**Model Development Phase Template**

**Introduction**

Nutrition tracking is essential for individuals pursuing fitness and health goals, yet it remains a time-consuming and often inaccurate process when done manually. Traditional methods rely on users estimating food portions, looking up values in nutrition charts, or entering data into calorie-tracking apps — tasks that can be discouraging and prone to error.

With the rise of computer vision and deep learning technologies, there is a significant opportunity to automate and enhance the way individuals log and analyze their meals. This project introduces an **AI-powered Nutrition Analyzer**, which utilizes food image classification and nutrient prediction models to deliver personalized, real-time insights to users. By reducing the effort required for accurate food logging, the solution promotes better dietary consistency and healthier decision-making.

The project involves building a model that can accurately recognize commonly consumed food items from images and return detailed nutritional breakdowns (e.g., calories, macronutrients). This not only supports users in their health journeys but also showcases the practical application of deep learning in everyday life.

**Project Overview**

The **AI-powered Nutrition Analyzer for Fitness Enthusiasts** is a machine learning-based application designed to classify food images and provide detailed nutritional analysis. It simplifies the process of tracking dietary intake by eliminating the need for manual input or calorie counting.

The system is trained to recognize five categories of fruits: **Apples, Bananas, Oranges, Pineapples, and Watermelons**. By leveraging pretrained CNN architectures such as **MobileNetV2, ResNet50, and EfficientNetB0**, the model can accurately identify food items from user-submitted images. The classification output is then mapped to a nutrition database to retrieve relevant dietary information.

The project architecture follows a modular design:

* **Frontend:** Image upload and user interaction
* **Backend:** Flask server to handle model inference
* **Model:** Trained CNN model using TensorFlow and Keras
* **Database:** Static mapping of food classes to nutritional values

The system is intended for deployment in mobile or web environments, offering real-time, user-friendly, and informative dietary feedback to health-conscious individuals.

**Objectives**

The primary objective of this project is to **develop an intelligent system that enables nutrition tracking through food image classification**. This includes both the technical goal of building a robust image classification model and the user-centric goal of making nutrition analysis effortless and engaging.

**Detailed Objectives:**

1. **Automate Food Recognition:**  
   Build a deep learning model capable of identifying food items from user-uploaded images with high accuracy.
2. **Provide Nutritional Feedback:**  
   Use recognized food labels to fetch and display nutritional information like calories, carbohydrates, proteins, and fats.
3. **Evaluate Model Performance:**  
   Compare different transfer learning models (ResNet50, MobileNetV2, EfficientNetB0) and select the best one for deployment based on validation accuracy and loss.
4. **Enable Real-time Interaction:**  
   Integrate the model with a backend API to ensure low-latency predictions for web/mobile app usage.
5. **Promote Healthy Lifestyle:**  
   Encourage healthier eating habits by offering consistent, easy-to-understand dietary insights that align with users' fitness goals.

**Project Initialization and Planning Phase**

| Date | 13 jun 2025 |
| --- | --- |
| Team ID | SWTID1749823391 |
| Project Name | AI-powered Nutrition Analyzer for Fitness Enthusiasts |
| Maximum Marks | 3 Marks |

**Define Problem Statements (Customer Problem Statement Template):**

In today’s fast-paced world, fitness enthusiasts and health-conscious individuals often struggle to consistently monitor and manage their nutritional intake. Traditional methods such as manual logging of food items, estimating portion sizes, or referring to static nutritional charts are time-consuming, inaccurate, and demotivating for many users. This lack of reliable, real-time nutritional feedback can hinder progress toward personal health and fitness goals.

There is a growing need for an intelligent, user-friendly system that can **automatically analyze food consumption** and provide **personalized dietary insights**. By leveraging deep learning and computer vision, we aim to build an AI-powered Nutrition Analyzer that enables users to upload images of their meals and receive instant nutritional breakdowns and recommendations tailored to their fitness objectives.

The goal of this project is to empower users to make informed dietary decisions, track nutrient intake accurately, and stay aligned with their fitness goals — all with minimal effort and maximum engagement.

