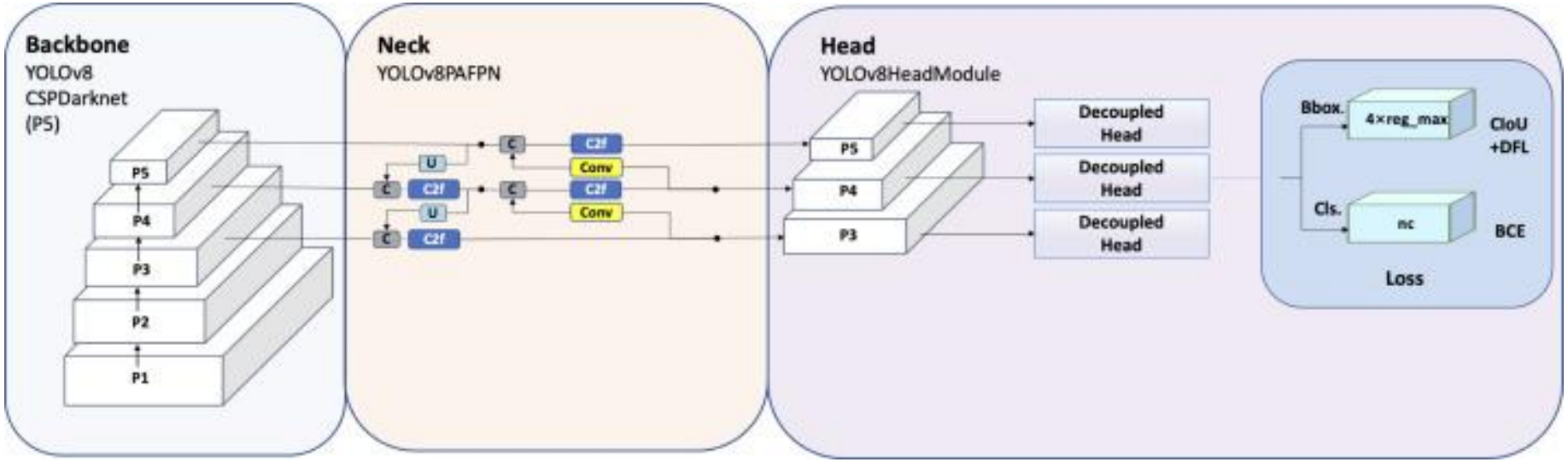
Methodology - [5]
(YOLOv8 for Nutritional Label Detection)



Neck: YOLOv8 PAFPN

- PANet fuses multi-scale features effectively.
- Combine features from P1 (32x32) to P5 (1024x1024).
- Upsample and downsample for accurate feature combination.
- Enhancing localization of entire nutritional label area.

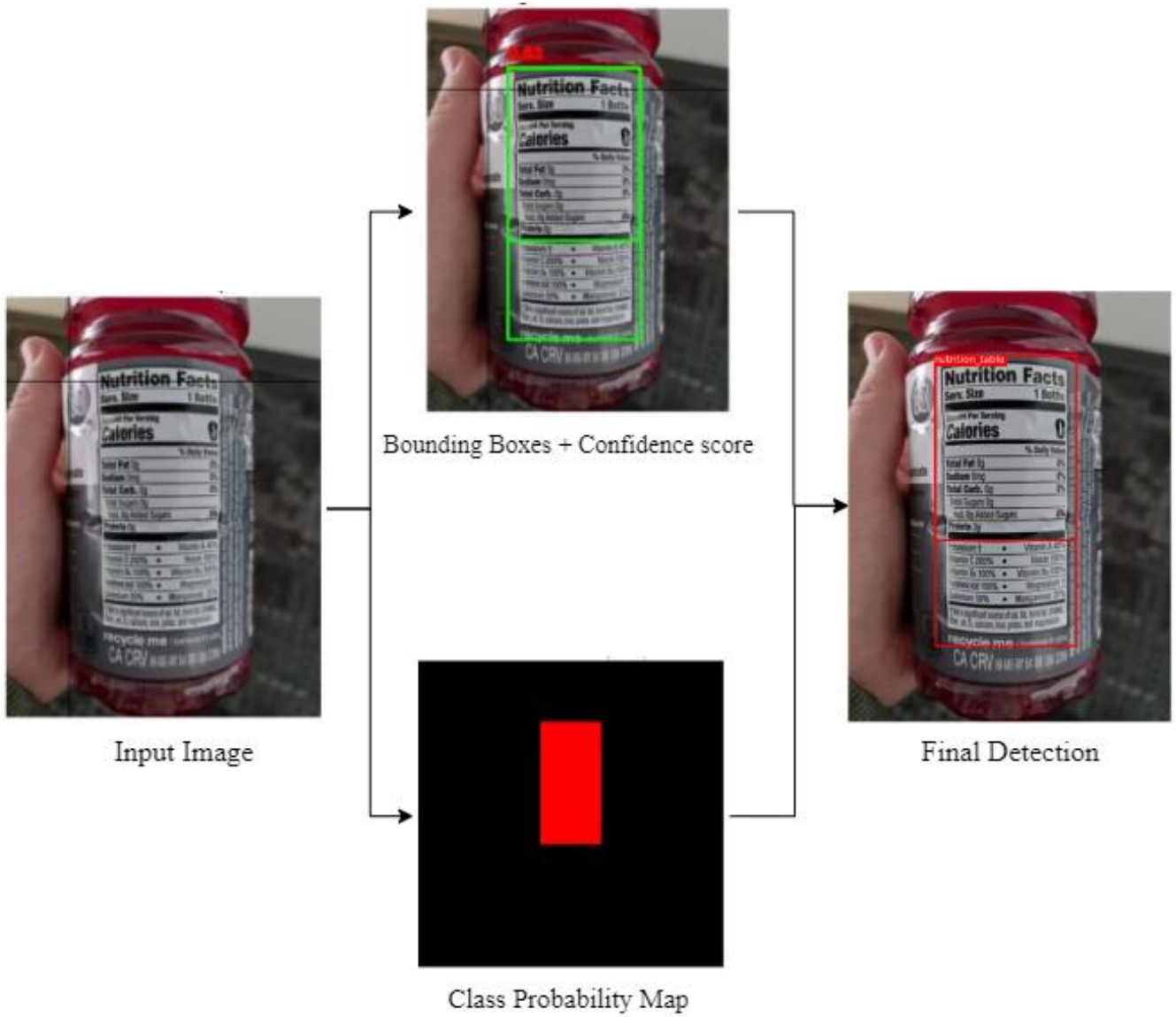
Methodology - [6]
(YOLOv8 for Nutritional Label Detection)



