Revolutionizing Cooking with AI: From Ingredients to Recipes

by

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DECLARATION

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We declare that this thesis entitled *Revolutionizing Cooking with AI: From Ingredients to Recipes* is the result of our own work except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Dedicated to Almighty Allah —
All praise to Him for His endless mercy and guidance.
Dedicated to my beloved parents for their love and support, and to all who inspired and encouraged me along the way.

– Al Shahriar Ahommed Shanto

To my ever-loving and supportive parents,
whose sacrifices, prayers, and unconditional love have been my greatest strength.

– Antu Marma

To my respected teachers, mentors, and well-wishers,
whose knowledge and encouragement have shaped my academic journey.

– Tajmin Khanam

ABSTRACT

This project addresses the growing demand for personalized, intelligent cooking assistance by developing a feature-rich recipe application powered by Flutter and Google's Gemini AI. Most traditional recipe applications offer only static content that is limited in its ability to adapt to individual dietary requirements, preferences and available ingredients. Therefore, this project will provide a dynamic solution to meet these requirements using artificial intelligence to generate personalized recipes, recognize ingredients via images, and offer customized weekly meal plans. The overall goal of this project is to bridge the gap between generic and specific cooking instructions allowing home cooks to meet their unique, real-world challenges and objectives. The methodology follows a structured software development lifecycle, which starts with detailed requirements analysis and user-centered UI/UX design. The implementation of the technology used in the project is based on Flutter framework and the Gemini API (for Natural Language Processing and Computer Vision). Additional functionalities (features) will be created iteratively, starting with a basic ingredient recipe generation system and user profile and proceeding with implementing functionality to recognise images, include offline functionality and the creation of a weekly automated planner. The backend used for Users Authentication, Data Storage and Analytics is Firebase. The project will be tested to ensure the developed features meet users' needs through Functional Testing, User Acceptance Testing and Performance Testing against predefined Success Metrics.

Keywords: Recipe Generation, Flutter Development, Gemini AI, Personalization, Mobile Application

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1. Introduction

1.1 Background

The fast evolution of the Internet and Artificial Intelligence has influenced the ways people approach cooking and meal preparation greatly [10, 26]. With growing busy lifestyles, a number of people cannot cook healthy meals on a regular basis and lack adequate cooking skills; as a result, they utilize available foodstuffs inefficiently and contribute to food waste [1]. Even though many traditional recipes are available online, they usually do not offer personalized guidance, cater to individual tastes, or consider locally available ingredients . Consequently, users are increasingly demanding smart cooking assistants capable of providing adaptive and customized meal recommendations [4].

Smart cooking applications are based on AI technologies that simplify the cooking process and enhance the user experience through personalization. When choosing meals, users must consider factors such as preparation time, caloric value, nutritional content, dietary restrictions, and allergen avoidance [5, 11]. In the absence of proper guidance, individuals may repeatedly consume the same meals or prepare excessive quantities of food, leading to increased waste . To overcome these challenges, this project proposes a Smart Recipe Generator that produces personalized recipes based on user preferences, available ingredients, cooking time, dietary requirements, and health conditions. By providing ingredient lists, preparation instructions, difficulty levels, and time estimates, the system aims to promote healthier eating habits, reduce food waste, and make cooking more accessible for users with varying levels of culinary expertise [9, 26].

1.2 Problem Statement

This project aims at developing a smart and intelligent personalized cooking assistant, which aids users in their daily meal preparation. Despite the presence of numerous online recipe platforms, most of them do not take into account real-life factors, such as the availability of ingredients, dietary and other limitations, time constraints, and user preferences, leading to inefficient meal planning and low user experience [10, 26].

Users are usually unable to identify which ingredients to use with the available ones, resulting in monotonous meals, unhealthy eating habits, and unnecessary purchasing of food [14]. This lack of personalization and non-directional guidance also contributes to household food waste and reduces motivation to cook at home [36]. Moreover, existing systems seldom combine AI-based personalization, image-based ingredient recognition, and nutritional analysis into a single platform, which limits their efficiency and usability [3]. To solve these problems, this project proposes an AI-based Smart Recipe Generator that offers ingredient-sensitive, personalized, and health-conscious recipe recommendations to enhance cooking efficiency, promote healthier eating habits, and reduce food waste [26].

Key Problems Identified

- **Absence of Intelligent Decision Support:** Users find it difficult to identify appropriate recipes based on the ingredients they have, leading to redundant meals and poor dietary choices [24].
- **Scanty Personalization:** Current platforms fail to account for user preferences, allergies, calorie intake, or dietary requirements.
- **Issues on Food Waste:** Inefficient use of ingredients and lack of proper cooking guidance contribute to increased household food waste [36].
- **Time and Knowledge Constraints:** Busy schedules and limited cooking skills discourage home cooking.
- **Poor User Interaction:** Existing recipe applications do not offer interactive or adaptive features, such as personalized meal planning and intelligent recommendations.

1.3 Motivation

The proposed project entails the creation of a fully integrated Smart Cooking Solution leveraging advanced Artificial Intelligence technologies to address key challenges in contemporary meal preparation [9, 22]. The system is designed to act as a comprehensive cooking assistant, offering features such as recipe generation using available ingredients, personalized user profiles, management of favorite recipes, tracking of cooking history, and monitoring of nutritional intake [5]. Moreover, an administrative dashboard allows management of recipe types, users, popularity analytics, feedback collection, and report generation, ensuring that the platform evolves into a scalable, data-driven solution rather than remaining a prototype [26].

A major motivation behind this project is to empower home cooks to balance preferences, health goals, and cooking constraints. By using AI-based recipe generation, including image-based ingredient recognition and personalized recommendations, users can receive tailored suggestions based on the ingredients available at home [3]. Incorporating advanced AI technologies such as generative language models for recipe creation and computer vision models for ingredient identification allows the system to provide guidance comparable to that of a professionally trained chef. This approach encourages healthier eating habits, enhances cooking efficiency, and reduces food waste [11].

1.4 Objectives of the Project

The primary objective of this project is to design, develop, and evaluate a fully integrated intelligent automation-enabled Smart Cooking Platform (SC Platform) that supports users with automated meal preparation through Artificial Intelligence (AI) automation and personalized meal recommendations [1]. Based on this overall objective, the project establishes the following specific objectives:

- **Purpose of App Development:** The primary aim is to develop a highly functional smart recipe application featuring secure user authentication, ingredient-based recipe generation, personalized user profiles, cooking history and favorite management, nutrition tracking, partial offline accessibility, and recipe export functionality [3]. These features enhance usability, data security, and personalized user experience.

- **Purpose of Recommended Personalized Recipes:** Another key objective is to implement an intelligent recommendation system capable of learning user preferences such as spice level, preferred cuisines, allergy information, and health or fitness goals. By analyzing user behavior and preferences, the system delivers customized recipe suggestions that align with individual needs and dietary constraints [5, 26].

- **Purpose of Recognizing Images of Foods/Ingredients:** This objective focuses on integrating computer-vision-based ingredient recognition, allowing users to upload images of food or ingredients which are automatically identified by AI models. Based on recognized ingredients, the system generates relevant recipe recommendations, improving convenience and reducing manual input.

- **Create an Advanced Administration and Analytics Suite:** An advanced administrative dashboard is designed to manage recipes, monitor user activities, analyze popular cuisines and ingredients, process user feedback, and generate

usage statistics. These analytics assist administrators in system optimization and data-driven decision-making.

- **Facilitate Seamless Integration with Advanced AI Solutions:** This objective aims to ensure smooth integration among the front-end application, back-end services, AI models, and data storage components. Such integration enables real-time recipe generation, meal planning, nutrition analysis, and community-based interactions within a unified platform [22].

- **Review System Performance and User Satisfaction:** The final objective is to evaluate the system through comprehensive functional testing and user feedback collection. This assessment measures correctness, performance efficiency, usability, and overall user satisfaction, ensuring the system meets both technical and user-centered requirements.

1.5 Project Scope

The project is based on the creation and technology of an AI-based Smart Recipe Generator application enabling the user to make a meal depending on the ingredients they have at hand and their preferences. The system enables consumers to create recipes by typing in ingredients or scanning ingredients by AI. It offers individualized suggestions of recipes based on diet, allergies, food tastes, and wellness objectives.
The app allows managing user profile, saving of recipes, regeneration and partial offline access to already saved recipes. It has an administrative module that tracks apply usage, content, and system performance analysis. The project is restricted to software-based cooking assistance and the nutritional values are just estimations and are not designed to be really accurate.

1.6 Relevance to Real-World Applications

The project has significant implications for real-world use as it provides solutions to issues faced by families, individual consumers, health-conscious users, and stakeholders in the food service industry [9]. With the increasing number of people leading busy lifestyles while being more aware of health and environmental sustainability, the AI-based Smart Recipe Generator serves as an effective tool to facilitate daily meal preparation .
For families and individuals, the Smart Recipe Generator acts as a personal cooking assistant that simplifies meal preparation, reduces decision fatigue, and delivers nutritious recipes based on available ingredients [9]. Efficient utilization of ingredients contributes to minimizing household food waste, which in turn reduces economic and

environmental impacts. Furthermore, personalized recipe generation supports users with dietary restrictions, allergies, and health-related objectives, making it particularly beneficial for individuals managing medical conditions or following structured nutrition plans [15].

The food service sector also represents a strong real-world application for this system. Grocery retailers, health and wellness platforms, and smart kitchen ecosystems can leverage such AI-based applications to enhance user engagement and service delivery [22]. By integrating grocery stores and online grocery delivery services with the recipe generator, customers can be offered tailored recipes directly linked to purchased products, improving customer satisfaction and retention [32].

Additionally, health and fitness platforms can utilize the nutrition analysis and meal planning modules of the application to deliver value-added services. These tools enable users to better understand food nutrition and adopt healthier lifestyles. Through personalized meal planning and nutrition guidance, health and wellness platforms can enhance lifestyle management programs and design more effective wellness solutions for their users [15, 22].

1.7 Financial Planning and Timeline

1.7.1 Budget Estimation

This presents a comprehensive financial analysis and cost estimation for the development of a Flutter-based Recipe Application utilizing Google's Gemini API. The project involves multiple phases including research, development, testing, and deployment.

Table 1.1: Development Cost Breakdown from Planning to Deployment

Phase	**Key Items**	**Cost (TK)**
Planning (2 weeks)	Research, Design, Documentation	0
Setup (2 weeks)	Environment, Firebase, GitHub	0
Core Features (6 weeks)	Recipe Generator, User Profile, API calls	2400
Advanced Features (4 weeks)	Image Recognition, Meal Planner, API upgrades	9000
Testing (1 week)	QA, Bug fixes, Security	0
Deployment (1 week)	App Store fees, Build, Submission	14880

Total Direct Costs:

26, 280 TK

1.7.2 Gantt Chart

This Gantt chart outlines a 23-week project timeline divided into seven primary phases. The schedule follows a progressive structure where foundational strategy and research overlap with the beginning of the development cycle.

