Enhanced Food Detection & Nutritional Inference System

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Introduction & Problem Definition

- Food recognition from images is a challenging task.
- Visual similarity multiple items and mixed dishes makes food identification difficult.
- Lighting, angles, and presentation affect accuracy.
- Need an intelligent system that detects, understands, and estimates nutrition automatically.
- Image recognition of foods is a difficult and complicated activity since foodstuff is usually served in mishmash with various foodstuffs on the same plate.
- Food classification, unlike normal object detection, has to contend with a high visual similarity among various dishes with small changes in food texture, food color or garnish sometimes indicating vastly different food.
- Also, the lighting conditions, camera angles, shadows, and the ways of presentation also play a significant role that influences the quality of images and the accuracy of the model used. These variations make traditional methods of classifying images impractical in generalizing to real-world food images.

Dataset Overview

- Food-101 Dataset

  - Food images across 101 categories used for training.

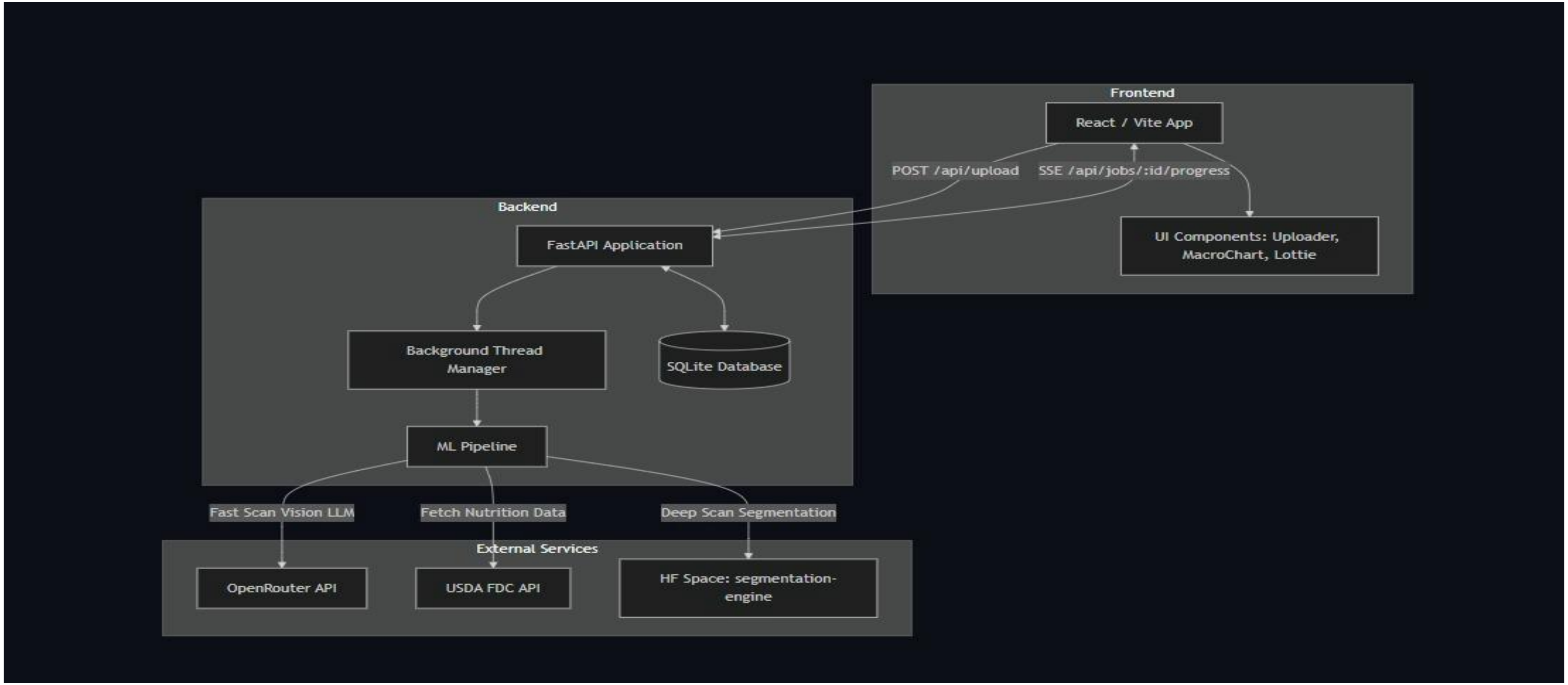
- UEC-Food256 Dataset

  - Food images with bounding box annotations for detection.