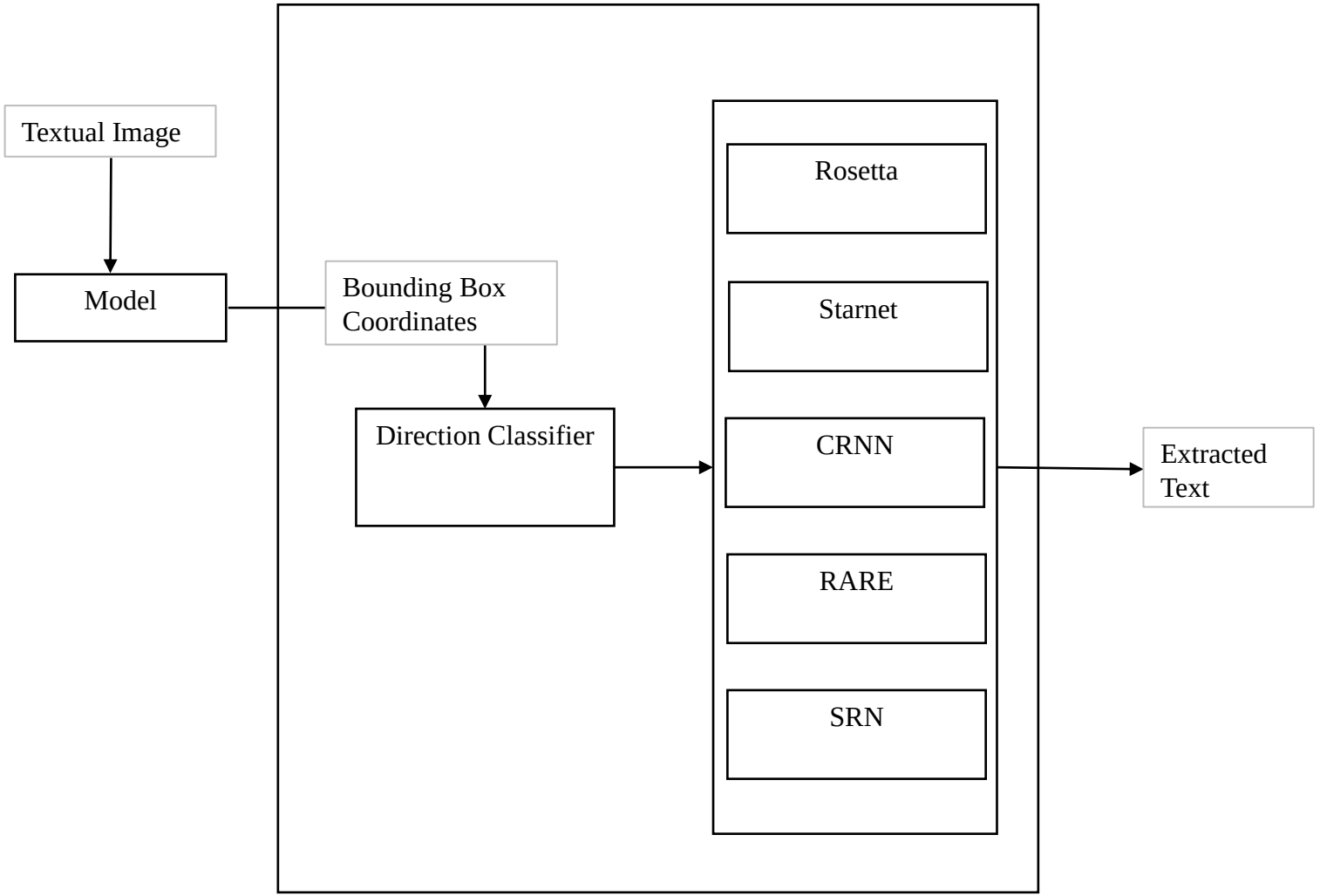
Head: YOLOv8 HeadModule

- Separate heads for regression and classification tasks.
- P3 (128x128) to P5 for detailed detection.
- Final bounding boxes for label area identified.
- Determining ROI (Bounding box) of nutritional label on packaging.

Methodology – [7]
(Workflow of Detection Model)



Methodology - [8]
(Text Recognition using OCR)



Methodology - [9]
(Architecture of PaddleOCR)

Direction Classifier

- Ensures misaligned text is properly oriented.
- Rotates text to be horizontal and readable.

Rosetta

- Captures text naturally from packaging images.
- Reads labels like "Calories" and numerical values.
- Interprets text appearance directly from packaging.

StarNet

- Corrects distortions from curved packaging surfaces.
- Ensures accurate recognition despite surface irregularities.
- Handles warping for clear text identification.

Methodology - [10]
(Architecture of PaddleOCR)

CRNN (Convolutional Recurrent Neural Network)

- Combines convolutional and recurrent layers for sequences.
- Captures spatial and temporal text features.
- Assists in recognizing sequential text accurately.

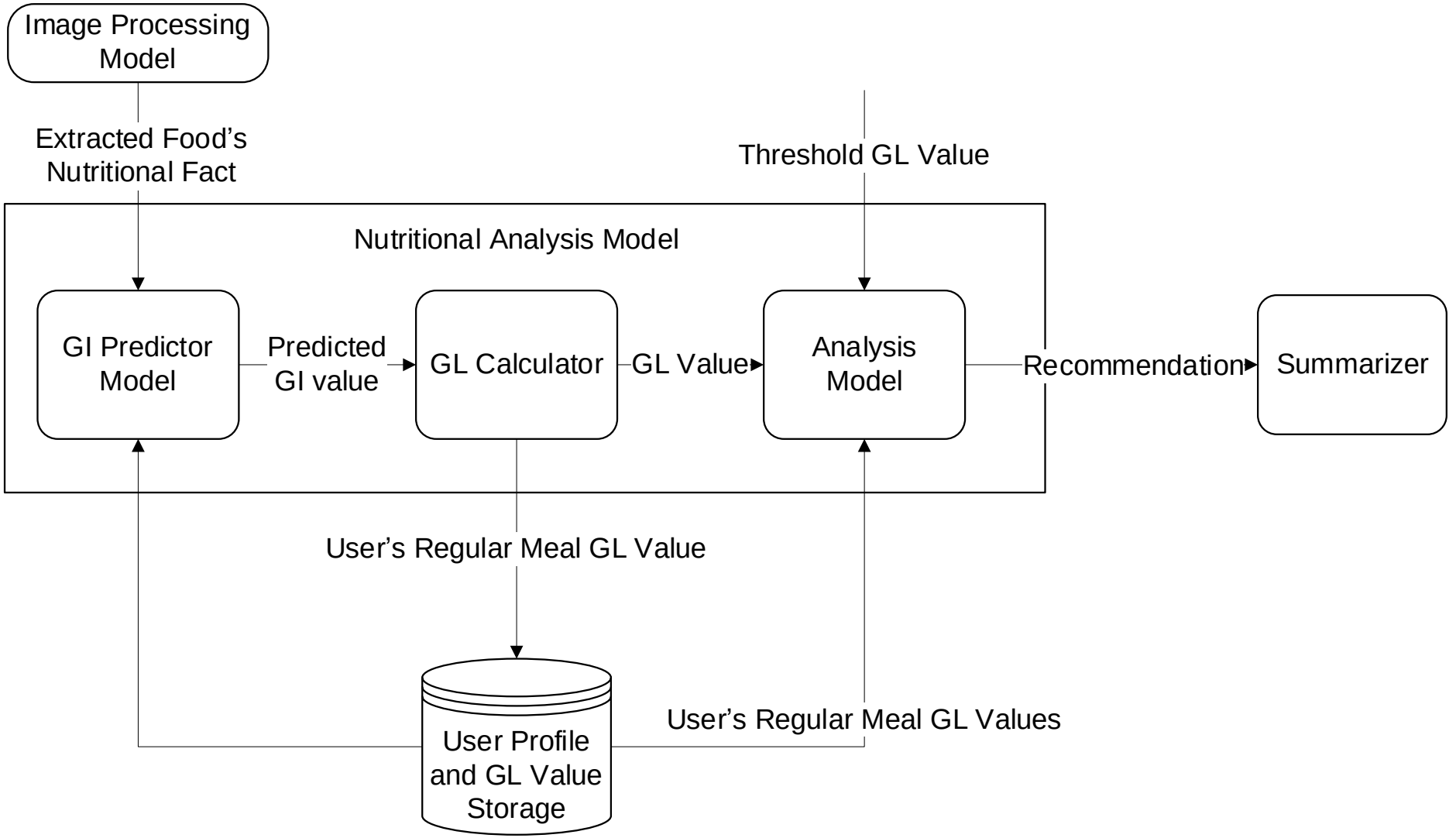
RARE (Robust Arbitrary Rectification Network)

