EasyChef
Design Document

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Contents

Section 1: Introduction

1.1 Project Overview

EasyChef is an Android application designed to help users quickly find tasty recipes. The app's main feature is ingredient identification through image recognition, allowing users to take pictures of their ingredients and discover matching recipes.

1.2 Document Purpose

The purpose of this document is to provide a detailed blueprint for EasyChef's internal design. It covers a wide range of components involved in the system, including the architecture, technologies, algorithms, diagrams, and designs that are crucial to the application.

This document illustrates the interactions between different system components using sequence diagrams, class diagrams, and wireframes, providing a detailed overview of both the UX and database design.

Additionally, it outlines the estimated time required for each section of the application, the importance of each feature, and potential challenges that may arise during the development process.

Section 2: System Design

2.1 System Overview

As stated EasyChef is going to be created as an Android Application. The main features of the application are as follows:

- Image Recognition: Identifies ingredients captured in a photo from the user's Android device:
    - **Camera X**: Used to take pictures of ingredients at the user's discretion, providing the image input for identification.
    - **MobileNet**: A pre-trained model (trained on ImageNet and further on the Food-101 dataset) is used for accurate recognition of ingredients. Once recognised, the ingredients are added to a list and sent to the Spoonacular API.

- Recipe Retrieval: Fetches recipes based on the user's inputted ingredients:
    - **Ingredients for Recipes**: Users can add ingredients either manually or by scanning a barcode:
        - **ZXing**: An open-source barcode scanning library used to scan barcodes from food items.
        - **Open Food Facts API**: Once a barcode is scanned, it is sent to the Open Food Facts API to identify the matching ingredient or food item.
    - **Spoonacular API**: Recognised and inputted ingredients are sent to the Spoonacular API to find recipes that match the available ingredients.
    - **Open Food Facts API**: Used to retrieve additional information about ingredients, such as calories, carbohydrates, proteins, etc.
- **Shopping List Creation**: Allows users to manage the ingredients for their recipes and suggests items based on previous recipes:
    - **User Interface**: The shopping list is managed through a simple, intuitive interface where users can easily add, remove, and organise items.

    - **Component Flow:** The app utilises the data layer to fetch previously identified ingredients and recipes, generating personalised suggestions for what items to buy.

2.2 Data Storage Design

EasyChef will utilise Firebase as the primary data storage solution to ensure a reliable and seamless experience for users. The following is covered in the data storage design:

- **Database Type**: Firebase will be used as the data storage for EasyChef. Firebase offers a NoSQL database that is well-suited for storing hierarchical data like recipes, ingredients, and user information, as well as providing real-time synchronisation capabilities.
- **Data Categories**:
    - **User Data**: User profiles, including login information and preferences, will be securely stored in Firebase using its integrated authentication service.
    - **Ingredients and Recipes**: All recognised ingredients, manually added items, and recipe details will be stored in Firebase, enabling efficient retrieval and updates.
    - **Shopping Lists**: Shopping lists will also be stored in Firebase, allowing for easy management and access across multiple devices.
- **Data Synchronisation**: Firebase's real-time capabilities will ensure that data is synchronised across devices automatically. This feature allows users to access and update their data seamlessly.

- **Data Security**:
    - **User Authentication**: Firebase Authentication will be used to ensure only authorised users can access their personal information.
    - **Image Deletion**: To ensure privacy, all images used for ingredient identification will be permanently deleted after processing. This helps prevent unnecessary storage of user data and adheres to privacy best practices.

Section 3: Technologies Used

3.1 Android Studio

Android Studio: The official IDE for Android development.

- **Features**:
    - Tools for designing, coding, and debugging Android applications.
    - **Layout Editor**: Drag-and-drop layout editor for building UIs efficiently.
    - **Profilers**: Tools for monitoring app performance, memory usage, and network activity.
- **Why It's a Good Choice**: Android Studio is the official IDE, packed with features tailored for Android development. Its deep integration with Android tools and services makes it the best choice for building, testing, and optimising the EasyChef app efficiently.

3.2 Koitlin

Kotlin: The main programming language used for developing the EasyChef Android application.

- **Features**:
    - **Concise Syntax**: Reduces boilerplate code compared to Java.
    - **Null Safety**: Prevents null pointer exceptions, leading to more robust applications.
    - **Interoperability**: Fully interoperable with Java, allowing seamless integration of existing Android components.
- **Why It's a Good Choice**: Kotlin is officially supported for Android development and offers a modern, expressive syntax that makes coding simpler and less error-prone. Its features make the app more maintainable and reliable.