- USDA FoodData Central

  - Nutritional database used for calorie and macronutrient information.

Architecture



Data Cleaning

- Removed unnecessary and duplicate data
- Standardized image formats and sizes
- Normalized image quality for consistent input
- Harmonized dataset labels into a common format.
- In data preparation stage, data that was unnecessary and redundant were critically eliminated to enhance the quality of the data sets and prevent redundancy.
- The removal of repetitions or irrelevant images will ensure there is no model bias and better general efficiency of the training.
- Data cleaning was performed and then the image formats and sizes were standardized so as to have a homogenous sample.

Outlier and Missing Handling

- During data validation and cleaning stage, the data entries that were missing or invalid were also detected keenly to avoid errors in model training.
- Null values, inappropriate formats, and inconsistent metadata of the records were analyzed and corrected or deleted.
- The sample was filtered out to remove damaged image files or partially labeled data that was corrupted or not complete to preserve the quality of the dataset.
- Identified missing or invalid dataset entries
- Removed corrupted or incomplete samples
- Handled inconsistent annotations and labels
- Ensured balanced and reliable data quality
- Prepared stable dataset for model training.

Feature Engineering

- Contrast Limited Adaptive Histogram Equalization (CLAHE) one of the main ways of improvement was applied to increase the contrast of images, enriching the localized information without excessively boosting the noise.
- This method works best in images of food when the lighting conditions can change greatly.
- Applied image preprocessing techniques to improve quality
- Enhanced contrast using CLAHE
- Normalized image resolution and color distribution
- Generated structured inputs for model processing