- Corrects arbitrary distortions in text regions.
- Adjusts perspective for better text clarity.
- Ensures accurate reading despite text distortions.

SRN (Sequence Recognition Network)

- Maintains correct order of text sequences.
- Ensures context of nutritional information.
- Accurately reads and predicts text sequences.

Methodology - [11] (Nutritional Analysis Model)



Methodology - [12]
(Nutritional Analysis Model)

- GI Predictor Model

  - Scanned food's nutritional information which is extracted by image processing model is passed as input to this model.

  - Trained on dataset with features as nutritional facts and target variable as Glycemic Index(GI) value.

  - It predicts GI value for scanned food.

  - Glycemic Index (GI) of a food is a numerical value (0-100) which represents how quickly the food raises blood glucose levels after consumption.

Methodology - [13]
(Nutritional Analysis Model)

- GL Calculator

  - Glycemic load (GL) is a measure that assesses the impact of carbohydrate consumption on blood sugar levels.
  - It combines both the Glycemic Index and quantity of carbohydrates in a food.
  - This calculator calculates the GL value from the predicted GI value by the below given formula:

$$\text{Gly}cemic\ Load = \frac{Glycemic\ Index * amount\ of\ carbohydrate\ in\ gram}{100}$$

Methodology - [14]
(Nutritional Analysis Model)

- Interpretation of GL Values

  - **Low GL (10 or less)**: Foods with a low glycemic load have a minimal impact on blood sugar levels.

  - **Medium GL (11-19)**: Foods with a medium glycemic load have a moderate impact on blood sugar levels. These can be included in a balanced diet but should be consumed in moderation, especially by those sensitive to changes in blood sugar.

  - **High GL (20 or more)**: Foods with a high glycemic load can cause significant spikes in blood sugar levels. These should be limited, particularly for individuals with diabetes.

Methodology - [15]
(Nutritional Analysis Model)