3.3 Firebase Firestore

Firebase Firestore: A NoSQL cloud database used for storing ingredient history and scanned items.

- **Integration**: Integrates directly with Android via SDKs.

- **Benefits**:
    - **Real-Time Synchronisation**: Data is synced across devices in real time.
    - **Offline Access**: Users can continue managing their ingredients and recipes even without an internet connection.
    - **Scalability**: The flexible data model is ideal for storing unstructured data like recipes and user preferences.
- **Why It's a Good Choice**: Firestore is highly scalable and offers easy integration with Android, making it suitable for storing recipe data and managing user interactions seamlessly. Real-time updates ensure the best user experience, especially for collaborative features like shopping lists.

3.4 CameraX

CameraX is a Jetpack library designed to make the process of integrating camera features into Android applications easier and more consistent across different devices.

- **Compatibility**: Supports Android 5.0 (API Level 21) and higher, ensuring broad device compatibility. The current version is Android 15.
- **Features**:
    - **Preview**: View live camera footage on the display.
    - **Image Analysis**: Access image buffers for further processing, such as ingredient identification.
    - **Image Capture**: Capture still images for use in identifying ingredients.
    - **Video Capture**: Record videos with audio.
- **Device Consistency**: Overcomes discrepancies between different cameras by using an automated test lab to standardise camera behaviour.
- **Extensions**: The Extension API includes features like HDR and night mode, enhancing the camera's capabilities.
- **Why It's a Good Choice**: CameraX simplifies camera integration across devices, minimising compatibility issues and reducing development time. Its

modern, easy-to-use interface makes it ideal for a project that heavily relies on image capturing for ingredient identification.

3.5 Tensoreflow Lie(Lite RT)

TensorFlow Lite is used for running machine learning models on mobile devices.

- **Purpose**: Optimised for on-device machine learning, TensorFlow Lite allows models to run without server connections, providing a fast, private, and reliable experience.
- **Key Features**:
  - **Low Latency**: Performs inference on-device, avoiding the need for network connections.
  - **Privacy**: Keeps data on-device, enhancing user privacy.
  - **Offline Capability**: No internet connection is required for using models.
  - **Lightweight**: Reduces the model size for optimal use on mobile devices.
- **Usage**: Models can be trained in TensorFlow and converted to .tflite format, or existing TensorFlow Lite models can be utilised.
- **Metadata**: TensorFlow Lite models can include metadata, simplifying pre- and post-processing pipelines.
- **Why It's a Good Choice**: TensorFlow Lite is highly efficient for on-device processing, which is essential for ingredient recognition without relying on internet access. Its small model size and optimised performance make it perfect for a mobile-based solution.

3.6 TensorFlow/Keras

TensorFlow/Keras: Used to train a custom machine learning model for ingredient detection.

- **Keras**: A user-friendly interface for TensorFlow that simplifies creating and training machine learning models.
- **Features**:
  - Offers simple, consistent APIs that reduce the complexity of writing ML models.
  - Includes pre-trained models for quick deployment and feature extraction.
  - Tools for data processing, hyperparameter tuning, and deployment.

- **Why It's a Good Choice**: Keras is known for its simplicity and flexibility, making it an ideal choice for prototyping and training custom ingredient detection models quickly. The integration with TensorFlow also means that models can be easily optimised and converted for mobile use.

3.7 MobileNet

MobileNet is a lightweight Convolutional Neural Network (CNN) architecture designed for mobile and embedded devices.

- **Purpose**: It is used for image classification and feature extraction with minimal computational resources.
- **Optimisation**: Uses **depthwise separable convolutions** to reduce the number of parameters and operations, making it lightweight.
- **Integration**: Can be paired with object detection frameworks, such as Single Shot Detector (SSD).
- **Why It's a Good Choice**: MobileNet is specifically designed for mobile environments, making it highly efficient for running on-device inference. Its lightweight nature ensures it runs smoothly on smartphones, which is perfect for real-time ingredient identification.

3.8 ZXing

ZXing ("Zebra Crossing") is an open-source library for barcode scanning.

