# CarboAI: Estimating Sugar Content in Meals Using Machine Learning

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## Background

### 1. Introduction

Poorly managed diabetes can lead to severe complications such as blindness, nerve damage, kidney failure, amputations, and premature death (WHO, 2021). While medication is commonly used to treat Type 2 Diabetes Mellitus (T2DM), it remains costly and unsustainable for both patients and healthcare systems. Evidence shows that dietary intake, particularly the quantity and quality of carbohydrates, plays a critical role in the prevention and management of T2DM (Grosse et al., 2018). Yet, nutritional interventions are not sufficiently emphasized in routine healthcare practice.

### 2. Problem statement

Despite growing awareness of diabetes prevention, accurate dietary monitoring remains inaccessible, especially in low-resource settings. Current methods rely on manual logging and estimations, which are subjective and error-prone. There is therefore an urgent need for a low-cost, automated solution that can estimate carbohydrate content from meal images to promote diet-focused diabetes self-management.


***Fig. 1*** *Image of plated food with its nutritional information*

## Current Work

### 1. Objectives

To develop a model that estimates the total amount of carbohydrates on a plate and indicates whether it is low, medium, or high.

### 2. Methodology

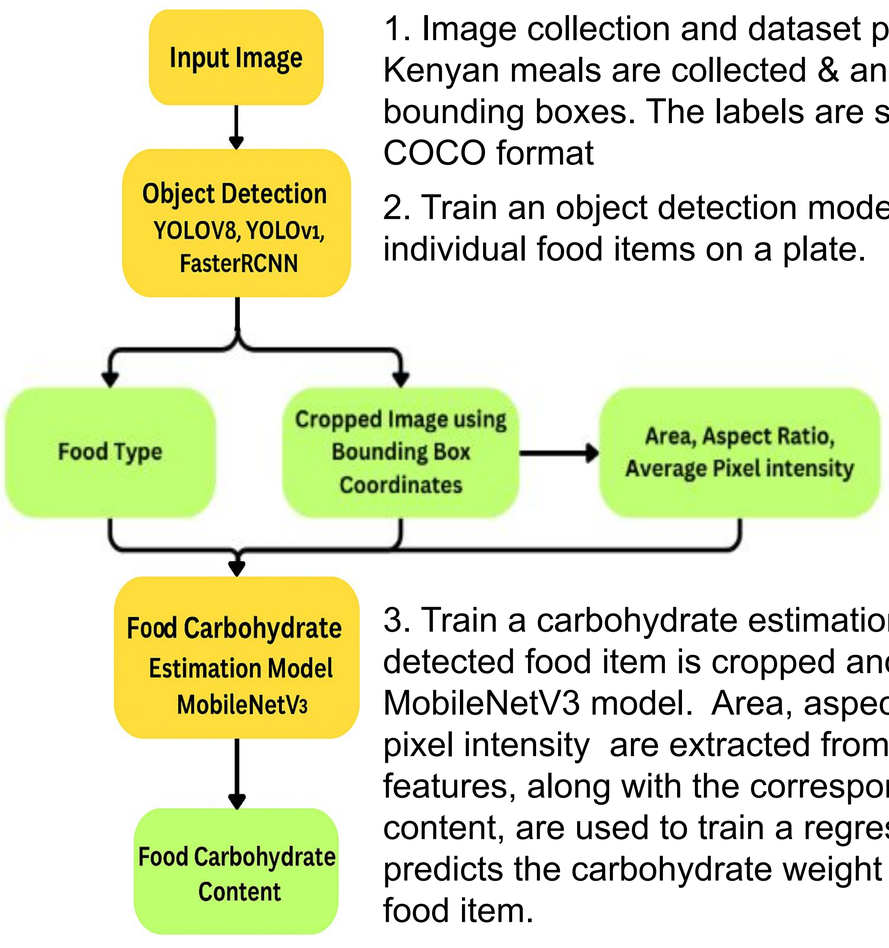


***Fig. 2 Carbohydrate content estimation model architecture***

1. Image collection and dataset preparation. Images of Kenyan meals are collected & annotated using bounding boxes. The labels are saved in YOLO and COCO format

2. Train an object detection model to detect and label individual food items on a plate.

3. Train a carbohydrate estimation model. Each detected food item is cropped and passed through a MobileNetV3 model. Area, aspect ratio, and average pixel intensity are extracted from each crop. These features, along with the corresponding carbohydrate content, are used to train a regression model that predicts the carbohydrate weight (in grams) for each food item.