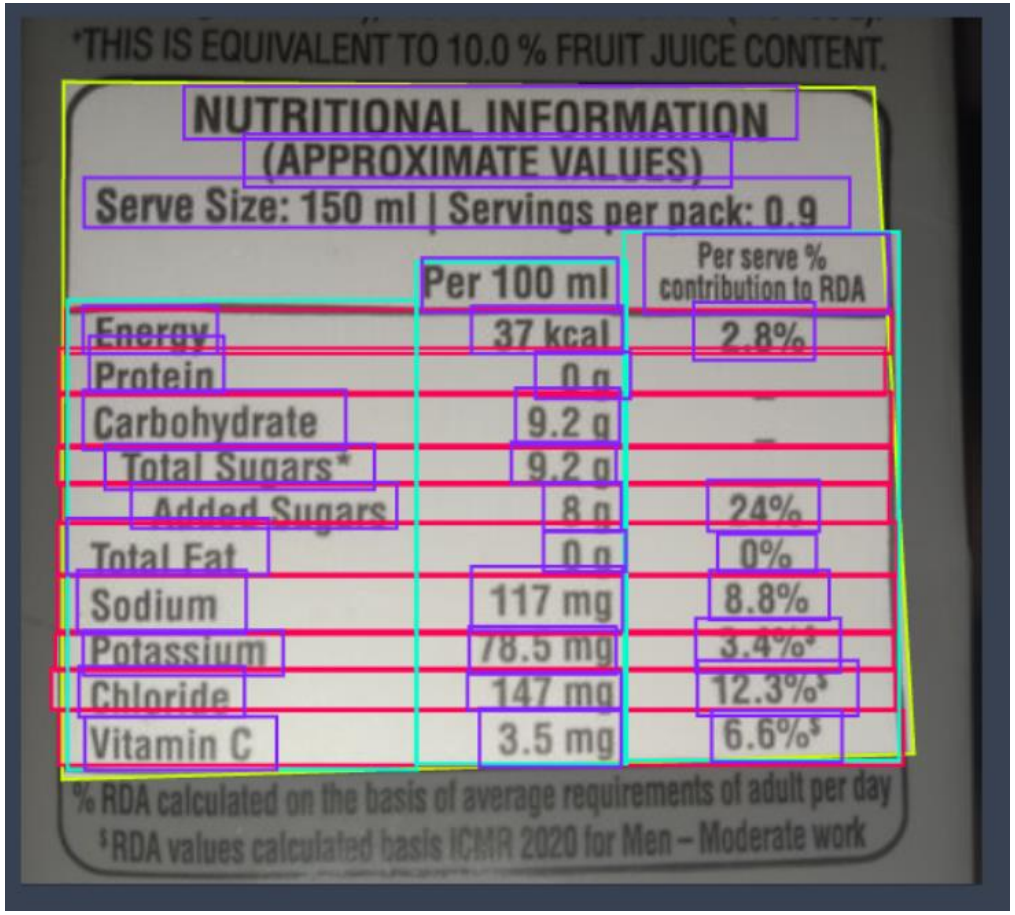
- Analysis model

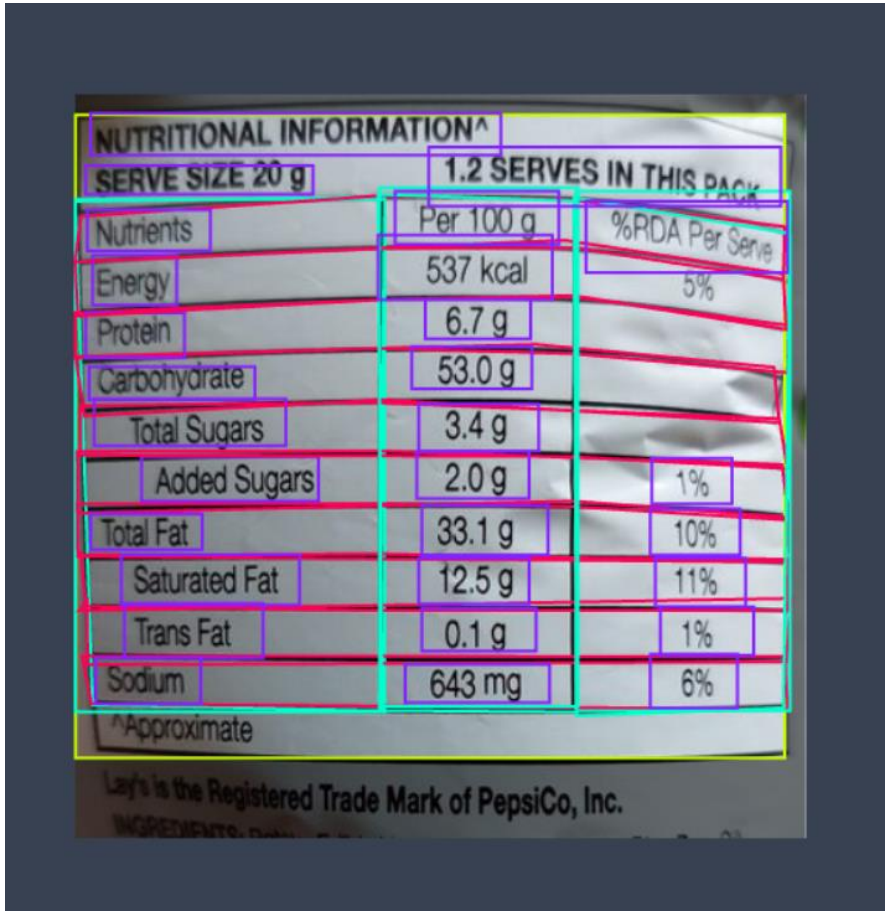
  - Receives Glycemic Load(GL) value stored in the database and threshold GL value as input.
  - Compares total sum of GL value of previous foods and scanned food from the database with threshold value.
  - If the total GL value of the user is less than or equal to the threshold value, then the food is recommended to consume otherwise not.
  - This information is passed as an output to the summarizer model for further processing.

Methodology - [16] (Summarizer)

- Summarizer
  - Uses Large Language Models (LLMs) like Llama or Mistral to generate summaries.
  - Processes detailed nutritional information, GL calculations, and comparison results.
  - Produces clear summaries indicating whether a food item is suitable for consumption.
  - Includes detailed explanations to ensure users understand the reasoning behind the recommendations.

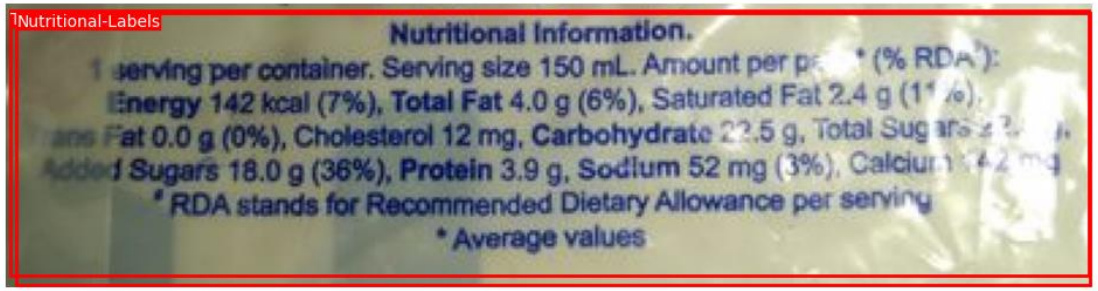
Methodology - [17]
(Dataset Annotation)

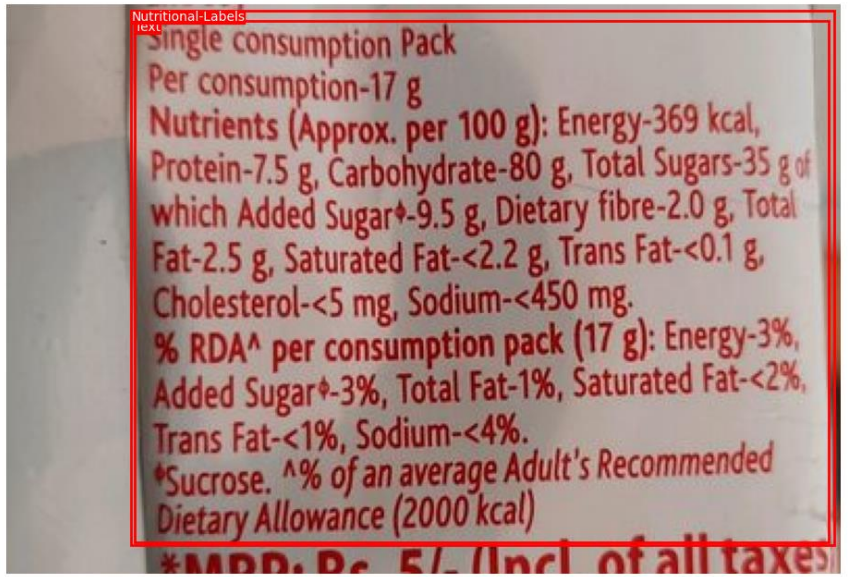




Results – [1]