- **Usage**: Used to scan 1D/2D barcodes from food items for easy ingredient input.
- **Implementation**: Implemented in Java, with ports to other languages, making it easy to integrate within Android.
- **Why It's a Good Choice**: ZXing is a well-established barcode scanning library with broad support and integration options. Its reliability and ease of use make it suitable for an app that needs to scan barcodes quickly to retrieve ingredient information.

3.9 Open Food Facts API

Open Food Facts API: A community-driven database providing information on various food products.

- **Purpose**: Used to retrieve ingredient details, nutritional values, and other product information.
- **Why It's a Good Choice**: Open Food Facts provides a vast amount of data for free, allowing for rich ingredient and nutritional information to be accessed. It helps provide accurate nutritional insights to users without additional development overhead.

3.10 Spoonacular API

Spoonacular API: A comprehensive API offering recipe suggestions, ingredient information, and meal planning tools.

- **Features**:
  - Provides a vast recipe database, ingredient nutritional information, meal planning, and cost estimation.
  - Offers detailed recipes filtered by dietary requirements and allergies.
- **Cost**: This is a paid service offering advanced features.
- **Why It's a Good Choice**: Spoonacular's vast recipe database, nutritional details, and advanced filtering options make it ideal for providing users with tailored recipe recommendations based on their available ingredients. Its depth of information and meal planning features make it highly versatile.

Section 4: System Architecture

4.1 Overview of System Architecture

The EasyChef application is designed to provide users with seamless functionality for identifying ingredients, suggesting recipes, and managing shopping lists. The system architecture brings together several key components, efficient data management, and external service integrations, ensuring a well-rounded user experience. The architecture includes the following main aspects:

1. **Core Components**:
   - The system is composed of several key components such as User Interaction, Image Processing, Recipe Management, and Data Storage. These components work together to deliver essential functionalities like ingredient recognition, barcode scanning, recipe recommendations, and shopping list management.
2. **Data Management**:
   - Firebase Firestore is used as the primary data storage solution for storing user information, identified ingredients, shopping lists, and

recipe preferences. Data management is designed to ensure real-time synchronisation across devices while also supporting offline capabilities for a seamless user experience.

3. **Integration with External Services**:
    - The application integrates with various external APIs to enrich its functionality:
        - Spoonacular API for fetching recipe suggestions based on the identified ingredients.
        - Open Food Facts API for providing detailed nutritional information.
        - ZXing for barcode scanning, allowing users to input ingredients more easily.

4.2 Component Architecture

The system architecture includes these main components:

- **User Interaction**:
    - Users interact with the app using the camera, chatbot, and manual input options.
    - User selections influence future recipe recommendations through stored preferences.
- **Image Processing**:
    - CameraX captures images, which are then processed using TensorFlow Lite.
    - The personally trained MobileNet-based model identifies ingredients within the image.
    - If the model struggles to classify an ingredient, users can manually input the ingredient name.
- **Recipe Management**:
    - Detected ingredients are sent to the Spoonacular API to fetch recipes.
    - Users can view recommended recipes, filter them based on dietary preferences, and save them for future reference.
- **Data Storage**:
    - Firebase Firestore is used to store user data, identified ingredients, and saved recipes.
    - Ingredient data and nutritional information are retrieved from Open Food Facts API.
    - Users' preferences, past recipe selections, and shopping lists are stored to personalise recommendations.

The interaction between these components is efficient and can be seen below:

- **User Interaction -> Image Processing**: The user captures an image, triggering ingredient detection.
- **Image Processing -> Recipe Management**: Detected ingredients are sent for recipe retrieval.
- **Recipe Management -> Data Storage**: Selected recipes and user preferences are stored for future recommendations.

4.3 Data Architecture

The data architecture is designed to efficiently handle ingredient recognition, recipe retrieval, and user preferences while ensuring real-time synchronisation across devices.

Data Categories and Storage Approach

- **User Data:** Stored in Firebase Firestore, including login credentials, preferences, and saved recipes.
- **Ingredient Data:** Identified ingredients are temporarily stored for recipe retrieval.
- **Recipe Data:** Recipes are fetched dynamically from Spoonacular API, with saved recipes stored in Firebase for quick access.
- **Shopping List:** Managed within Firebase, allowing users to track their commonly eaten ingredients.