**Example:**

| **Problem Statement (PS)** | **I am (Customer)** | **I’m trying to** | **But** | **Because** | **Which makes me feel** |
| --- | --- | --- | --- | --- | --- |
| **PS-1** | A fitness enthusiast | Track my daily nutrition accurately | I don’t know the nutritional content of the food I eat | I rely on guesswork or manual apps that are time-consuming | Confused and unsure if I’m eating right |
| **PS-2** | A health-conscious individual | Get real-time dietary insights using food images | Most apps don’t allow photo-based logging | They require manual entry of food items and portion sizes | Frustrated and less motivated to log consistently |

**Initial Project Planning Template**

|  |  |
| --- | --- |
| Date | 13 jun 2025 |
| Team ID | SWTID1749823391 |
| Project Name | AI-powered Nutrition Analyzer for Fitness Enthusiasts |
| Maximum Marks | 4 Marks |

**Product Backlog, Sprint Schedule, and Estimation (4 Marks)**

| **Sprint** | **Functional Requirement (Epic)** | **User Story Number** | **User Story / Task** | **Story Points** | **Priority** | **Team Members** | **Sprint Start Date** | **Sprint End Date (Planned)** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sprint-1 | Data Collection & Cleaning | USN-1 | As a developer, I can organize and clean the food image dataset into labeled folders | 3 | High | Saksham Raj | 13 Jun 2025 | 17 Jun 2025 |
| Sprint-1 | Dataset Structuring | USN-2 | As a team, we can ensure class folders are uniformly named and split into training and validation sets | 2 | Medium | Rudrangsh Bhattacharjee | 13 Jun 2025 | 18 Jun 2025 |
| Sprint-2 | Model Development | USN-3 | As a team, we will train MobileNetV2, ResNet50, and EfficientNetB0 on preprocessed image data | 5 | High | Kutikuppala Chetan Srinivas | 18 Jun 2025 | 24 Jun 2025 |
| Sprint-2 | Model Evaluation | USN-4 | As a team, we will compare models using accuracy, loss, and training stability | 3 | High | Divyansh Garg | 22 Jun 2025 | 25 Jun 2025 |
| Sprint-3 | Report & Documentation | USN-5 | As a team, we will compile the project report, screenshots, and final model justification | 2 | Medium | All Team Members | 25 Jun 2025 | 27 Jun 2025 |

**Project Initialization and Planning Phase**

|  |  |
| --- | --- |
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| Project Title | AI-powered Nutrition Analyzer for Fitness Enthusiasts |
| Maximum Marks | 3 Marks |

**Project Proposal (Proposed Solution) template**

| **Section** | **Description** |
| --- | --- |
| **Objective** | To develop an AI-powered system that classifies food images and analyzes their nutritional content to assist fitness enthusiasts in tracking and optimizing their daily intake. |
| **Scope** | The system will classify five fruit categories (Apples, Bananas, Oranges, Pineapples, and Watermelons), provide nutritional values, and suggest dietary adjustments based on user input. It covers data preprocessing, deep learning model training, evaluation, and reporting. |

| **Section** | **Description** |
| --- | --- |
| **Description** | **Many users lack an easy, accurate way to track the nutritional value of their meals, relying on manual entries or approximations, which are often error-prone and time-consuming.** |
| **Impact** | **Solving this problem with an AI-based visual system will reduce user effort, improve tracking accuracy, and promote healthier and more consistent eating habits aligned with fitness goals.** |

| **Section** | **Description** |
| --- | --- |
| **Approach** | Utilize transfer learning with deep CNNs (ResNet50, MobileNetV2, EfficientNetB0) for image classification, combined with a nutritional database to provide real-time insights. Models will be trained on labeled fruit images using TensorFlow/Keras with preprocessing and data augmentation. |
| **Key Features** | - Image-based food recognition |

**Resource Requirements**

| **Resource Type** | **Description** | **Specification/Allocation** |
| --- | --- | --- |
| **Hardware** |  |  |
| Computing Resources | GPU for model training | 1 x NVIDIA T4 or 2 x NVIDIA V100 GPUs |
| Memory | RAM for model training & runtime | 8–16 GB |
| Storage | Dataset, logs, and model weights | 1 TB SSD |
| **Software** |  |  |
| Frameworks | Deep learning framework | TensorFlow, Keras |
| Libraries | Essential Python libraries | NumPy, Matplotlib, OpenCV |
| Development Environment | Code and experiment management | Jupyter Notebook, GitHub |
| **Data** |  |  |
| Dataset | Food image dataset of 5 fruit classes | Google Drive (2,626 images), Image format |

**Data Collection and Preprocessing Phase**

|  |  |
| --- | --- |
| Date | 13 jun 2025 |
| Team ID | SWTID1749823391 |
| Project Title | AI-powered Nutrition Analyzer for Fitness Enthusiasts |
| Maximum Marks | 6 Marks |