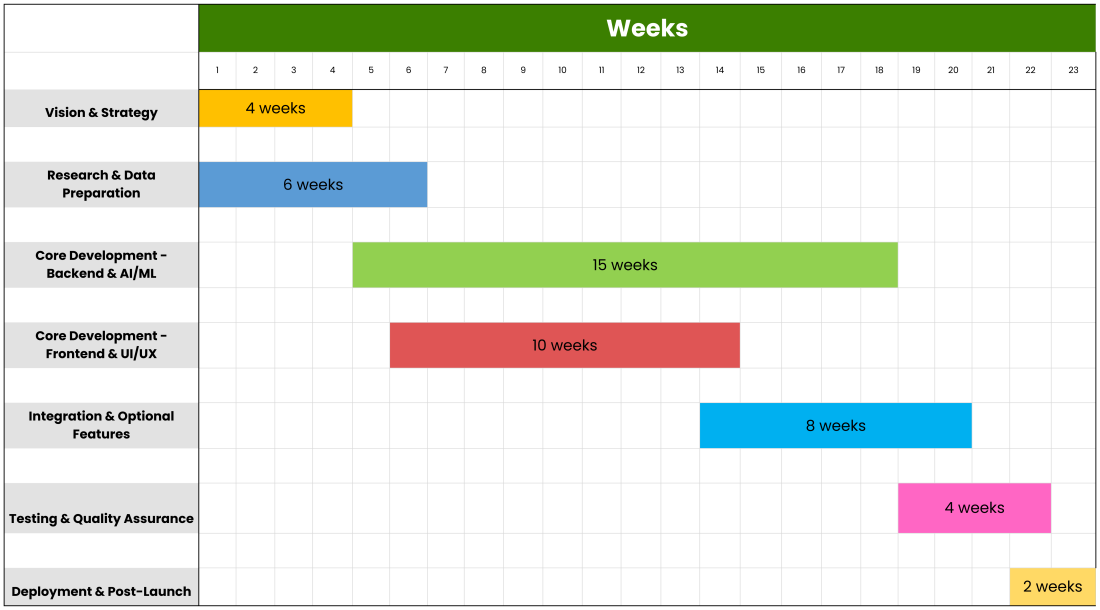

Figure 1.1: Gantt Chart of Develpment Process

1.8 Project Outline

Chapter 1: Introduction
The background for and rationale and objectives for the project; it describes how relevant the proposed system should be to real life, and it describes the report that follows.

Chapter 2:Literature Review
Review of the literature, looking back at existing research and technologies regarding intelligent recipe generation, AI-based recommendation systems, nutrition-aware meal planning, and image-based ingredient recognition. The discussion of current findings will allow the researcher to articulate the current problems and gaps that exist in the literature and that will be addressed through this proposed system.

Chapter 3: Methodology
The overall workflow of the system is described in this chapter, including user input processing, ingredient analysis, personalization logic, AI-generated recipe generation, nutrition assessment, and meal planning capabilities. Methods and methods of processing information using AI and methods of processing data using AI are described.

Chapter 4: System Design
The architecture of the smart recipe platform and contains base diagrams and descriptions of each component of the smart recipe platform - including the user interface (UI), the application server (back end), the database, and how the components of the smart recipe platform interact to provide a real-time personalized cooking assistance service.

Chapter 5: Implementation
The development of the elements in the application, including development of the user interface, management of user profiles, entering the user's ingredients, recognition of these ingredients via inputting a photo of them, generating recipes via AI generation, developing an admin page to control the inventory, and integrating AI resources. Additionally, development challenges are discussed throughout the development process, along with how to overcome them.

Chapter 6: Results and Discussion
This will provide an analysis of the effectiveness of the system based on functional accuracy of the output, the time cut-off for the response when boots and cook initially, user feedback, usability test scores, and the improvements to the whole cooking experience.

Chapter 7: Engineering Considerations
Covers ethical, societal, and environmental aspects of user data privacy and security, the ethical use of AI/ML, the health and nutrition responsibility we have, our environmental responsibility (sustainability) as well as scalability of the system.

Chapter 8: Conclusion and Future Work
Finally it will conclude with what our contribution and outcome has been. The chapter will make suggestions for what we can develop into the future, such as improved models for nutrition information, real-time cooking assistance, integration into smart kitchen devices, and use of mobile apps.

1.9 Summary

The Smart Recipe Generator is an AI-based application that helps individuals with hectic schedules to create healthy and time-saving recipes. Unlike traditional recipe platforms, it considers real-life factors such as available ingredients, cooking time, dietary restrictions, allergies, and individual taste preferences. Users can input ingredients manually or upload images, which are analyzed using artificial intelligence and computer vision techniques to generate personalized, step-by-step recipes [1].

The system also includes features such as recipe customization, offline access, favorite recipe storage, meal planning, and recipe sharing. By combining an intuitive user interface with AI-powered services and a scalable backend, the application aims to reduce food waste, promote healthier eating habits, improve cooking confidence, and provide a sustainable, user-centric solution to modern meal planning challenges [2].

2. Literature Review

2.1 Introduction

This chapter summarizes several key technologies and research utilized in the execution of this project. Through recent developments in areas such as artificial intelligence (AI), mobile computing, and image recognition technology, the user experience of food-related applications has changed dramatically [9, 10]. There has been a shift away from static recipe database applications toward more personalized, intelligent, and interactive systems that provide cooking support to consumers .
This literature review evaluates existing publications and systems for generating recipes based on specific ingredients , customizing recipes for individual users [5], identifying food images , analyzing nutritional value [9], providing offline capability , and developing community-driven solutions [2], all of which contribute to the development of AI-based recipe applications.

2.2 Ingredient-Based Recipe Generation

Traditional recipe recommendation systems have focused on providing recipes based solely on ingredients a user already has or on simple rule-based filtering of available recipes [1, 2]. For example, platforms like AllRecipes and Yummly provide recipes based on user-submitted ingredients. However, these systems generally do not accommodate dietary restrictions, age-specific requirements, caloric information, cooking time, or recipe difficulty .
With recent developments in Artificial Intelligence (AI), such as RecipeGAN [7], a new type of recipe generation has emerged using generative adversarial networks (GANs). This allows for the generation of realistic recipes that are consistent with the ingredients used, the preparation process, and the presentation of the final product . Despite these advances, most recipe generation systems still provide limited customization based on individual user preferences, which is a crucial requirement for modern intelligent recipe systems [4].

- The RecipeGAN architecture utilizes both global and local discriminators to evaluate recipe quality based on overall characteristics and stepwise evaluation

[7].

- There is an emphasis on the semantic relationship between ingredients and cooking techniques to reduce illogical combinations .
- Limitations of RecipeGAN include mode collapse (generating the same recipe repeatedly) and limited ability to represent rare or unique ingredients [19].

2.3 Smart Personalization in Food Applications

User-centered personalization is essential for increasing user satisfaction and engagement. Important functions of personalization include the ability to alter spiciness levels, select a preferred cuisine type, and manage allergy restrictions [9, 10]. Recent research indicates the need to incorporate user profiles that reflect previous recipe preferences, dietary restrictions, and preferred cooking styles to provide effective recommendations [5]. While current technologies allow for high levels of personalization, many existing systems do not adjust recipes to meet changing user needs, nor do they have the capacity to deliver personalized recommendations in real-time [22]. The AI Recipe App is designed to fill this gap by allowing users to dynamically adjust parameters such as spice level, amount of oil, and portion size based on their individual profile [9, 15].

- Various factors associated with cooking influence the way users select items [10].
- Using behavioral history to improve the accuracy of recommending recipes based on what users have previously enjoyed or prepared .
- Most past recommendation systems do not consider sudden shifts in user preferences or constraints when recommending flexible recipes [22].

2.4 Image-Based Recipe and Ingredient Recognition

The rise of computer vision technology has provided a new way of generating recipes from food photos; users take a snapshot, and the software determines which ingredient(s) are present [30]. One of the earliest examples of such a method was Im2Recipe, which utilized deep learning to assign actual recipes to user-uploaded food images . While these algorithms proved useful for creating basic recipes, complex or multi-stage recipes were difficult to handle, and many applications did not incorporate nutritional information or user-specific requirements [11, 22].
Our approach leverages Gemini AI technology to automatically identify ingredients in uploaded food photos while also considering user preferences for personalized recipe suggestions.

- Im2Recipe was developed using a combination of convolutional neural networks (CNNs) for image feature extraction and embedding-based approaches to retrieve recipes from images [8, 20].
- This work identifies several important challenges associated with identifying complex or multi-ingredient dishes .
- Additionally, few image-based systems incorporate user personalization and dietary restrictions to enhance usability [5].

2.5 Offline Access and User Convenience

The majority of recipe apps today require a constant internet connection, which severely limits usability in low-connectivity areas [16]. Examples of recipe applications that allow offline access to users' saved recipes include Paprika and Cookpad . By allowing offline access to stored recipes, these applications make it more convenient for users to find, prepare, and create meals [33].
The AI Recipe App proposes providing similar offline access to the user's most favorite and saved recipes, while continuing to offer all advanced AI features, including personalized recipe suggestions [22].

2.6 Analytics and Community Features

Contemporary recipe apps employ analytics to analyze the most commonly favored cuisine, food, and user engagement [10, 26]. Communities such as Tasty and AllRecipes allow social sharing for recipes, where users can upload, like, and comment on recipes . The use of AI to aid improvements in these recipes is minimal [9].
Our app uses the following Gemini AI capabilities:

- Improve recipes from the community based on taste, nutrition, and practicality .
- Evaluate popular cuisines and food ingredients [14].
- Collect user feedback to improve the system .

Key Points:

- Recipe sharing, which benefits the community, is further enhanced by the use of AI [9].
- Analytics help in understanding user behavior and preferences .

2.7 Identified Gaps in Existing Systems

Although considerable progress has been made, there remain certain gaps in current recipe applications:

- Lack of integration of image-based recognition solutions with personal recommendation services [20].
- Lack of real-time customization based on user preferences.
- Minimal offline AI capabilities [36].
- Limited AI involvement for the refinement of community recipes .

Generally, most available apps contain popular or standard recipes only and do not provide flexibility for unique recipes or custom menus [28].