Section 5: Detailed Use Cases

Use Case Name	Create Recipe
Unique ID	WW015
Actors	Users, Database, Spoonacular, AI Model
Description	This use case is initiated when a user selects create recipe. This feature will create a new recipe using the AI Model and the Spoonacular API. It will use like

	items from the user's liked foods and will prompt the user for recipe details. With the information it will display a recipe the user can save.
Preconditions	User is registered and logged in
Trigger	The user selects create recipe.
Main Path	1. The user prompts the system to create the recipe. 2. The recipe uses liked foods and prompts the user for extra information to create the recipe. 3. Once the user has input the data it will use the AI Model and Spoonacular API to display a recipe for the user. 4. The user accepts the recipe, and it gets added to the database for the user to view.
Post Conditions	The user has an added recipe in the database
Alternative Flows	4a: 4. The user rejects the recipe. 5. The system gets a new recipe and prompts it to the user.

Use Case Name	Take Picture of Ingredient
Unique ID	WW016
Actors	User, AI Model, Spoonacular API
Description	The user opens the camera in the app and take a picture that include all relevant ingredients they wish to be a part of the recipe. The AI Model will identify the items and search the Spoonacular API for a relevant recipe.

	The user is then shown recipes and they can decide whether they like it or not. If the user likes the recipe it will be added to the database.
Preconditions	- The user is registered and logged in. - The user has given the app permission to access the camera.
Trigger	The user opens the camera in the app.
Main Path	1. User opens the camera 2. The user takes a picture of the ingredients they wish to have in the recipe. 3. The AI Model then recognises the ingredients identifying each one and then making a list to send to the Spoonacular API. 4. The user will get prompted to take another picture to add more ingredients 5. The Spoonacular API then checks for a matching recipe and then it get displays to the user 6. The user then accepts the recipe and the recipe gets added to the database for the user to view.
Post Conditions	New recipe is added to the database
Alternative Flows	2a: 2. The user takes a picture of the barcode. 3. The item then gets checked against Open Food Facts API.

	4. The item is temporarily stored, and the user is prompted to scan again 3a: 3. The system cannot pick up any items. This can be due to poor picture or unclear items. 4. The system prompts the user to take another picture. 6a: 6. The user rejects the proposed recipe, and the system then finds a new one.

Use Case Name	Interact with AI Chat Bot
Unique ID	WW017
Actors	User, AI Model
Description	Using the OpenAI API as the base, this chatbot allows users to interact and talk about their recipes and shopping lists. Using the information from the AI Model (which contains like/dislikes) the chatbot will be able the help the user achieves the ideal recipe and shopping lists.
Preconditions	The user must be registered and logged into the system.
Trigger	The user selects the AI chatbot
Main Path	1. The user is logged in an has selected the chatbot. 2. The user prompts the chatbot with a question(“I want more protein in my diet”) 3. Using the information provided by the system, such as user

	recipes, shopping list, preferences the chatbot thinks of a response 4. The chatbot will respond prompting the user to reply again. ("A good solution would be to replace recipe X's chicken thighs with chicken breast, would you like me to make this change?") 5. The user accepts this change the recipe will be updated accordingly. ("Yes")
Post Conditions	The recipe has been updated in the database
Alternative Flows	5a. User Rejects Recommendation: 1. The user rejects the chatbot suggestion and no changes are made.

Section 6: Critical Algorithms

6.1 AI-Based Ingredient Identification

The AI-Based Ingredient Identification system enables users to take pictures of ingredients, which are then processed to detect and classify food items. This functionality is implemented using a trained model built on top of MobilNet in TensorFlow Lite, optimised for on-device performance.

Process Flow

1. **Image Capture**
   - The user captures an image using CameraX.
   - The image is resized to 224x224 pixels for compatibility with the model.
2. **Preprocessing**
   - The image is normalised and converted into a ByteBuffer format.
   - The TensorFlow Lite model processes the image to extract key features.

3. **Inference**
    - The model classifies the image, assigning confidence scores to detected ingredients.
4. **Post-processing**
    - The detected ingredients are mapped to their corresponding labels.
    - Users can confirm, or remove detected ingredients.

5. **Data Integration**
    - Confirmed ingredients are temporarily stored in Firebase Firestore.
    - The final ingredient list is passed to Spoonacular API..

Challenges and Considerations

- **Lighting Conditions** – Poor lighting and shadows may impact accuracy.
- **Similar Ingredients** – Visually similar foods (e.g., cauliflower vs. broccoli) may require user confirmation.
- **Performance Optimisation** – TensorFlow Lite ensures low-latency inference directly on the device.

6.2 Recipe Recommendation

The Recipe Recommendation system suggests recipes based on detected ingredients using the Spoonacular API. This ensures that users receive relevant recipes.