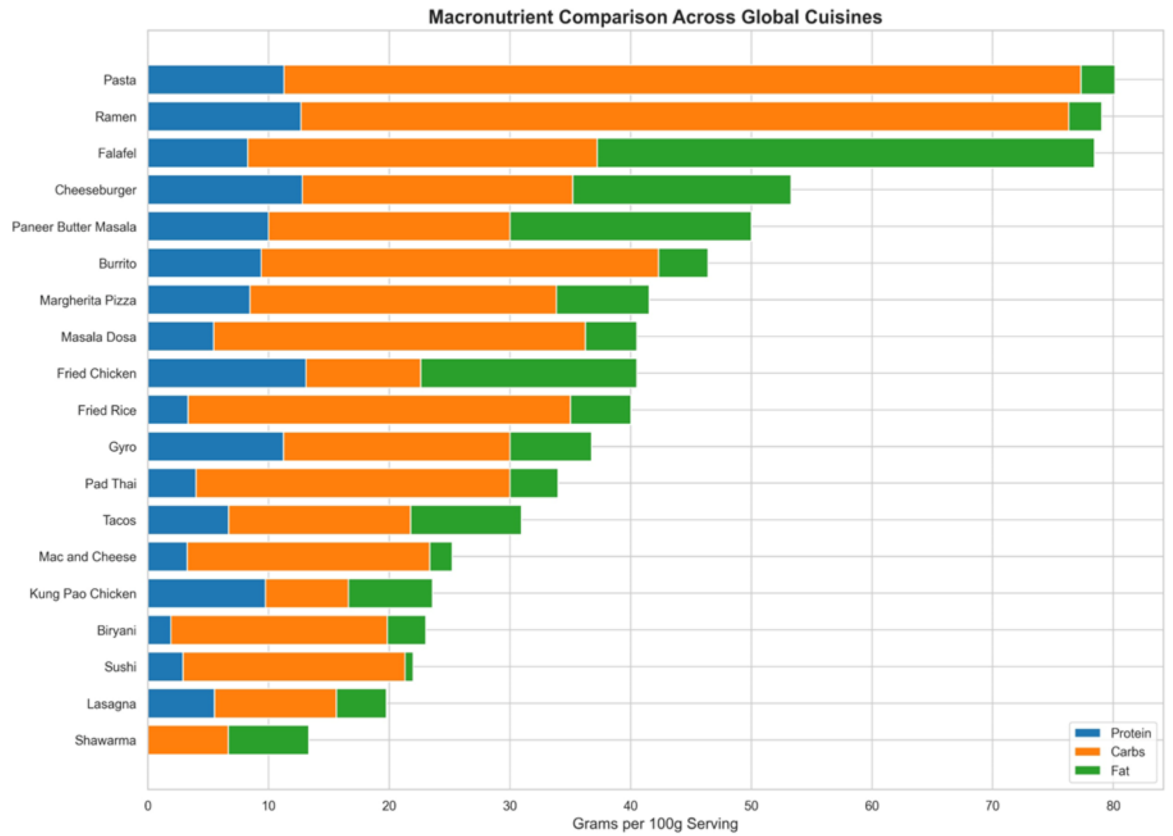
Feature Scaling

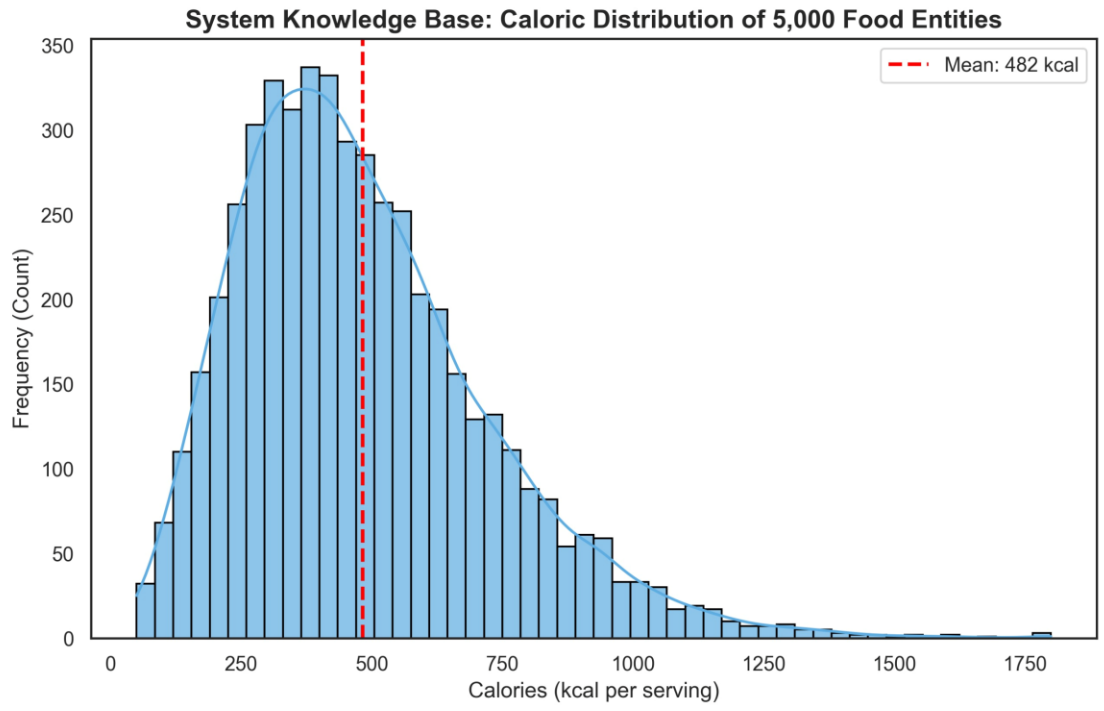
- Standardized image sizes for uniform model input
- Normalized pixel values for consistent training
- Reduced variation caused by lighting differences
- Improved model stability and learning performance

Exploratory Data Analysis

- Analyzed distribution of food categories across datasets
- Checked image quality, resolution, and variations
- Reviewed sample images and annotations
- Identified patterns to improve model training
- Observed class imbalance between food categories