2.8 Contribution of the Current Work

The proposed AI Recipe App fills these gaps in the following ways:

- Recipe creation based on ingredients with step-by-step cooking instructions, time, difficulty, and calorie calculation .
- Personalized user profiles that consider spiciness level, cuisine, and food allergies [24].
- Picture-based ingredient identification for auto-recipe suggestions [30].
- Offline viewing of saved and favorite recipes .
- Analytics for popular cuisine and ingredients [26].
- Community-based recipe creation, involving AI-assisted refinement and feedback .

All these factors come together in the app, and their contribution goes beyond improved usability to further the development of intelligent recipe systems that are centered on users [4].

2.9 Summary

This chapter provided an overview of previous research on the use of artificial intelligence in recipe generation. Conventional ingredient-based systems such as AllRecipes and Yummly can generate basic recipes, but they lack the flexibility required to adapt to individual user preferences and deliver personalized recommendations [1, 26]. State-of-the-art AI-based systems such as RecipeGAN generate more natural and realistic recipes using generative models; however, they often perform poorly when handling unconventional ingredients and diverse user preferences .

Research on personalized recommendation systems has emphasized the importance of user profiling, dietary restrictions, and food preferences to improve recommendation accuracy [5]. Additionally, image-based approaches such as Im2Recipe enable the detection of ingredients from food images, providing a novel method for recipe generation . Despite these advancements, significant gaps remain in the integration of image recognition with personalized recommendations, real-time customization, offline availability, and AI-assisted community recipe refinement [26, 36].

The proposed AI Recipe App addresses these shortcomings by integrating ingredient-based recipe creation, personalized user profiles, image-based ingredient recognition, offline functionality, analytics, and AI-powered community features. As a result, the system is optimized to enhance user experience, usability, and the overall effectiveness of intelligent recipe recommendation systems [15, 28].

3. Methodology

This AI-enabled recipe app provides users with an intuitive way to combine their input with AI and create customized meal experiences [4, 9]. The app allows users to input food items by text or photos, which then generates recipes based on the user's tastes and preferences . The app combines features that allow users to create recipes based on ingredients, utilize smart personalization, work offline, and provide a platform for recipe sharing and collaboration to effectively and efficiently find, create, and share recipes [5, 15].
The methodology describes how these features will be developed through the use of analytics and administrative tools [26]. The features include ingredient recognition, recipe generation from ingredients, nutritional content estimation, meal planning, and community interaction . The overall purpose of the methodology is to create a user-friendly environment that is adaptive, intelligent, and interactive, catering to users' culinary needs and improving the cooking experience [15].

3.1 System Architecture

The System Architecture was created to enable smooth integration between Front End, Back End, AI Modules, and Databases [15].

Front End Mobile/Web: Users access a mobile or web app to enter ingredients and images, follow step-by-step recipes, manage their profile (e.g., save favorite recipes), and share recipes with others . Users can also export printable versions of recipes [33].

Back End: This system manages authentication, user profiles, recipe storage, and provides API connections for AI modules. The back end also includes cached information for offline use and connects to databases for food and user history [**?**].

AI Modules: The application includes multiple AI modules to enhance user experience and provide advanced capabilities [4, 15]:

- **Recipe Creator by Ingredients:** Utilizes a GPT-based language model fine-tuned with recipe datasets to input ingredients, desired cooking time, and difficulty

level [28].

- **Image-based Ingredient Recognition:** Utilizes CNNs to scan and recognize ingredients in images via the Gemini platform [30].
- **Personalized Recipes:** Filters and ranks recipe recommendations based on user preferences and allergies.
- **Nutritional Value:** Provides caloric and nutritional information via ML models or nutrition APIs [9].
- **Meal Planner:** Uses optimization algorithms to create weekly meal plans based on user preferences and saved recipes .
- **Refined Community Recipes:** AI refines user-submitted recipes for consistency and quality [36].

Database: The Database stores user profiles, preferences, allergy data, recipes, history, and favorites, along with community submissions. It also supports caching recipes offline and saves user-generated analytics data [36].

3.2 Requirement Analysis

In our Requirement Analysis section, the key goal of the project is to create a Smart AI Recipe App that takes available ingredients along with user preferences and dietary restrictions to generate personalized recipes [24]. The Smart AI Recipe App also incorporates additional features such as image-based ingredient recognition, nutritional information estimation, offline availability, and community engagement [20, 21].

Functional Requirements include:

- **Recipe Generation:** Generates recipes from user-supplied ingredients considering preparation time, difficulty, calorie count, and step-by-step instructions [4].
- **Personalization:** Users can create profiles for spice level, favorite cuisines, and food allergies .
- **History/Favorites:** Users can save favorite recipes, revisit previously generated recipes, and create modified versions [15].
- **Images for Recipe Creation:** Users upload photos of ingredients or finished dishes, and AI detects ingredients for recipe suggestions .

- **Offline Mode:** Users can access previously saved or favorite recipes while offline [36].
- **Nutrition:** Recipes include estimated calories and nutritional breakdown .
- **Administrative/Analytical:** Application collects user information to analyze usage trends such as most-requested cuisines and ingredients [10].

Non-Functional Requirements:

- **Performance:** The app generates recipes, identifies ingredients, and provides personalized suggestions in a timely manner .
- **Scalability:** The app must support multiple users and AI requests simultaneously without significant performance loss [15].
- **Reliability:** Continuous access to saved and cached recipes, with backup and restore options .
- **Security/Privacy:** Users' profiles, preferences, and images are stored securely with encrypted data and restricted access [36].
- **Usability:** Intuitive and easy-to-use UI with step-by-step instructions .
- **Maintainability:** Modular design to facilitate upgrades, bug fixes, and new feature additions [22].

3.3 Workflow Methodology

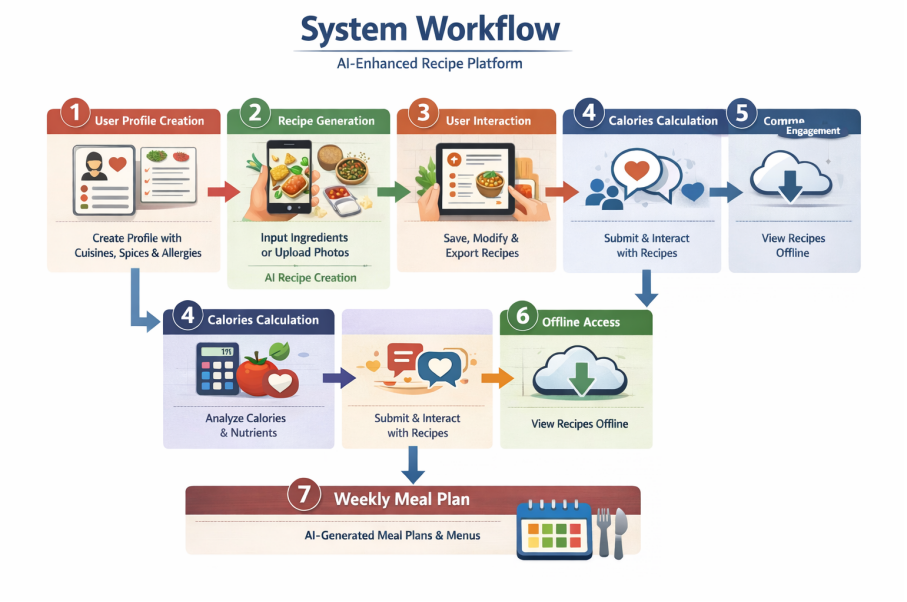

Figure 3.1: System Workflow Diagram

The system workflow was designed to provide a smooth, user-friendly experience while integrating AI-enhanced capabilities .

Step 1: User Profile Creation

Users create profiles with their favorite spices, cuisines, and allergies. Profiles are stored in the database for tailored recipe suggestions [24].

Step 2: Recipe Generation

Users input ingredients manually or upload images. Image Recognition AI identifies ingredients, and the Recipe Generator provides step-by-step instructions, estimated time, difficulty, calorie count, and personalized modifications .

Step 3: User Interaction with Recipes

Users can save, modify, or re-create recipes, as well as export recipes as PDF or image files. Recipe instructions remain step-by-step [36].

Step 4: Calories Calculation

AI calculates estimated calories and nutritional content based on ingredient quantities, helping users manage their diet .

Step 5: Community Engagement

Users submit recipe suggestions or prompts, which AI processes, standardizes, and makes available for engagement (liking, commenting, saving) by other users [36].

Step 6: Offline Functionality

Users can access favorite or previously found recipes offline .

Step 7: Weekly Meal Plan

AI generates weekly meal plans based on saved recipes, dietary needs, and user preferences, optimizing for variety and balanced calories [9].

3.4 AI/ML Implementation

An application that uses AI technologies has multiple intelligent modules to optimize how the user experiences, personalizes, and participates in the app as a community member [4]. Each module is responsible for completing different tasks within the app, including generating recipes using available ingredients , detecting ingredients in photos [30], calculating nutrition information , and developing a meal plan for the upcoming week [9]. The application will also enhance all the recipes submitted by users to improve quality and consistency [36]. A summary of the app's AI modules is provided in the table below, along with the data that was input into the modules, the outputs that will be generated by each module, and the AI methods/models used to develop the modules.

Table 3.1: AI Features in Recipe App

Feature	Input	Output	AI Technique
Ingredient-Based Recipe	Ingredients, time, difficulty	Recipe steps, calories, difficulty	GPT-based LLM
Image Recognition	Food/photo	Identified ingredients	CNN (Gemini)
Personalization	Profile (spice, cuisine, allergies)	Ranked recipe suggestions	ML scoring / collaborative filtering
Nutrition Info	Ingredients, quantities	Calories & nutrients	API or regression model
Meal Planner	Saved recipes, preferences	Weekly meal plan	Constraint-based optimization

3.5 Testing and Validation

To guarantee dependability and satisfaction among users, the application is put through stringent evaluations [4]:

- **Single Unit Testing:** Testing each module of artificial intelligence (AI) independently for precision, including recipe generation, image-based ingredient detection, and nutrition calculation [11].
- **Integration Testing:** Verifying effective connection between each of the components, i.e., back-end, front-end, and AI modules [36].
- **User Acceptance Testing (UAT):** Confirmation of offline capability, meal planner functionality, engagement with other users, and personalization of the product .
- **Performance Testing:** Confirmation of the time it takes for AI to produce recipes and identify food items based on the submitted image .
- **Analytics Validation:** Determines if the trends of popular dishes, ingredients, and user response to them are recorded accurately in the collected data [**?**, 22].

3.6 Tools and Technologies

3.6.1 Development Environment and Tools

The development environment includes Flutter for cross-platform application development , Firebase for backend services , and GitHub for version control and collaboration

[15]. Testing tools such as Flutter Test, Firebase Test Lab, and Postman were used for ensuring application quality [15].