Process Flow

1. **Ingredient Input**
    - The ingredient list is retrieved from Firebase Firestore.
    - Users can add or remove detected ingredients before proceeding.
2. **Recipe Retrieval**
    - The Spoonacular API is queried with the confirmed ingredients.
    - The API returns recipes with ingredients and instructions.
3. **Filtering and Ranking**
    - Recipes are filtered based on user preferences (e.g., dietary restrictions).

- Recipes are ranked based on:
  - Ingredient Match % (how many provided ingredients match the recipe).
  - User Preferences (if the user has previously saved or liked similar recipes).

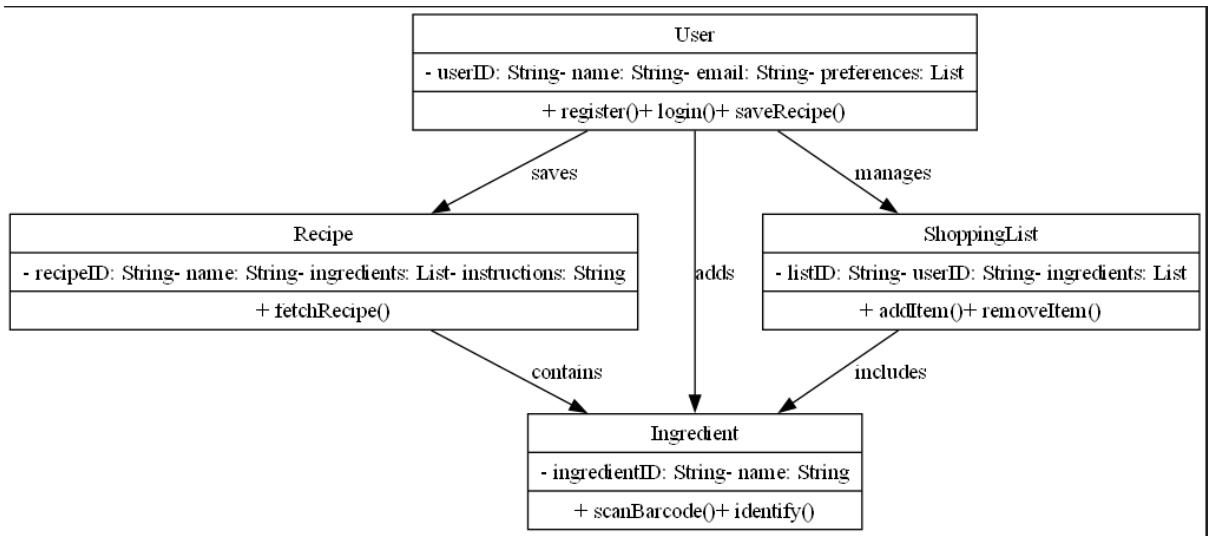
4. **User Interaction**
   - Suggested recipes are displayed with details.
   - Users can:
     - Save recipes to their profile.
     - Request new recommendations.
     - Modify ingredients and regenerate results.

Challenges and Considerations

- **Ingredient Substitutions** – The system must handle cases where an exact match isn't available.
- **User Preferences** – Ensuring personalised recommendations based on dietary needs.