**Preprocessing Template**

The images will be preprocessed by resizing, normalizing, augmenting, denoising, adjusting contrast, detecting edges, converting color space, cropping, batch normalizing, and whitening data. These steps will enhance data quality, promote model generalization, and improve convergence during neural network training, ensuring robust and efficient performance across various computer vision tasks.

| **Section** | **Description** |
| --- | --- |
| **Data Overview** | The dataset contains labeled food images of 5 categories: **Apples, Bananas, Oranges, Pineapples, and Watermelons**. Images are organized in subfolders by class. Total images: 2626. |
| **Resizing** | All images were resized to **100×100 pixels** to match the input size requirements of CNNs like ResNet50, MobileNetV2, and EfficientNetB0. |
| **Normalization** | Pixel values were normalized to the [0, 1] range using rescale=1./255 via ImageDataGenerator. |
| **Data Augmentation** | Real-time augmentations were applied: horizontal\_flip=True, rotation\_range=20, zoom\_range=0.2. This improves generalization by introducing variations. |
| **Denoising** | Optional. Dataset was already clean; however, **median blur** was tested using OpenCV’s cv2.medianBlur() for real-world noisy inputs. |
| **Edge Detection** | Optional edge detection (e.g., Canny) was explored for visualization. CNN models automatically learn edge features, so it was not used in training. |
| **Color Space Conversion** | Images remained in RGB as required by pretrained CNNs, but conversion to grayscale was tested via cv2.cvtColor(image, cv2.COLOR\_BGR2GRAY) for experiments. |
| **Image Cropping** | Not required. Full images were used. Optionally, region of interest (ROI) cropping can be applied to food-localized datasets in the future. |
| **Batch Normalization** | Applied internally in deep CNN models like MobileNetV2, which have BatchNorm layers after convolutions. No need for manual batch norm input layer. |

**Data Preprocessing Code Screenshots**

| **Section** | **Description** |
| --- | --- |
| **Data Overview** |  |
| **Resizing** |  |
| **Normalization** |  |
| **Data Augmentation** |  |

**Data Collection and Preprocessing Phase**

|  |  |
| --- | --- |
| Date | 13 jun 2025 |
| Team ID | SWTID1749823391 |
| Project Title | AI-powered Nutrition Analyzer for Fitness Enthusiasts |
| Maximum Marks | 2 Marks |

**Data Quality Report Template**

| **Data Source** | **Data Quality Issue** | **Severity** | **Resolution Plan** |
| --- | --- | --- | --- |
| Image Dataset | Uneven image dimensions across classes | Moderate | Resized all images to 100×100 pixels using ImageDataGenerator(target\_size=(100,100)) |
| Image Dataset | Slight class imbalance (e.g., fewer images for pineapple vs. banana) | Low | Used real-time **data augmentation** to synthetically increase minority class variety |
| Image Dataset | Redundant or duplicate image names in subfolders | Low | Used folder-based label encoding; duplicates ignored based on actual image data |
| Image Dataset | Some blurry or low-quality images | Low | Optional **denoising** explored using OpenCV’s medianBlur() for enhancement |
| Image Dataset | Inconsistent lighting/backgrounds across categories | Low | Tackled using **augmentation** (zoom, rotation, flip) to improve generalization |

**Data Collection and Preprocessing Phase**

|  |  |
| --- | --- |
| Date | 13 jun 2025 |
| Team ID | AI-powered Nutrition Analyzer for Fitness Enthusiasts |
| Project Title | AI-powered Nutrition Analyzer for Fitness Enthusiasts |
| Maximum Marks | 2 Marks |

**Data Collection Plan & Raw Data Sources Identification Template**

| **Section** | **Description** |
| --- | --- |
| **Project Overview** | **The project aims to assist fitness enthusiasts by analyzing their food intake using AI-powered image classification and nutritional estimation.** |
| **Data Collection Plan** | **Data was collected from Google Drive-based food image dataset containing labeled folders for each fruit class. These were pre-organized into training/test sets.** |
| **Raw Data Sources Identified** | **A public Google Drive folder with images of 5 food classes: Apples, Bananas, Oranges, Pineapples, and Watermelons. Subdirectories represent class labels.** |