3.6.2 Programming Languages and Frameworks Used

- **Frontend**: Flutter (Dart) – for cross-platform mobile and web applications [9].
- **Backend**: Firebase (Authentication, Firestore, Cloud Functions) – for user management, data storage, and serverless logic [9].
- **AI/ML Services**:
  - Google's Gemini API – for natural language processing (recipe generation) and image-based ingredient recognition .
  - Nutrition API (Edamam) – for calorie and nutrient estimation [11, 9].
- **Database**: Firebase Firestore (NoSQL) – for storing user profiles, recipes, favorites, and analytics .
- **Version Control**: GitHub – for collaborative development and version tracking [15].
- **Testing**: Flutter Test, Firebase Test Lab, Postman – for unit, integration, and performance testing [15].

3.6.3 Implementation Details by Module

- **Recipe Generator:** Uses Gemini API to generate recipes from ingredients or images with cooking steps, time, difficulty, and calories .
- **User Profile & Personalization:** Stores preferences (spice, cuisine, allergies) to tailor recipe suggestions [22].
- **Favorites & History:** Save, view, and re-generate recipes with modifications .
- **Image-Based Recognition:** Detects ingredients from photos and suggests recipes [20].
- **Offline Mode:** Access cached favorites and previous recipes without internet .
- **Nutrition:** Edamam API provides calorie and nutrient info .
- **Admin & Analytics:** Tracks popular cuisines, ingredients, and feedback via Firebase [26].
- **Recipe Export & Sharing:** Export recipes as PDF/images and share with the community .

3.6.4 Integration of Modules

All modules are integrated via Firebase services and APIs. The frontend communicates with the backend using Firebase Cloud Functions and Firestore for real-time data updates. AI services are invoked through API calls [15, 22].

3.7 Security and Privacy

The app provides safe and secure management of user data, including profile information and allergy information. Encryption of the data, secure storage, and control by users over what they share with others are top priorities to protect user privacy and build trust [15, 36].

3.8 Summary

Our Recipe Generator is made using a system that gives people recipes that are just right for them. This system starts by looking at ingredients or pictures in a way. Then it considers what the person using it likes and does not like. After that, it matches ingredients with recipes. The Recipe Generator ensures that the recipes it generates meet the user's preferences and dietary requirements, and are suitable for their cooking style [4, 9]. The Recipe Generator accomplishes all this to make sure the recipes are accurate, interactive, and user-friendly for a variety of input types.

4. System Design

4.1 Introduction

The aim of this chapter is to provide an overview of the system design for the Recipe Generator Application. An effective system design can provide a secure, scalable, and efficient solution. A structured approach to designing the system separates the main web application (responsible for user interaction, profile, and recipe management) from the application service (AI-based recipe generation). The main advantage of this architecture is that it improves the efficiency and scalability of both the application service and the AI-based recipe generation, allowing for seamless operation of the personalized recipes, ingredient-based recipes, and image-based recipes without degrading the responsiveness of the application [4, 15]. Diagrams are included in this chapter to aid understanding of the high-level architecture of the system.

4.2 Design Objectives

The Recipe Generator system was made to achieve several objectives. These include ensuring that all information about user profiles, preferences, and recipe history is stored securely and consistently, maintaining data integrity, and keeping the information accurate and up to date [15, 36].

- **Modularity and Scalability of Architecture:** To allow independent scaling and maintenance of the core application and the AI-driven recipe generation service .
- **High Security for Users:** To ensure secure authentication, protection against vulnerabilities, and encrypted communication for user data [22].
- **User-Friendly Design:** To provide users with an easy-to-use, responsive interface to browse, generate, and save recipes .
- **Performance Optimization:** To reduce latency and improve responsiveness through efficient queries, caching, and asynchronous processing [15].
- **Extensibility:** To ensure modularity that allows integration of future features such as new AI models, meal planners, or external recipe APIs .

4.3 Requirement Analysis

Analysis of requirements for the Recipe App involves understanding both the functional and non-functional requirements to ensure the system meets its intended functions properly [15, 21].

Functional Requirements:

- **Recipe Generation on the basis of Ingredients:** It allows users to input their preferred ingredients and generate a list of recipes based on attributes such as time, difficulty of preparation, and approximate calories [1, 3].
- **Personalization:** The system retains user profiles and preferences such as spice level, cuisine type, and allergies to personalize recipe suggestions .
- **History and Favorites:** Users can store favorite recipes, revisit previous creations, and optimize recipes with variations such as reduced oil or increased seasoning .
- **Image-Based Recipe Suggestions:** Users can upload images of food or ingredients, and the AI system identifies them and displays suitable recipes [1].
- **Offline Mode (Limited):** Cached recipes and favorites must be available offline without internet access .
- **Nutrition Information:** The system estimates nutritional information for recipes to aid healthier food preparation [9].
- **Admin and Analytics:** The application monitors popular recipes, ingredients, and user reviews [22].
- **Meal Planner & Recipe Export:** Users can generate weekly meal plans and export recipes as PDFs or images [22, 15].
- **Community Features:** Users can create recipe prompts and improve recipes with AI-assisted refinements .

Non-Functional Requirements:

- **Performance:** The app should respond promptly to inputs and requests [21].
- **Scalability:** It should support a growing number of users and recipes without degrading performance .
- **Security:** User data, preferences, and allergies should be stored and transmitted securely [22].

- **User Friendliness:** The interface should be intuitive, clean, and aesthetically pleasant .
- **Reliability:** The system should provide accurate recommendations with minimal downtime .

This ensures that the Recipe App is functional, user-friendly, secure, and delivers a high-quality personalized cooking experience [24].

4.4 System Architecture

The system architecture of the AI-powered Recipe Generator platform employs a microservices architecture to ensure scalability, performance, and maintainability [22, 36]. The microservices architecture separates core responsibilities and enables the recipe-generating engine, user management, and analytics service components to be developed and operated as independent services while still allowing communication and data interchange through secure API integration interfaces [15]. This architecture enables the platform to provide users with an efficient means of interacting with the system for recipe generation, processing of recipes, recognition of ingredients via images, providing personalized experiences for users, and offering administrative analytics, without causing slowdowns or performance bottlenecks . The architecture also isolates the AI services from the main web application, allowing complex AI computations to occur without degrading the user experience, while ensuring a more responsive, scalable, and future-proof system [22].

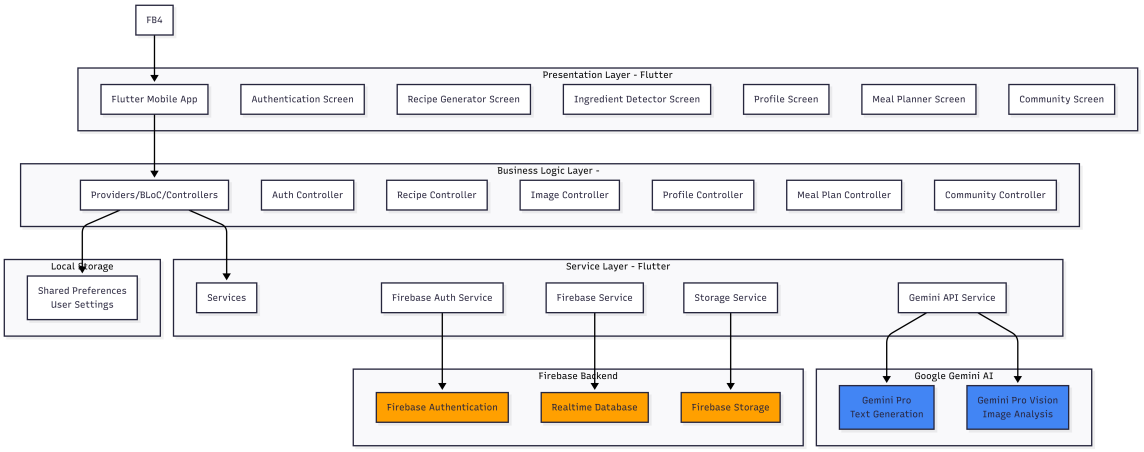

Figure 4.1: System Architecture

4.5 Software Development Life Cycle (SDLC)

Choosing the right Software Development Life Cycle (SDLC) is paramount for the success and risk management of the Recipe Generator project, which incorporates

complex AI capabilities via the Gemini engine . Various SDLC models were compared with respect to project-specific factors such as adaptability to requirement changes, prototyping capability, risk management, and integration with multiple technologies [15]. The Spiral Model was selected because it is iterative, risk-focused, and allows testing of AI outputs at early stages while integrating user feedback . It also supports hierarchical incorporation of multiple technologies such as Python/AI models and PHP/Redis/MySQL backend services [15]. Overall, the Spiral Model ensures a user-friendly, scalable, and efficient system for personalized AI-based recipe generation .

Table 4.1: Comparison of SDLC Models for Recipe Generator Project

Criteria	**Priority**	**Waterfall**	**Agile**	**Prototype**	**Spiral**
Handling High-Risk Features	5	No	Yes	No	Yes
Requirement Flexibility	5	No	Yes	Yes	Yes
Early Prototyping	4	No	Yes	Yes	Yes
Customer/User Feedback Frequency	5	No	Yes	Yes	Yes
Project Complexity Handling	4	Yes	Yes	No	Yes
Structured Planning & Documentation	3	Yes	No	No	Yes
Integration of Diverse Technologies	4	No	Yes	No	Yes
Risk Management Capability	5	No	Yes	No	Yes
Total Score	-	14	35	23	**40**

4.6 Data Flow Diagrams (DFD)

Data Flow Diagrams are used to represent the flow of data between different system components.

4.6.1 Level 0 Data Flow Diagram (DFD)

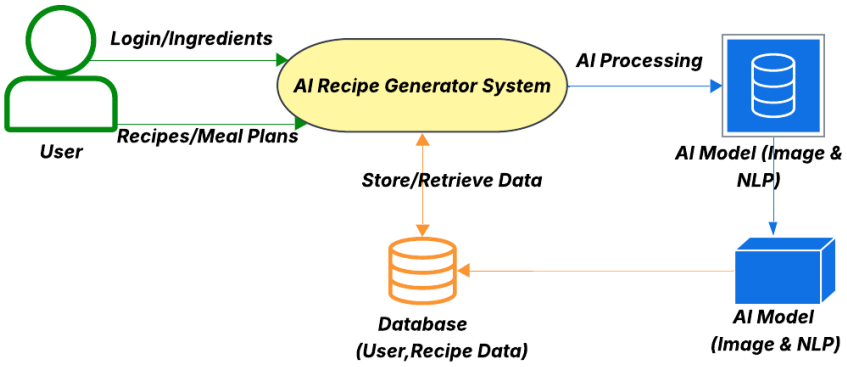

Figure 4.2: Level 0 Data Flow Diagram

The Level 0 Data Flow Diagram (DFD) provides a high-level overview of the AI-Based Recipe Generator System by illustrating the main interactions between the user, the system, the AI model, and the database. At this level, the entire system is represented as a single process where users provide inputs such as ingredients and personal preferences, which are then processed by the AI engine to generate personalized recipes and calorie-based meal plans . User profile information and recipe data are stored and retrieved from the database to support personalization and continuity across sessions [21]. The generated results are finally delivered to the user in the form of customized recipe recommendations, ensuring an efficient, user-friendly, and streamlined workflow within the system [22].