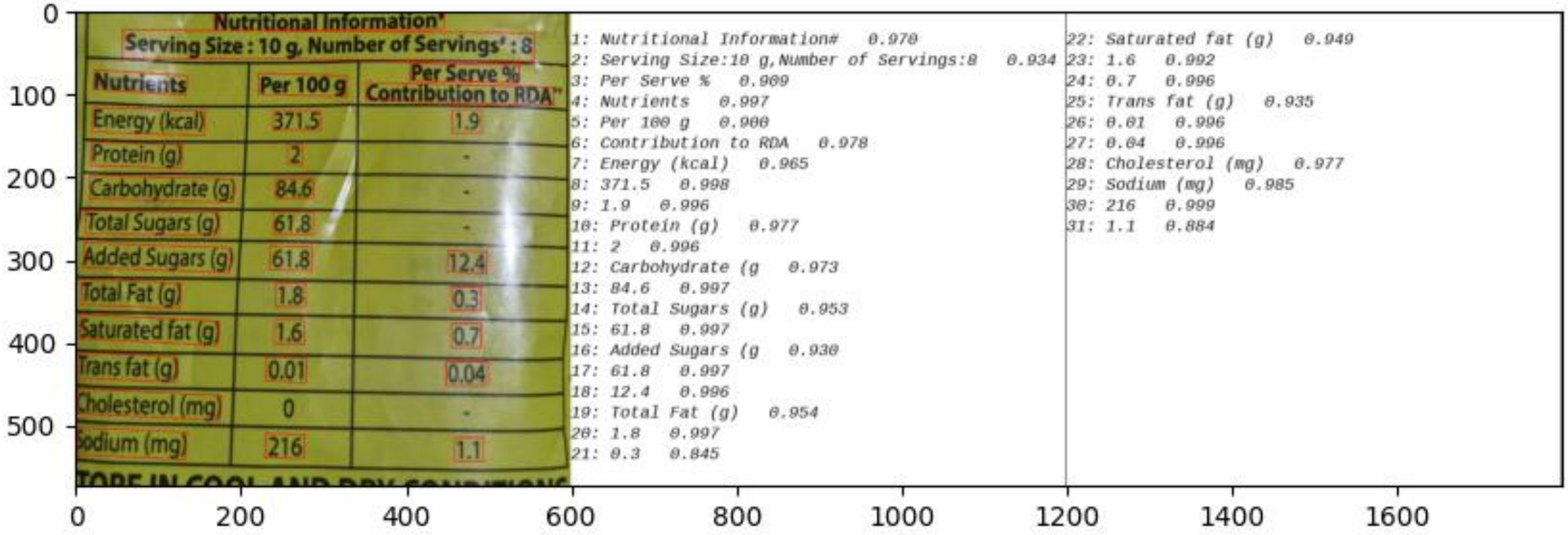
Detecting tabular nutritional label



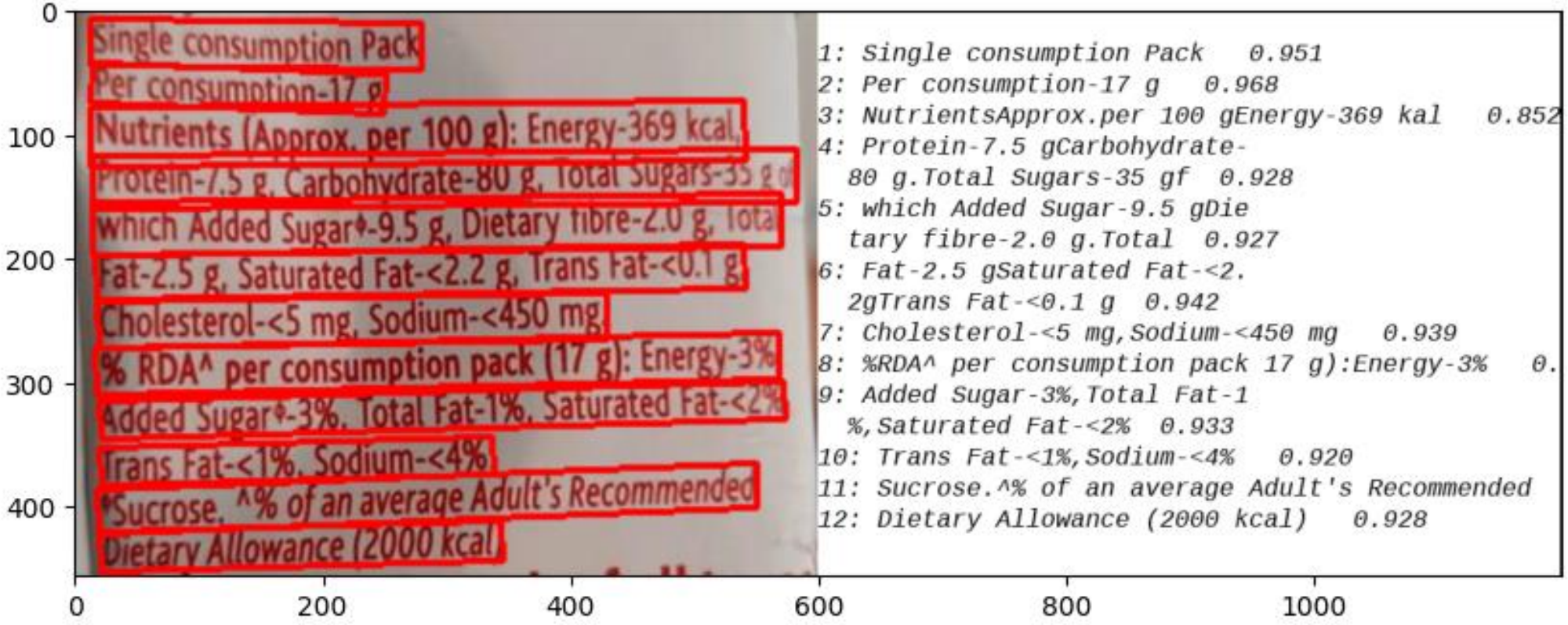


Detecting nutritional label in paragraph format

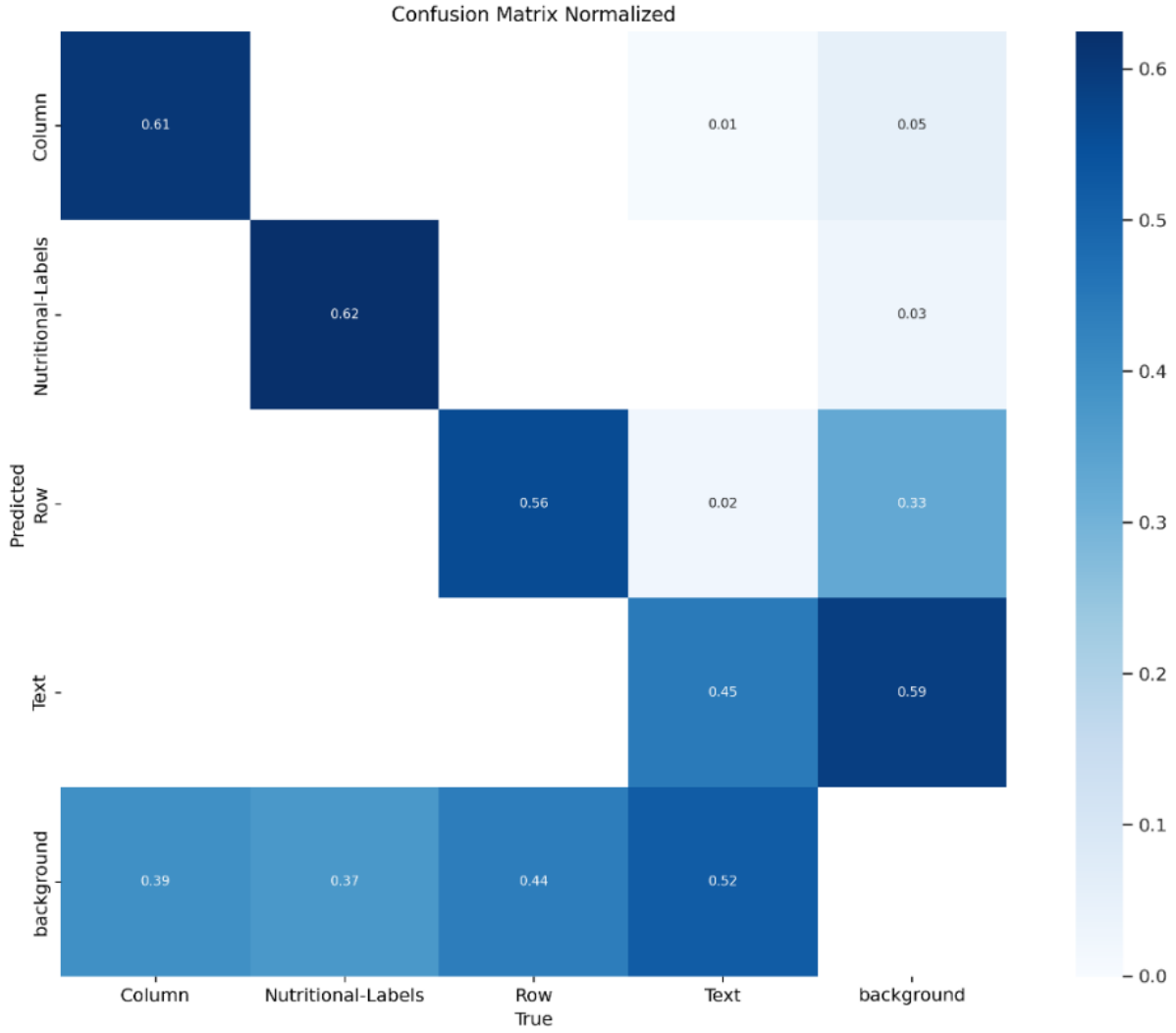
Results – [2]
(Output of OCR)