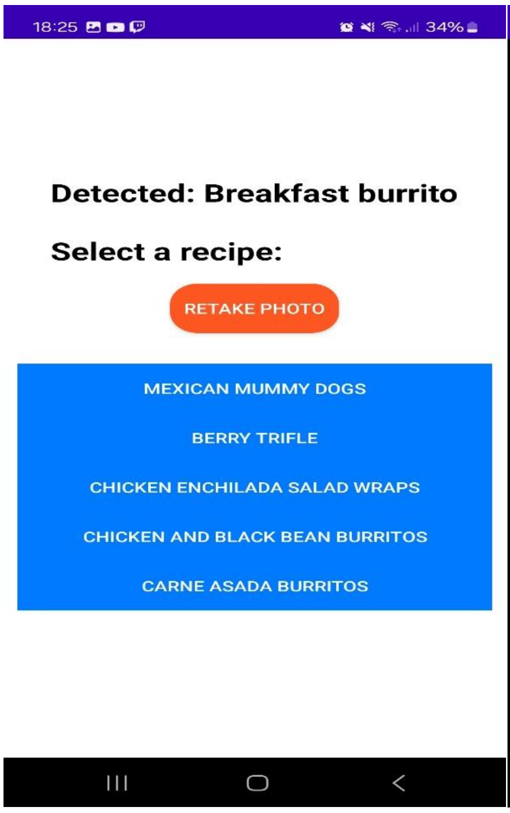
Section 7: Class Diagrams

7.1 Major Components (User, Recipe, Ingredient, etc.)



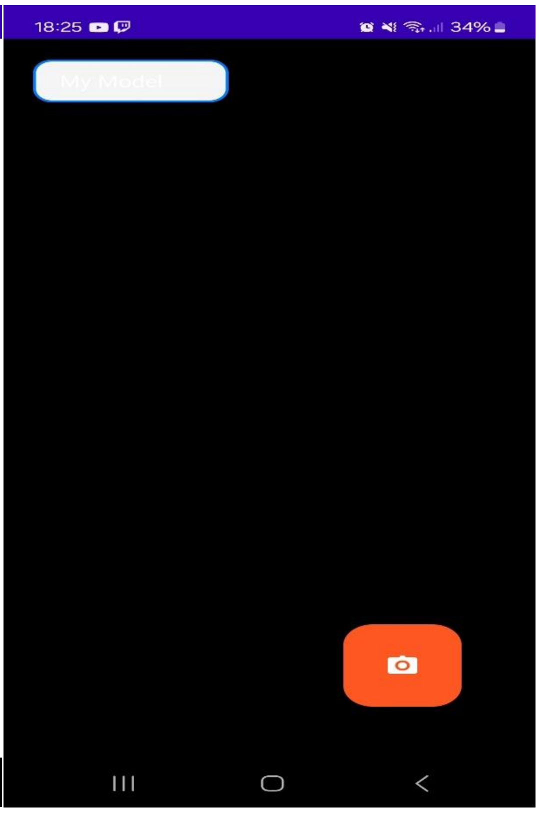
User
- userID: String- name: String- email: String- preferences: List
+ register()+ login()+ saveRecipe()
saves
manages
adds
Recipe
- recipeID: String- name: String- ingredients: List- instructions: String
+ fetchRecipe()
ShoppingList
- listID: String- userID: String- ingredients: List
+ addItem()+ removeItem()
contains
includes
Ingredient
- ingredientID: String- name: String
+ scanBarcode()+ identify()

Section 8: UI/UX Design


18:25 34%

Detected: Breakfast burrito

Select a recipe:



Section 9: Security Considerations

9.1 User Data Handling (GDPR compliance)

The app complies with the General Data Protection Regulation (GDPR) to ensure user data is handled securely and transparently. The following measures are implemented:

Data Storage & Retention

- User data (account details, saved recipes, preferences) is stored securely in Firebase Firestore.
- Ingredient and recipe data are stored temporarily for processing and deleted once processed.
- Users have the option to delete their account and all associated data upon request.

Data Encryption & Secure Transmission

- User passwords are securely stored using hashed and salted encryption mechanisms.

9.2 Authentication and Authorization

To protect user accounts and data, EasyChef implements secure authentication and role-based authorization mechanisms.

Authentication Mechanisms

- Firebase Authentication is used to securely manage user logins.
- Supports email/password authentication.

Authorization & Access Control

- The app follows **Role-Based Access Control (RBAC)**:
    - **Regular Users:** Can access their own saved data, shopping lists, and preferences.
    - **Admin (Future Feature):** Can manage general app settings and monitor system performance.

Session Management

- Uses secure session tokens to authenticate users after login.
- Session expiration is implemented to automatically log out users after a period

Section 10: Conclusion

10.1 Summary of the App Design

EasyChef is designed to simplify meal planning through AI-powered ingredient recognition, recipe recommendations, and shopping list management. Key features include:

- **Ingredient Identification:** A custom MobileNet model (TensorFlow Lite) for real-time detection(Also can be identified by barcode).
- **Recipe Recommendations:** Retrieves recipes from the Spoonacular API based on identified ingredients.
- **Nutritional Information:** Fetched from the Open Food Facts API.

- **User Authentication:** Firebase Authentication ensures secure login and data protection.
- **Shopping Lists:** Allows users to add and modify lists using Firebase Firestore.

10.2 Next Steps in Development

- Integrate Shopping List and Preferences, allowing frequently used ingredients to be stored and utilized for improved recipe recommendations.
- Implement User Login System using Firebase Authentication.