4.6.2 Level 1 Data Flow Diagram (DFD)

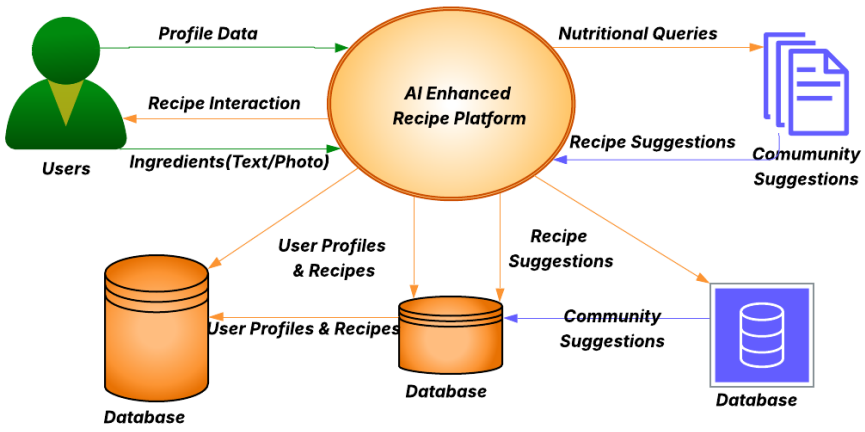

Figure 4.3: Level 1 Data Flow Diagram

The Level 1 Data Flow Diagram (DFD) of the AI-Based Recipe Generator provides a more detailed view of the key processes and data flows between users, system modules, and data repositories. The main interface of the Recipe Generator Mobile App allows users to register or log in, add ingredients manually, upload images of ingredients, create meal plans, post content, and receive personalized recipes . The system also supports community engagement, enabling users to submit recipes, like and comment on posts, and save content for future reference [15]. Overall, the Level 1 DFD illustrates the seamless integration of AI, data management, and user interaction to deliver a highly personalized and engaging user experience [18]. The application interacts with Google Gemini AI models to recognize ingredients in food images and generate stepwise recipes, ensuring accurate and contextually appropriate cooking instructions [16].

4.7 UML

4.7.1 Use Case Diagram

Figure 4.4: Use Case Diagram

Recipe Generator Use Case Diagram provides the functional requirements of the system as required by the users. Users are able to create and log in, update profiles, find recipes and ingredients, build recipes by typing or uploading ingredients, are able to save favorites, access history, plan meals, and export recipes in PDF and image file

formats. The diagram indicates the topmost elements that enable individualized recipe development and meal planning in order to have a better cooking experience.