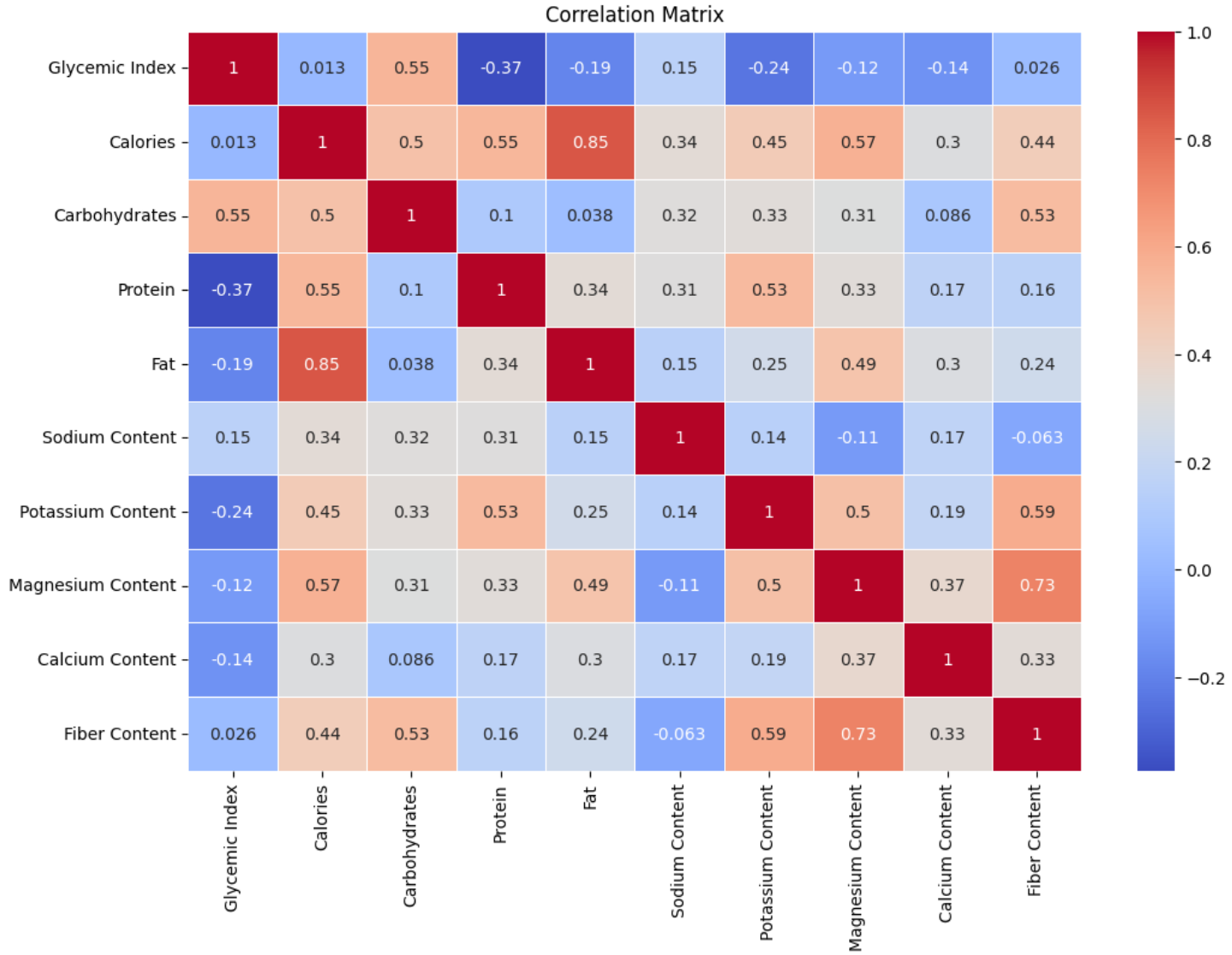
Results – [3]
(Output of OCR)



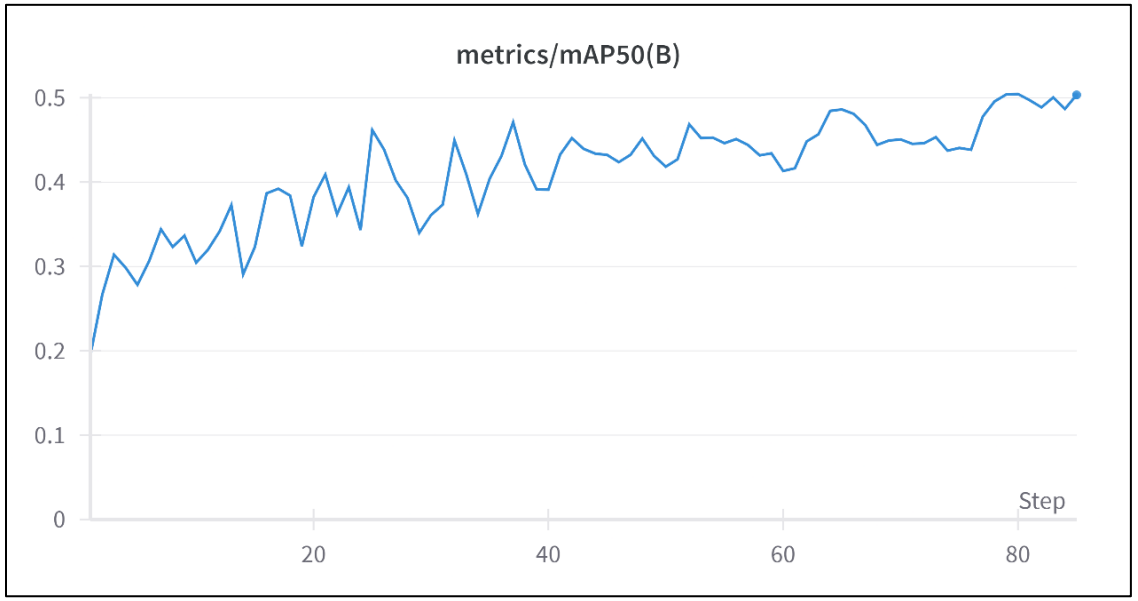
Results – [4]
(Confusion Matrix of YOLO model)