### 3. Results

| Model | Epochs | Prediction accuracy | Precision | Recall | FI | Dataset |
|---|---|---|---|---|---|---|
| Yolov8 | 50 | 78.17% | 63.11% | 51.70% | 55.22% | Original images |
| Yolov8 | 100 | 84.73% | 75.62% | 64.80% | 68.16% | Original images |
| Yolo11 | 50 | 86.07% | 78.00% | 68.64% | 71.71% | Original images |
| Yolo11 | 100 | 98.65% | 98.38% | 97.48% | 97.65% | Augmented images |
| Yolo11 (overfitting) | 150 | 98.11% | 97.75% | 96.46% | 96.76% | Augmented images |
| fasterrcnn_resnet50_fpn | 10 | 54.73% | 77.35% | 54.58% | 61.88% | Augmented images |
| Faster R-CNN-MobileNetV3 | 20 | 85.84% | 50.85% | 45.10% | 46.93% | Augmented images |

***Fig. 3*** *Performance per object detection model trained*

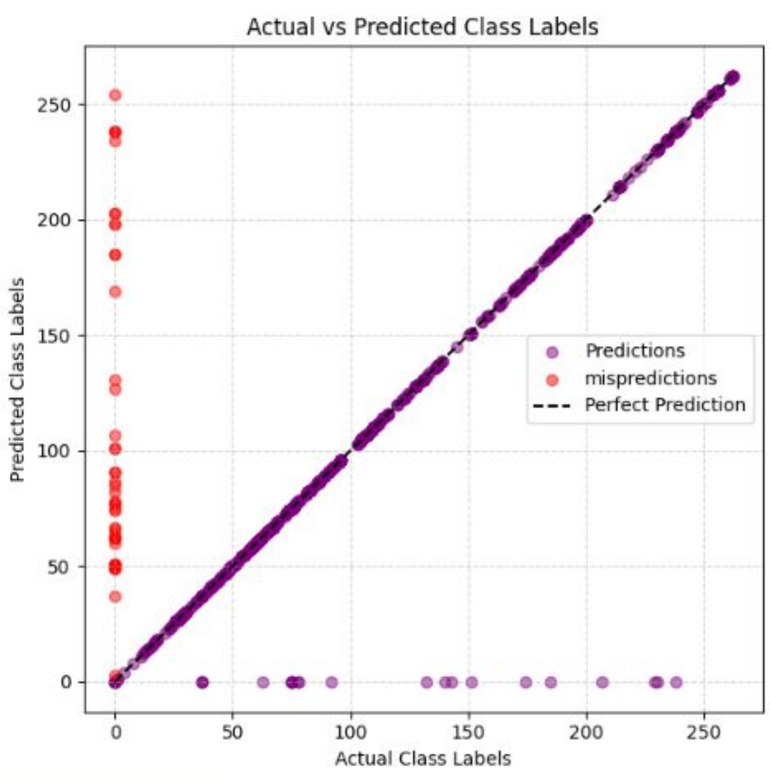


***Fig. 4*** *Object detection model actual labels vs predicted class labels scatter plot*

## Conclusion & Expectations

- This research demonstrates that computer vision can be applied to automate nutritional estimation using photos of meals. The approach is especially useful in resource-constrained settings, where traditional food tracking apps that require inputting weight information fall short.
- Further work is being done to improve the model's performance ie hyperparameter tuning and image augmentation to increase the dataset so as to improve prediction accuracy and generalization across diverse food types.
- The model is expected to be deployed and integrated into an Android application, enabling users to take a photo of their meal and receive instant feedback on sugar intake levels.

## References & Acknowledgment (if needed)

- goFOOD: An Artificial Intelligence System for Dietary Assessment
- Estimating Nutritional Content from Meal Images Using a Deep Food Detection and Regression Model

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