4.7.2 Class Diagram

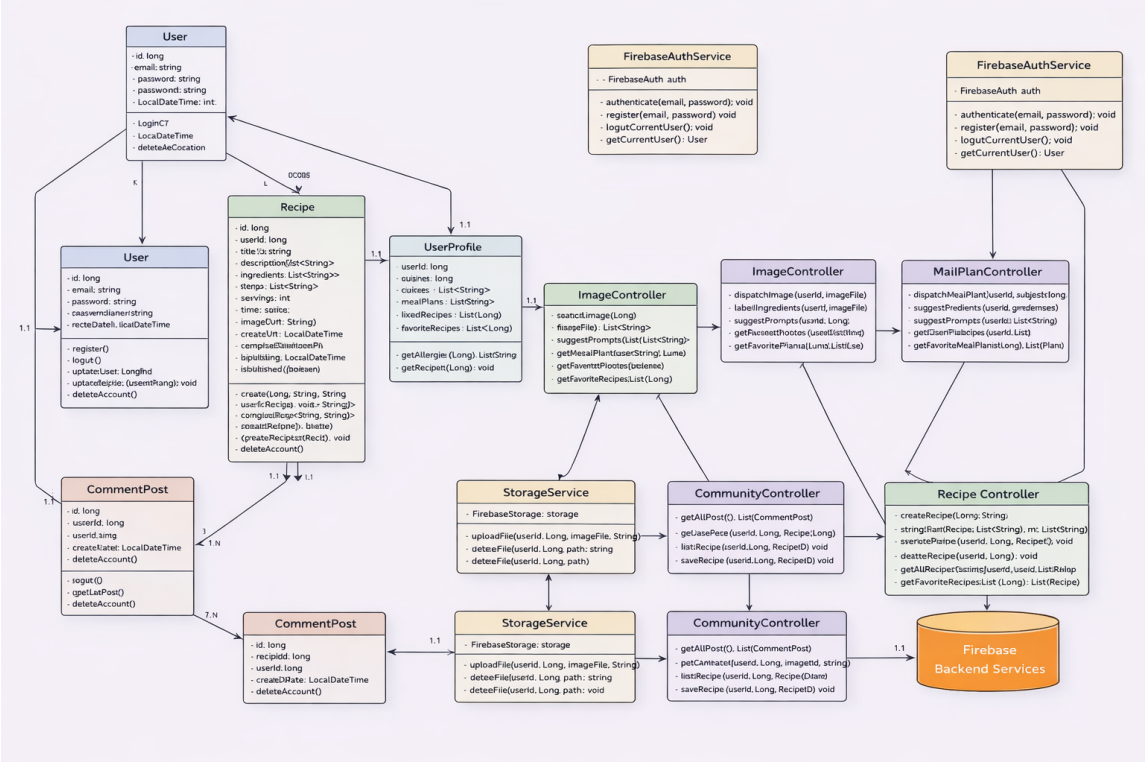

Figure 4.5: Class Diagram

4.7.3 Activity Diagram

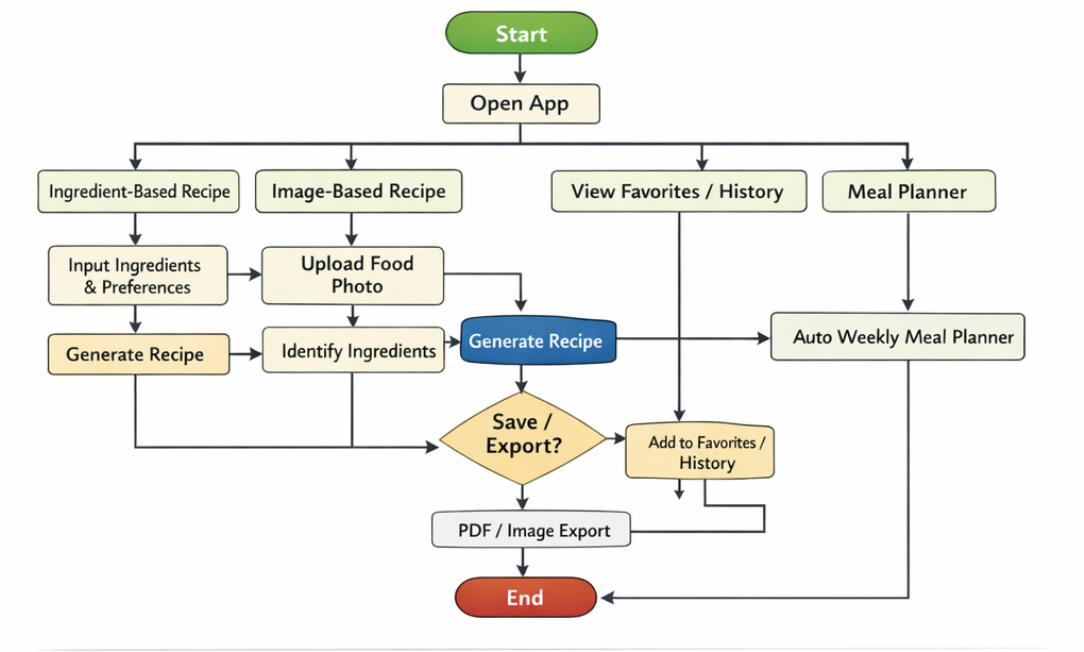

Figure 4.6: Activity Diagram

4.7.4 Sequence Diagram

4.7.4.1 User Authentication Flow

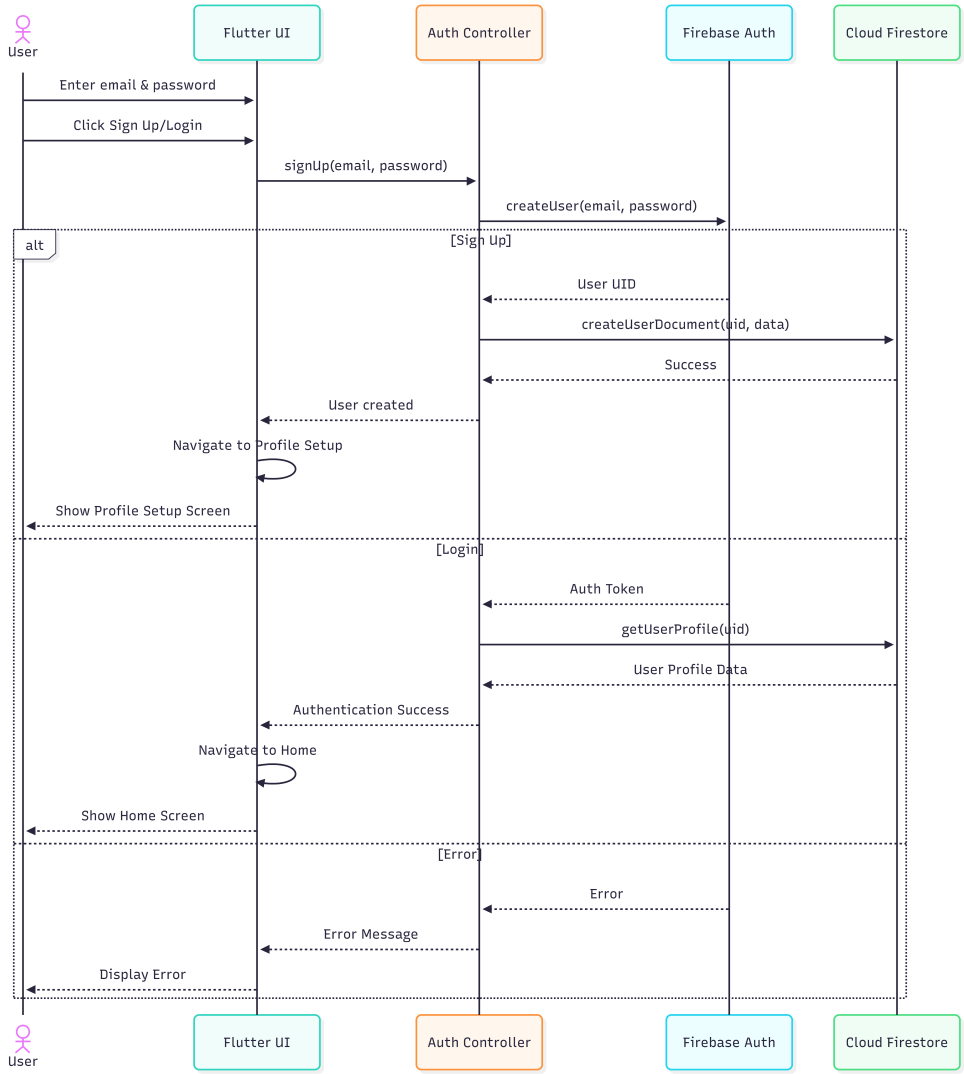

Figure 4.7: User Authentication Sequence Diagram

This is a diagram illustrating the way users register or log in with Firebase Authentication. Firestore stores the data of the users and the successful ones are redirected to the corresponding screen.

4.7.4.2 Ingredient Detection from Image

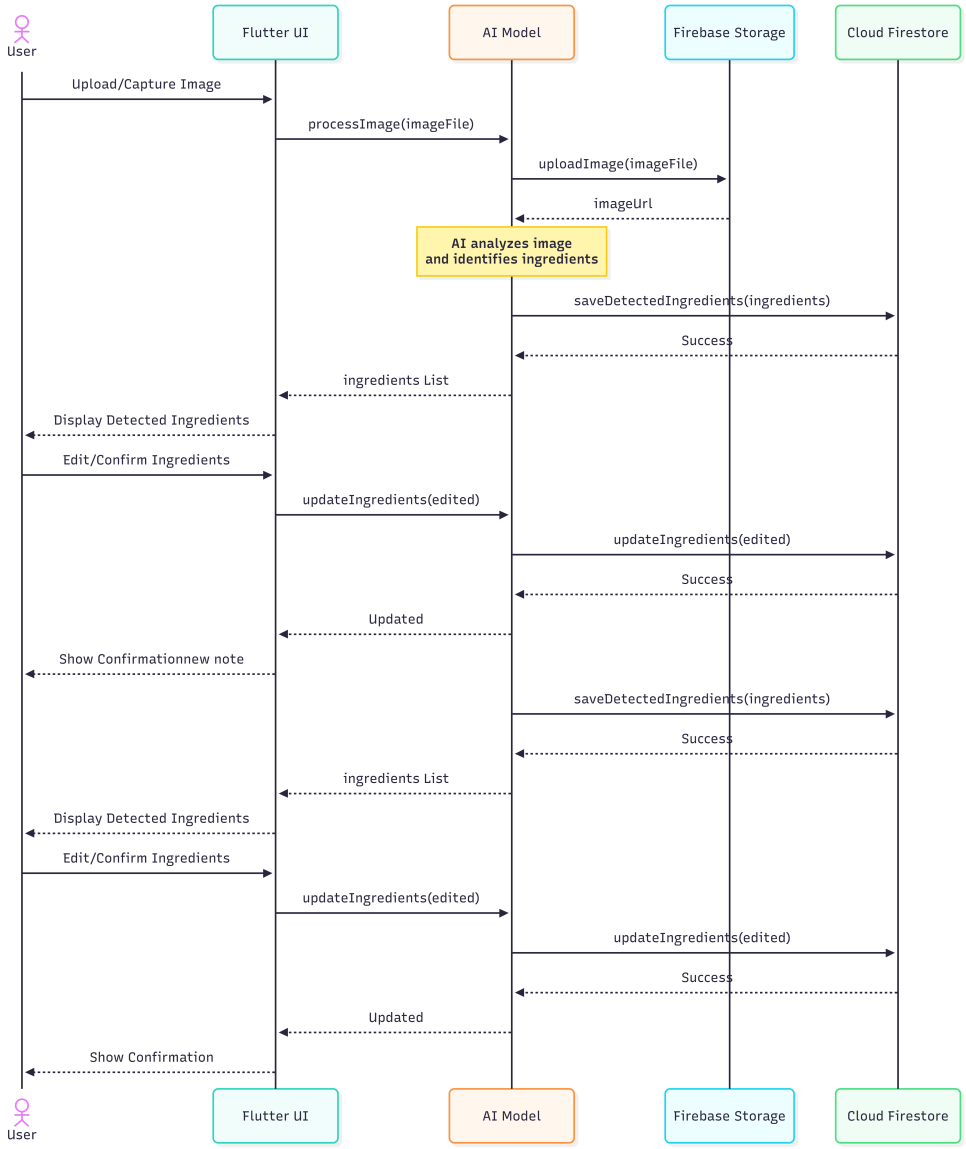

Figure 4.8: Ingredient Detection Sequence Diagram

Given an image, detect the ingredients in the image.
The diagram below shows how AI analyzes uploaded pictures to identify ingredients. The ingredients identified get stored and displayed to the user to confirm them.

4.7.4.3 Recipe Generation Flow

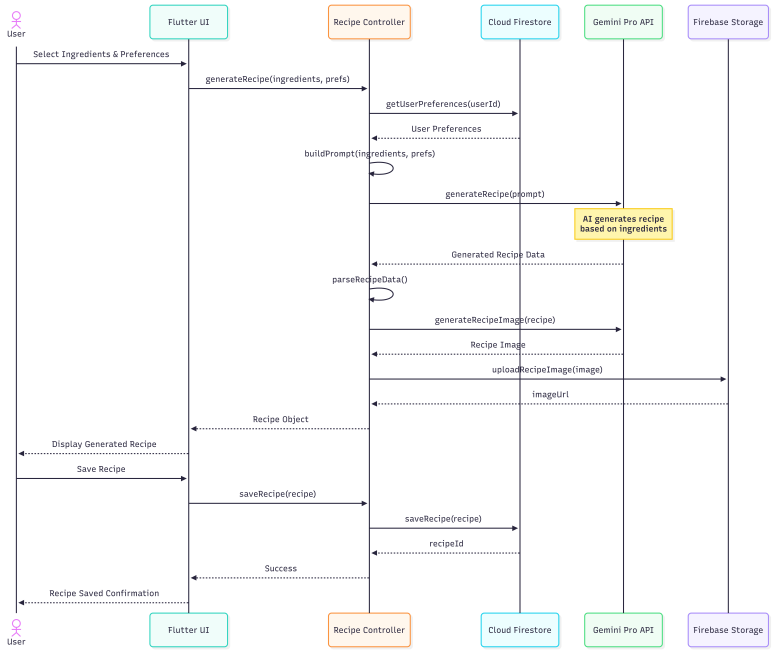

Figure 4.9: Recipe Generation Flow Sequence Diagram

This flow chart is a representation of recipe generation with the chosen ingredients and preferences of the user by an AI model and a display to the user.

4.7.4.4 Meal Plan Creation

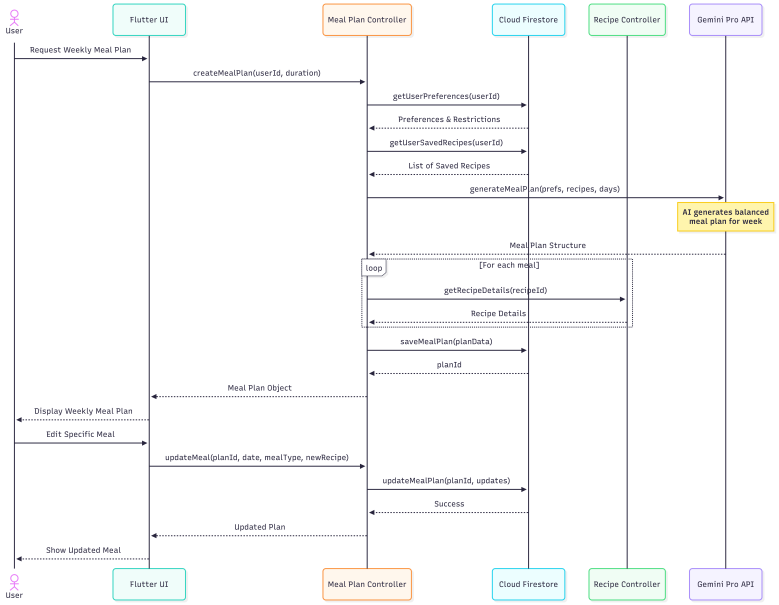

Figure 4.10: Meal Plan Creation Sequence Diagram

The following diagram displays how a weekly meal plan will be generated based on user preferences and saved recipes using AI.