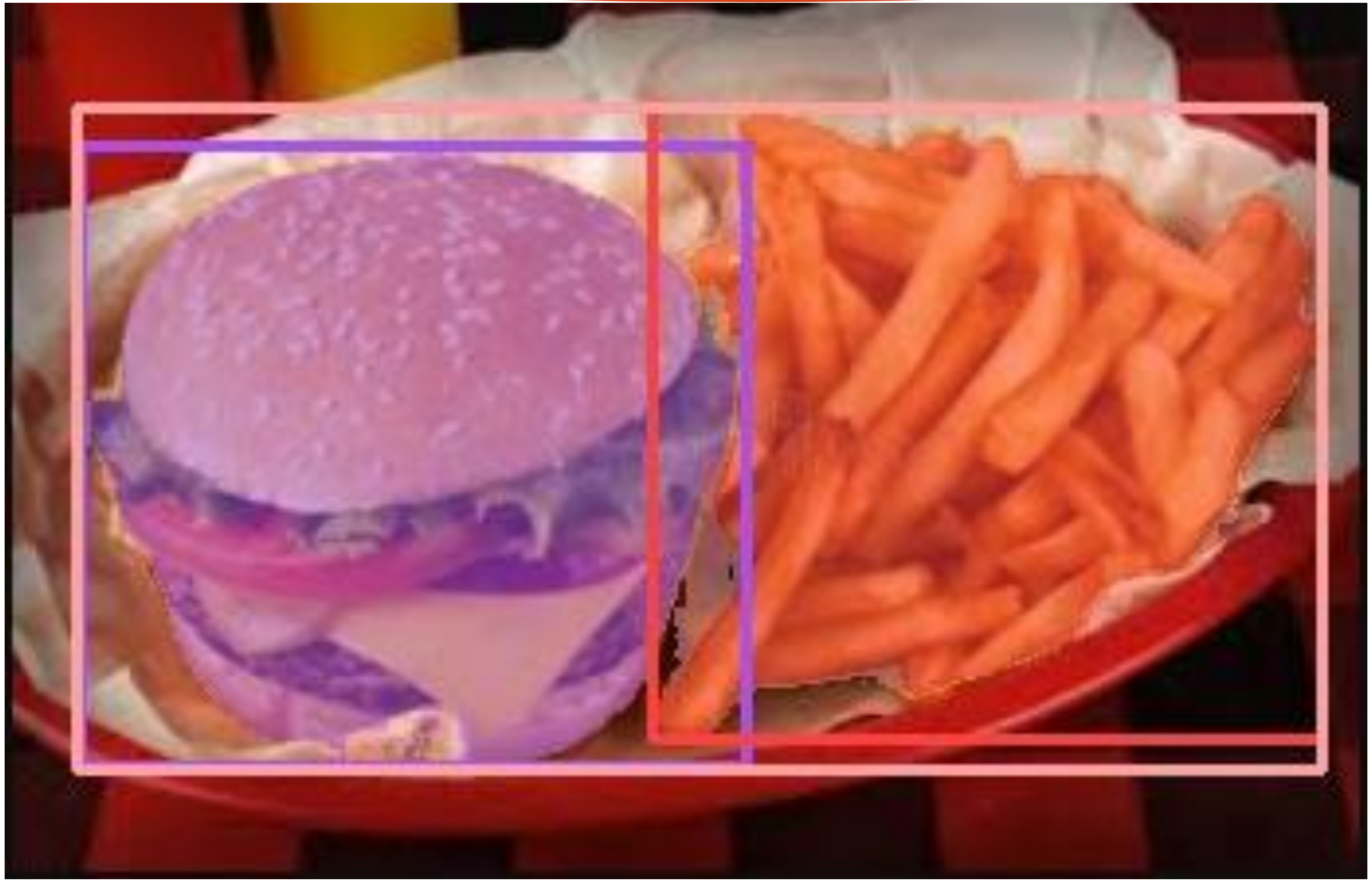
Macro nutrient & Caloric Distribution





Model Development Strategy

- Prepared cleaned and preprocessed dataset for training
- Used SAM for food object detection
- Applied bounding-box annotations for localization
- Integrated AI reasoning (gpt4o,Qwen-VLM) for food identification
- Connected model output with nutrition API for final results