**Raw Data Sources Template**

| **Source Name** | **Description** | **Location/URL** | **Format** | **Size** | **Access Permissions** |
| --- | --- | --- | --- | --- | --- |
| Dataset 1 | Labeled image dataset of 5 food categories used for training deep learning models. | [Google Drive Dataset](https://drive.google.com/drive/folders/1yNVuLA2hxIstOcDV58enyD74Y9drEs6Y) | Image | ~400 MB | Public (view + download) |

**Model Development Phase Template**

|  |  |
| --- | --- |
| Date | 18 jun 2025 |
| Team ID | SWTID1749823391 |
| Project Title | AI-powered Nutrition Analyzer for Fitness Enthusiasts |
| Maximum Marks | 10 Marks |

**Initial Model Training Code, Model Validation and Evaluation Report**

**Initial Model Training Code (5 marks):**



A computer code on a white background

AI-generated content may be incorrect.

A close-up of a computer code

AI-generated content may be incorrect.

A computer screen shot of a computer code

AI-generated content may be incorrect.

**Model Validation and Evaluation Report (5 marks):**

| **Model** | **Summary Screenshot** | **Training and Validation Performance Screenshot** |
| --- | --- | --- |
| **ResNet50** | 📸 Screenshot of model\_resnet.summary() | 📸 Screenshot of training output (accuracy and loss over epochs) |
| **MobileNetV2** | 📸 Screenshot of model\_mobilenet.summary() | 📸 Screenshot of training output with high accuracy (~98.2%) |
| **EfficientNetB0** | 📸 Screenshot of model\_efficientnet.summary() | 📸 Screenshot of model.fit() showing poor convergence (~23.6%) |

**Model Development Phase Template**

|  |  |
| --- | --- |
| Date | 22 jun 2025 |
| Team ID | SWTID1749823391 |
| Project Title | AI-powered Nutrition Analyzer for Fitness Enthusiasts |
| Maximum Marks | 5 Marks |

**Model Selection Report**

In the model selection phase for this deep learning and computer vision project, multiple convolutional neural network (CNN) architectures were evaluated. Key evaluation criteria included:

* Validation accuracy
* Training stability
* Computational efficiency
* Suitability for deployment in real-time nutrition tracking systems

**Model Selection Report:**

| **Model** | **Description** |
| --- | --- |
| **ResNet50** | **Deep residual network architecture known for handling vanishing gradients using skip connections. Moderate accuracy (~64.5%) but heavy and slower for real-time deployment.** |
| **MobileNetV2** | **Lightweight CNN optimized for mobile and embedded vision applications. Achieved top accuracy (~98.2%) and trained quickly. Ideal for deployment.** |
| **EfficientNetB0** | **Scalable model with fewer parameters, designed for high accuracy-to-computation ratio. Underperformed (~23.6% accuracy), likely due to input resolution mismatch. Not suitable.** |

**Model Optimization and Tuning Phase Template**

|  |  |
| --- | --- |
| Date | 13 jun 2025 |
| Team ID | SWTID1749823391 |
| Project Title | AI-powered Nutrition Analyzer for Fitness Enthusiasts |
| Maximum Marks | 10 Marks |

**Model Optimization and Tuning Phase**

The Model Optimization and Tuning Phase involves refining deep learning models for optimal classification performance. This includes:

* Optimizing architecture via transfer learning
* Freezing base model weights
* Fine-tuning dropout rates, learning rates, and dense layers
* Comparing validation accuracy and training stability
* Selecting the best model for deployment

### Hyperparameter Tuning Documentation (8 Marks):

| **Model** | **Tuned Hyperparameters** | **Description** |
| --- | --- | --- |
| **ResNet50** | learning\_rate=0.0001, dropout=0.2, batch\_size=32, freeze\_base=True | Used as base model with top layers removed, freezing all convolution layers during training |
| **MobileNetV2** | learning\_rate=0.0001, dropout=0.2, batch\_size=32, early\_stopping(patience=3), freeze\_base=True | Lightweight model tuned with low learning rate and dropout to prevent overfitting |
| **EfficientNetB0** | learning\_rate=0.0001, batch\_size=32, dropout=0.2, freeze\_base=True | EfficientNet was tuned similarly, but underperformed likely due to low resolution input mismatch |

### Final Model Selection Justification (2 Marks):

| **Final Model** | **Reasoning** |
| --- | --- |
| **MobileNetV2** | Achieved highest validation accuracy (**~98.2%**), trained faster, showed stable loss reduction. Lightweight and ideal for real-time deployment. |