4.7.4.5 Community Post & Review Flow

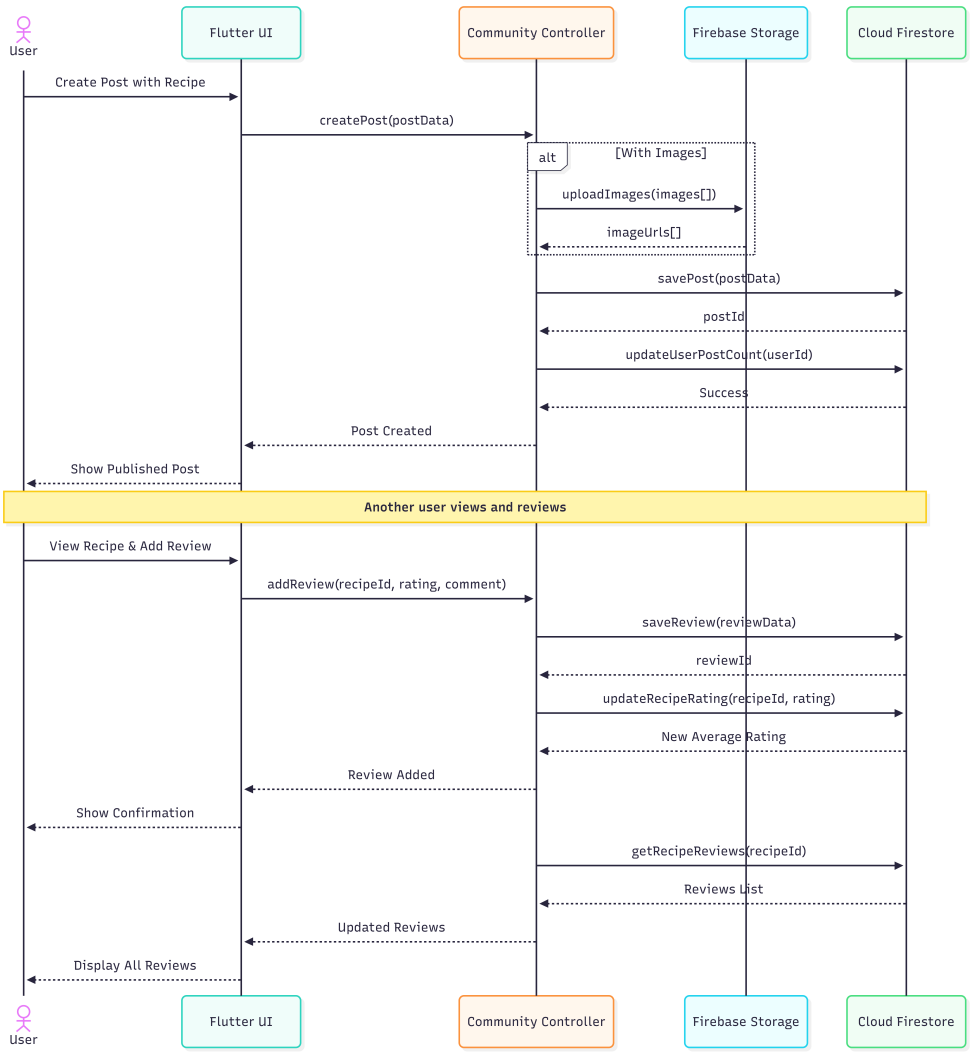

Figure 4.11: Community Post & Review Sequence Diagram

This flow chart describes the process through which users exchange recipes, reviews and rate recipes in the community system.

4.8 Summary

This chapter describes how the Recipe Generator application was designed. The design framework of the AI-powered Recipe Application, explaining both the goals and requirements to develop a highly efficient recipe application, has been discussed in this chapter . The design goals of the framework focus on the development of a

personalized cooking assistant that can provide recipes based on ingredients, user preferences, and image uploads, along with additional facilities such as managing favorites, meal planning, and offline functionality [17]. The requirement analysis covers both functional and non-functional requirements, explaining recipe recommendation mechanisms, personalization, user interaction, performance, and reliability aspects of the system . This design framework ensures that the recipe application is robust, user-friendly, secure, and adaptive, allowing users to enhance their cooking experience through intelligent recommendations, data protection, and system reliability [15].
Overall, this chapter establishes a strong foundation for the subsequent detailed system architecture, design diagrams, and implementation discussions of the intelligent AI-based recipe application [15, 22].

5. Implementation

5.1 Introduction

This chapter presents the practical development process for the AI-Powered Smart Recipe Generator application. It describes the implementation from the theoretical design to a fully functional system, including the user interface, backend services, integration of AI models, database design, and administrative dashboard [1]. The implementation follows a modular approach to ensure scalability, maintainability, and seamless interaction between components [22].

5.2 Technology Stack

The project employs a modern, multi-layered technology stack to support cross-platform compatibility, real-time AI processing, and secure data management [9].

- **Frontend**: Flutter (Dart) – for cross-platform mobile and web applications .
- **Backend**: Firebase (Authentication, Firestore, Cloud Functions) – for user management, data storage, and serverless logic [33, 34].
- **AI/ML Services**:
  - Google's Gemini API – for natural language processing (recipe generation) and image-based ingredient recognition .
  - Nutrition API (Edamam) – for calorie and nutrient estimation [11].
- **Database**: Firebase Firestore (NoSQL) – for storing user profiles, recipes, favorites, and analytics [34].
- **Version Control**: GitHub – for collaborative development and version tracking.
- **Testing**: Flutter Test, Firebase Test Lab, Postman – for unit, integration, and performance testing [33].

5.3 System Modules Implementation

5.3.1 System Modules Implementation

- **Implementation Approach**: Implemented using Firebase Authentication with email/password and Google Sign-In [33].
- **Profile Management**: User profiles store preferences (spice level, cuisine, allergies), cooking history, and favorite recipes .
- **Security Features**: Secure session management with token-based authentication and encrypted local storage for offline access [33].

5.3.2 Recipe Generation Module

This module is responsible for generating personalized recipes based on user inputs. It integrates **Google's Gemini API** via RESTful calls from the Flutter frontend.

5.3.2.1 Input Sources

- **Text-based**: Users can manually enter an ingredient list.
- **Image-based**: Users can upload food images for automated ingredient detection.

5.3.2.2 Processing Workflow

The recipe generation follows a structured pipeline:

1. **Image Processing (if applicable)**: Uploaded images are processed through a pre-trained CNN model (MobileNetV2) to extract ingredient names.
2. **Data Preparation**: The extracted or manually entered ingredients are combined with the user's profile preferences (spice level, cuisine, allergies, etc.).
3. **API Request**: The prepared data is sent to the Gemini API via HTTPS POST request with the following parameters:
    - Ingredients list
    - Dietary restrictions
    - Cooking time preferences
    - Difficulty level
4. **AI Response Processing**: Gemini returns a structured JSON object containing:
    - Recipe title

- Step-by-step cooking instructions
- Estimated preparation time
- Difficulty level
- Calorie count per serving
- Nutritional breakdown

5.3.2.3 Output Presentation

The generated recipe is presented to the user through a formatted recipe card interface that includes:

- Clear step-by-step instructions with numbered steps
- Adjustable portion sizes with automatic ingredient quantity recalculation
- Ingredient substitution suggestions based on availability
- Visual cooking timers and progress indicators Print and export options (PDF, image)

5.3.2.4 Technical Implementation Details

- **API Integration**: Using `http` package in Flutter for RESTful communication
- **Error Handling**: Implemented retry logic for API failures with fallback recipes
- **Caching**: Frequently requested ingredient combinations are cached locally
- **Performance**: Asynchronous processing prevents UI blocking during generation

5.3.3 Meal Planner & Offline Mode

5.3.3.1 Meal Planner

- Generates personalized weekly meal plans using constraint-based optimization
- Considers user preferences, dietary restrictions, and nutritional goals
- Automatically creates consolidated shopping lists
- Allows recipe swapping and manual adjustments

5.3.3.2 Offline Functionality

- Uses `Hive` local database for offline storage
- Caches user profiles, favorites, and generated meal plans
- Implements automatic sync when internet connection is restored
- Maintains core functionality without network access