Regression Model Implemented

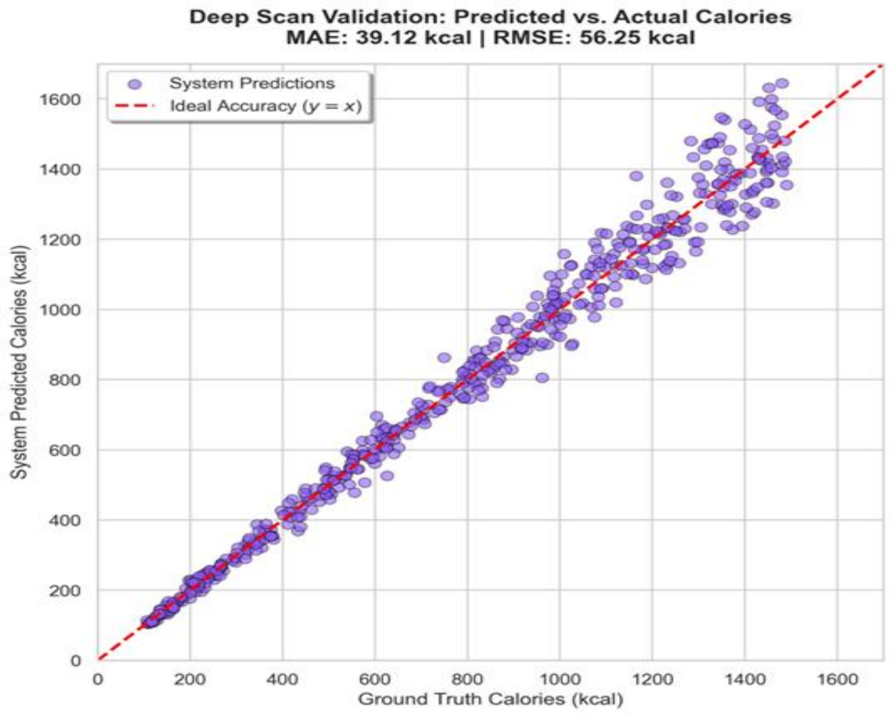
- AI-based food detection and identification system
- Vision-language reasoning using Gemini API
- Nutritional mapping using SQLite database
- Integrated backend processing with FastAPI
- End-to-end workflow connected to web application

Evaluation Metrics

- Detection accuracy of food items
- Precision and Recall for model performance
- Mean Average Precision (MAP) for detection
- Validation loss and training performance tracking
- Overall pipeline output verification

Baseline Results

- Initial model trained on prepared dataset
- Achieved stable food detection performance
- Correct predictions for majority of samples
- Some confusion in visually similar categories
- Results used as reference for further improvements



Cross Validation

- Model tested on different validation samples
- Performance checked on unseen data
- Ensured consistency across multiple runs
- Reduced risk of overfitting
- Improved reliability of predictions

Final Conclusion

- Developed an AI-based system for food detection and nutrition estimation
- Integrated object detection, AI reasoning, and database mapping
- Achieved strong localization and reliable nutritional output
- Project is in final integration and testing phase
- System is ready for completion and final demonstration

Tech Stack

- **Frontend:** React.js
- **Backend:** FastAPI (Python)
- **Database:** SQLite
- **AI Reasoning:** Gemini API
- **System:** Food detection & nutrition inference pipeline

Future Scope

- Improve model accuracy with larger datasets
- In another way to increase system performance, the accuracy of the models may be enhanced by training them on bigger and more diverse data sets.
- Food images that are taken in reality, under varying lighting conditions, angle, and cultural differences will increase the chances of the model generalizing and minimize misclassification.
- Artificial enhancement of the level of diversity of datasets and robust learning can also be achieved through data augmentation techniques.
- Add real-time food detection capability
- Extend system for mobile and cloud deployment
- Enhance nutrition estimation with advanced models

THANK YOU