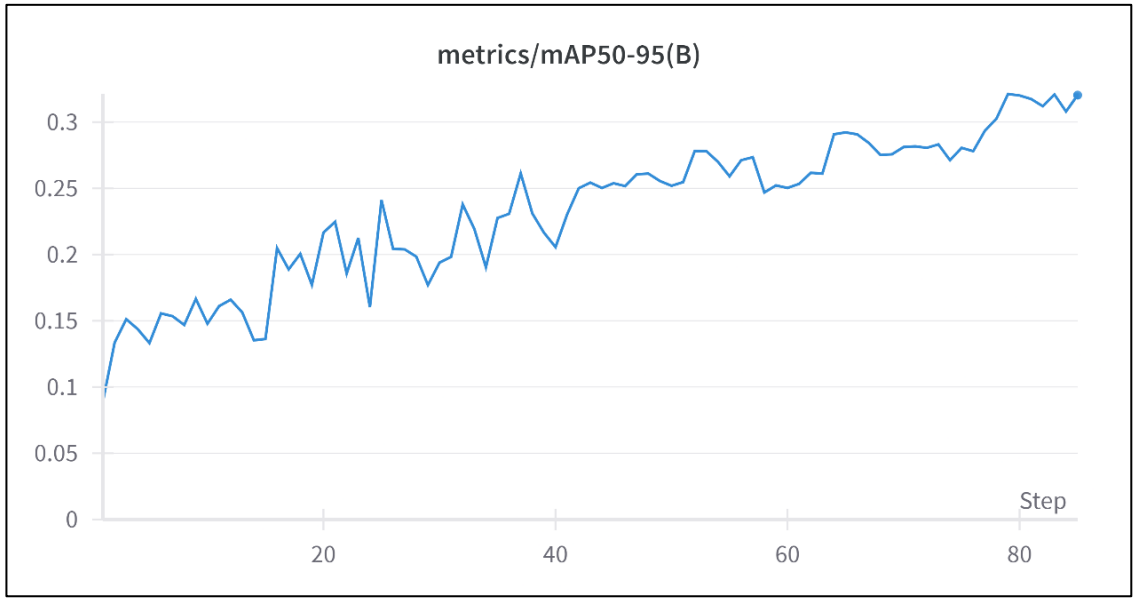


Results – [5]
(Relationship between GI and other Nutritional Contents)



Results – [6]
(Mean Average Precision)

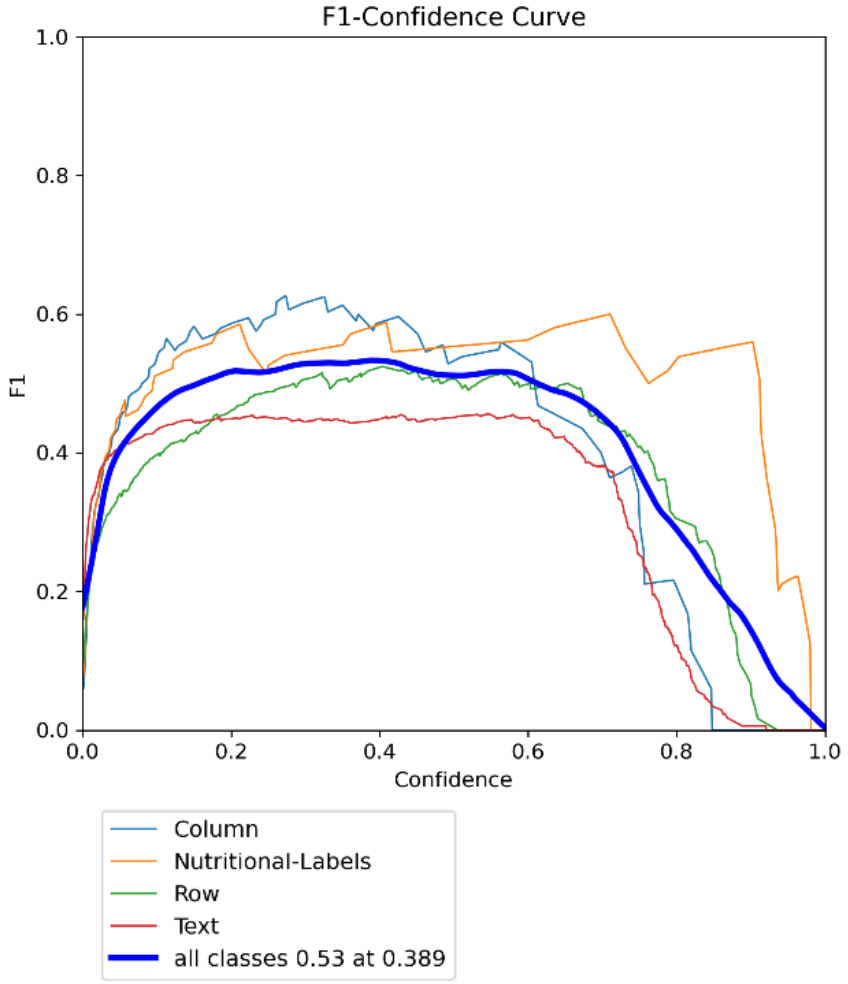


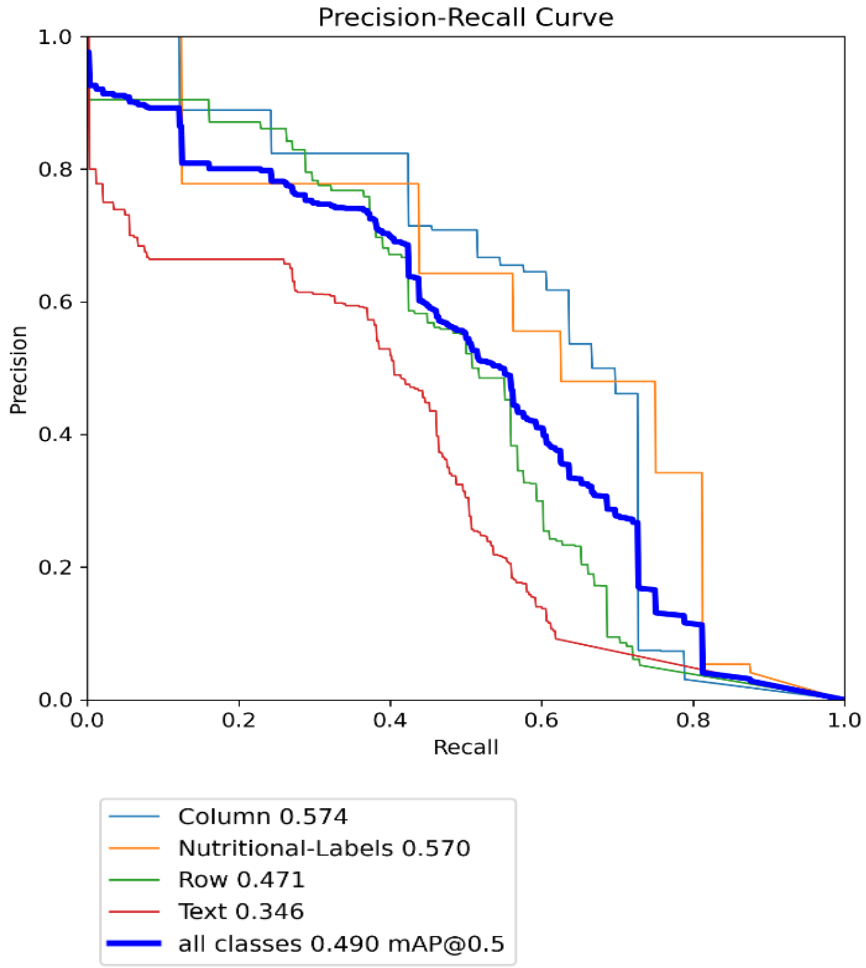


- Mean Average Precision at IoU 0.50
- mAP50 metric starts at 0.2, peaks, and valleys
- Overall mAP50 trend increases, reaching 0.5

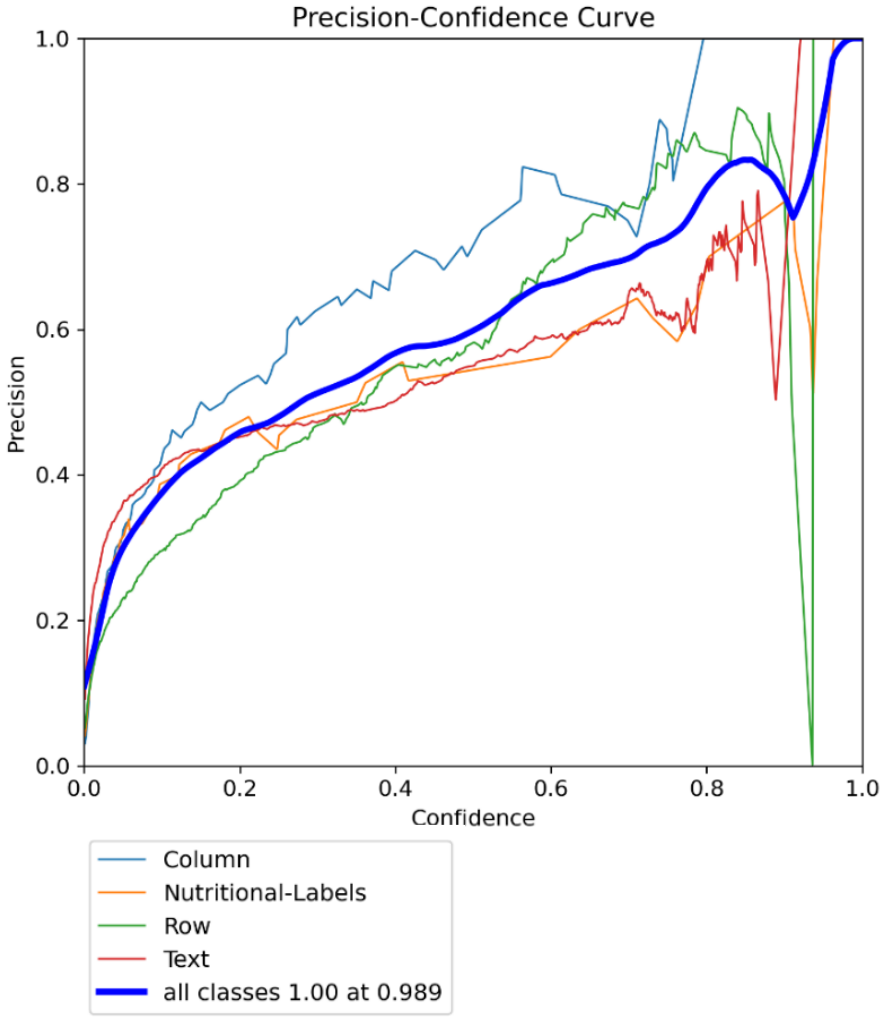
- Mean Average Precision for IoU 0.50-0.95
- mAP50-95 metric starts at 0.1, fluctuates, peaks
- Overall mAP50-95 trend increases, reaching 0.3

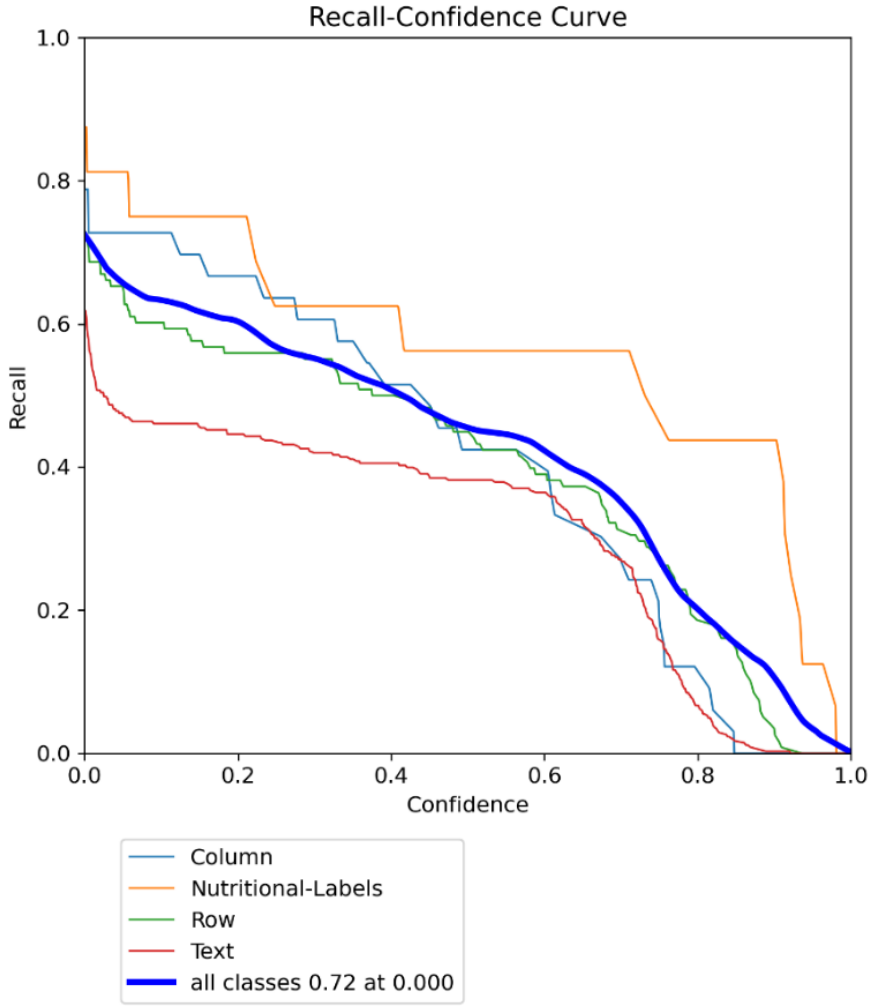
Result Analysis – [1] (Various Curves)





Result Analysis – [2] (Various Curves)





Remaining Tasks

- Nutritional Label Post-Processing
- Dataset exploration for GI Calculation
- GI value prediction model training
- Summarizer model exploration
- Mobile Application development
- Integration of all the models

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THANK YOU