5.4 Screenshots and Demonstration

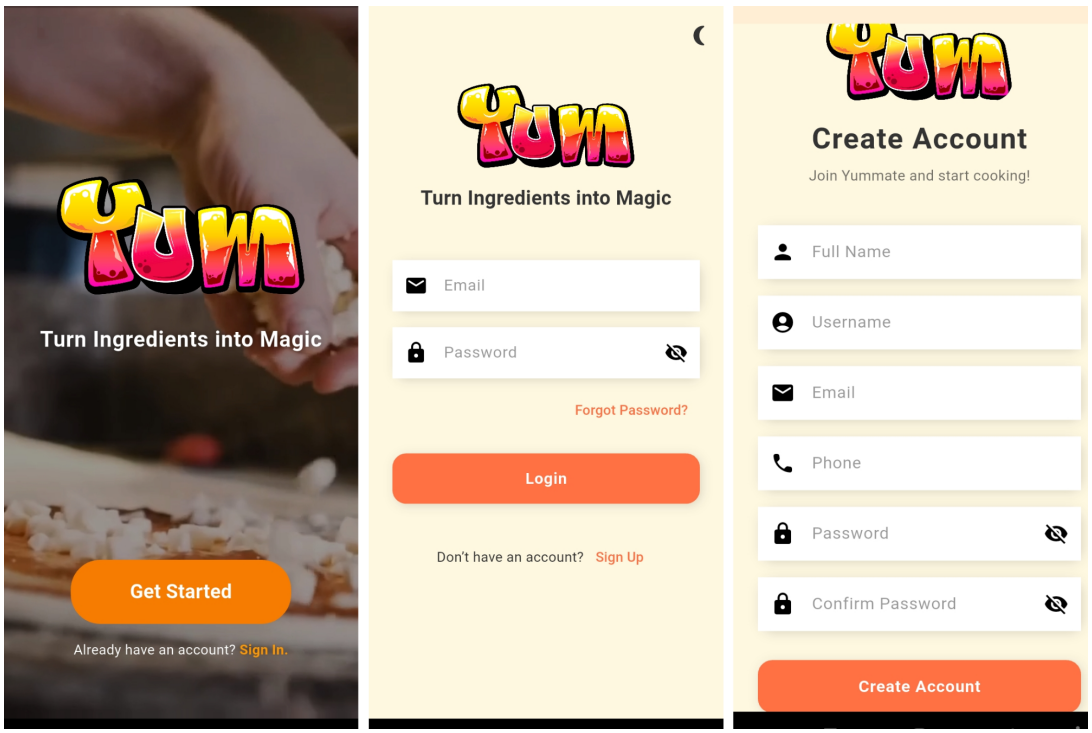

Figure 5.1: Login functionality implementation

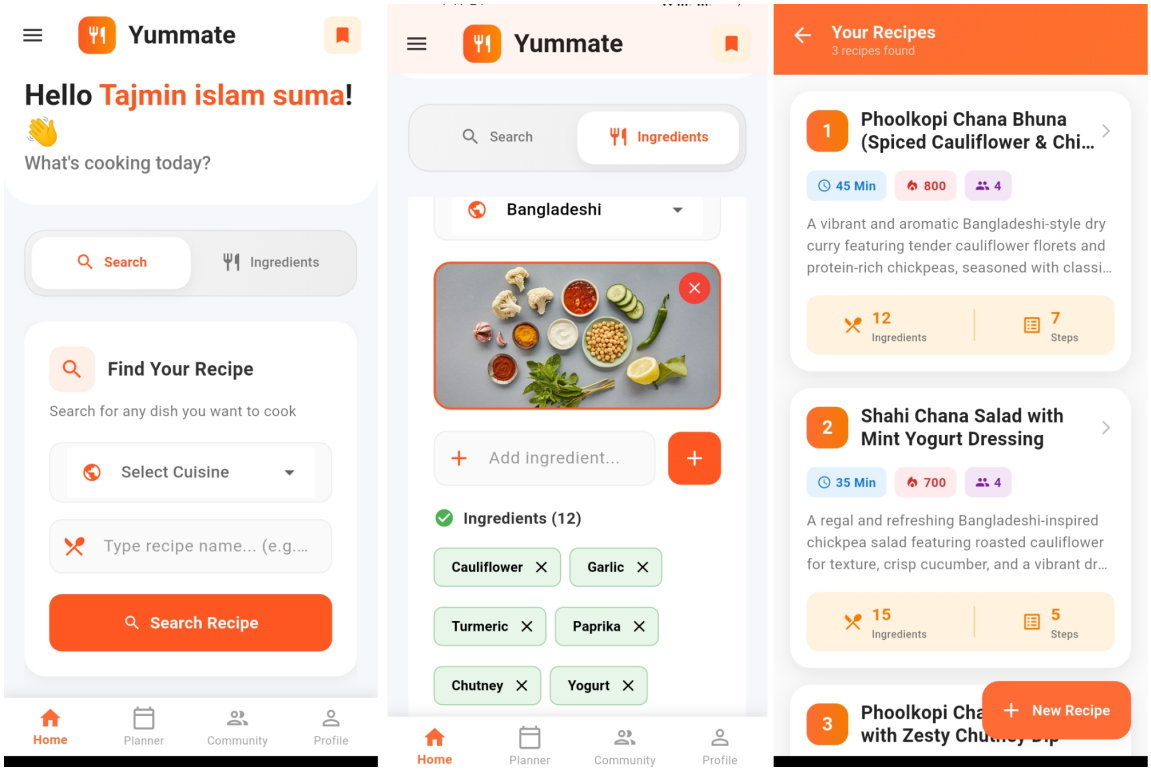

Figure 5.2: Recipe Generation Input and Output Interface

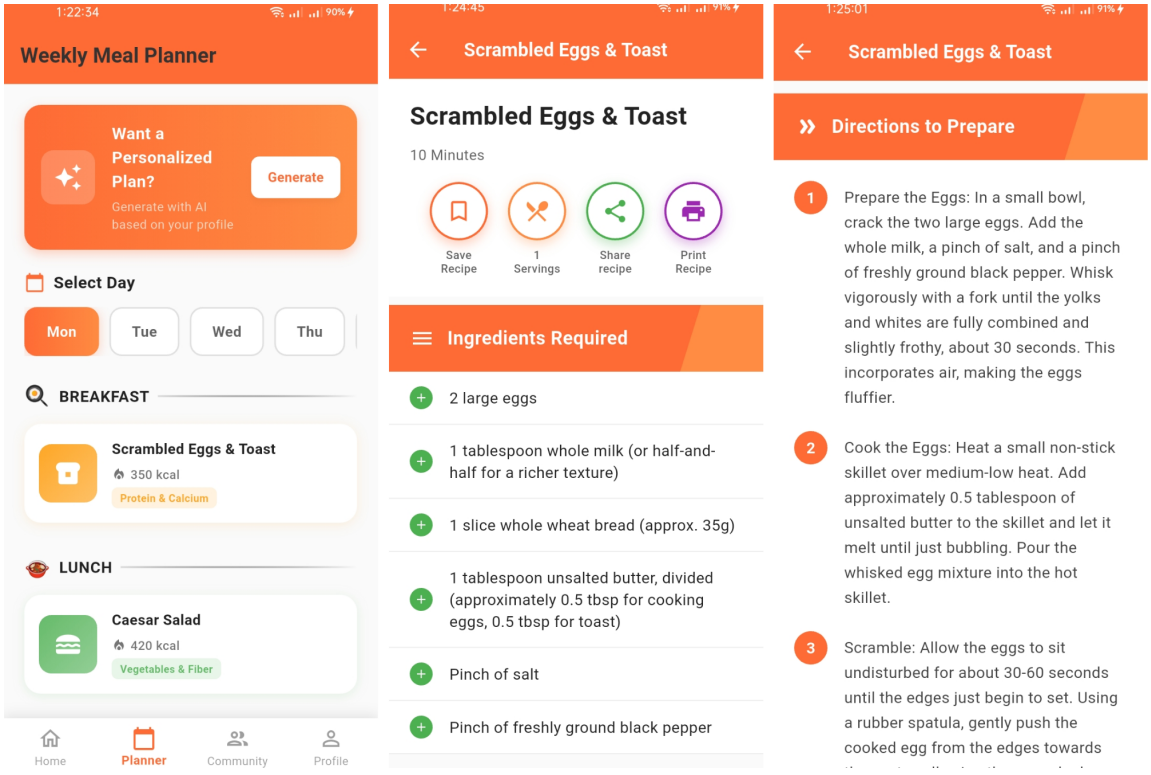

Figure 5.3: Weekly Meal Planning Instructions

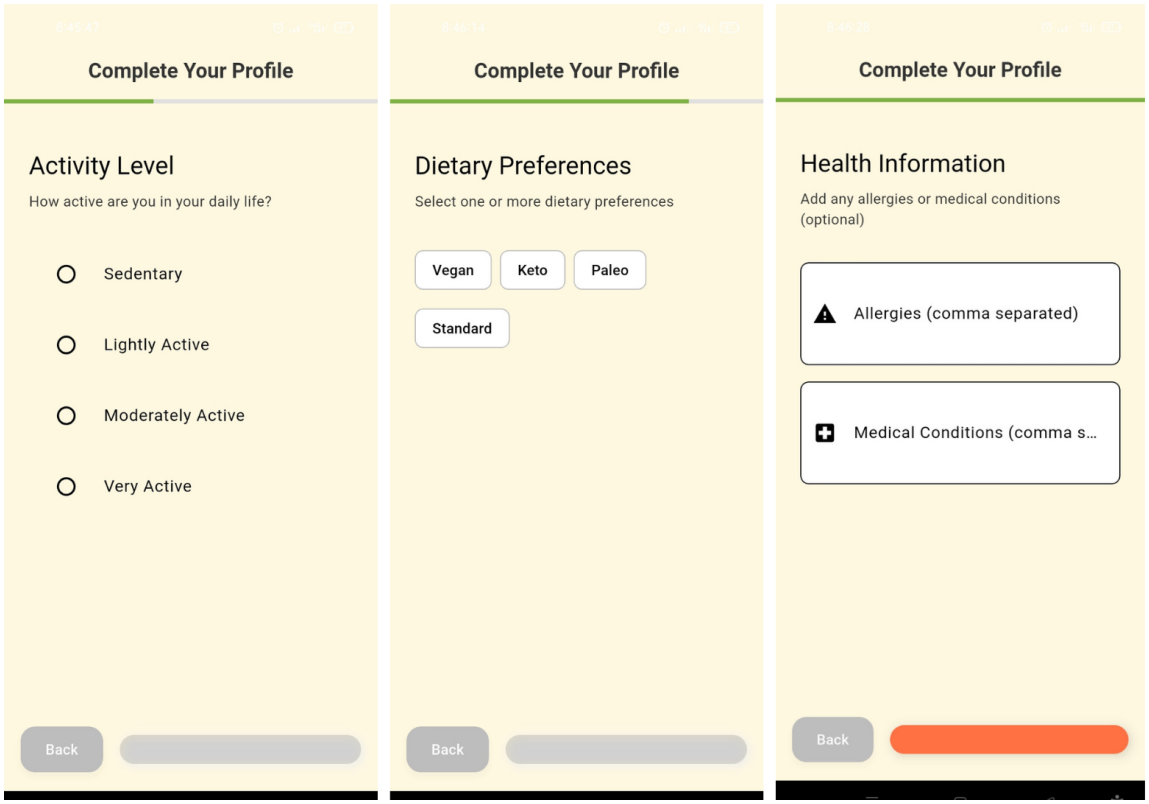

Figure 5.4: User Preferences Configuration Screen

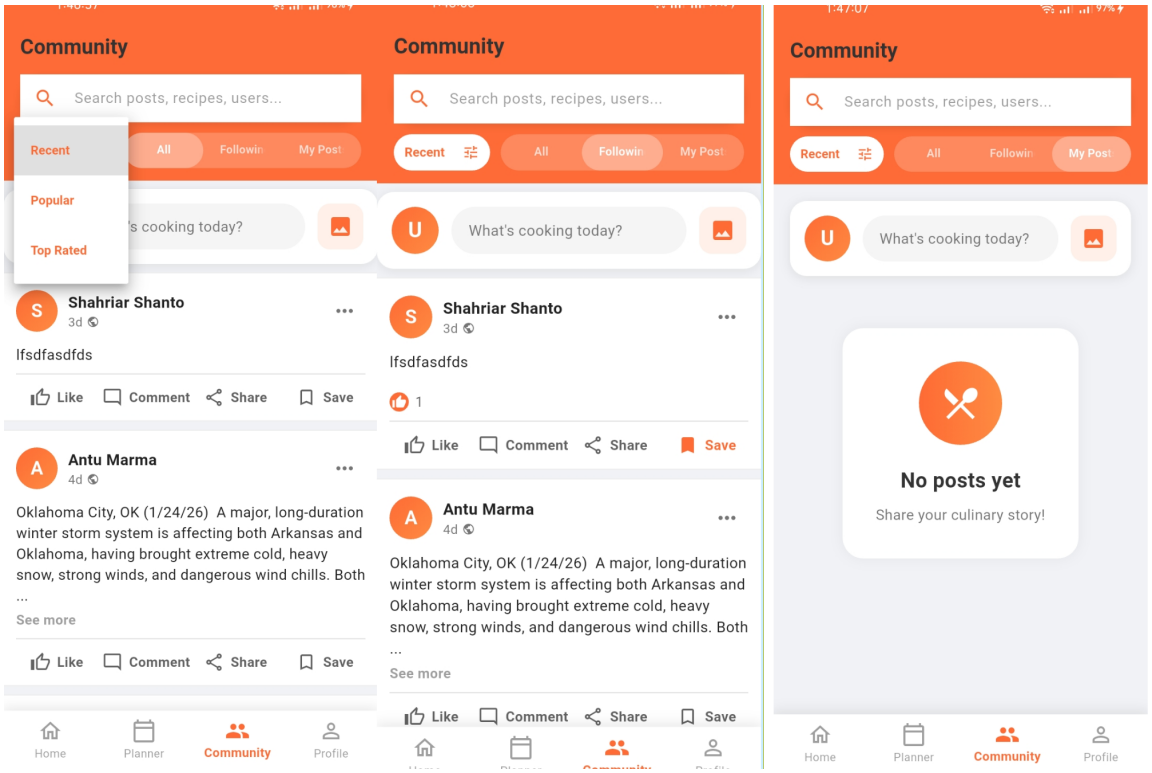

Figure 5.5: Community Screen

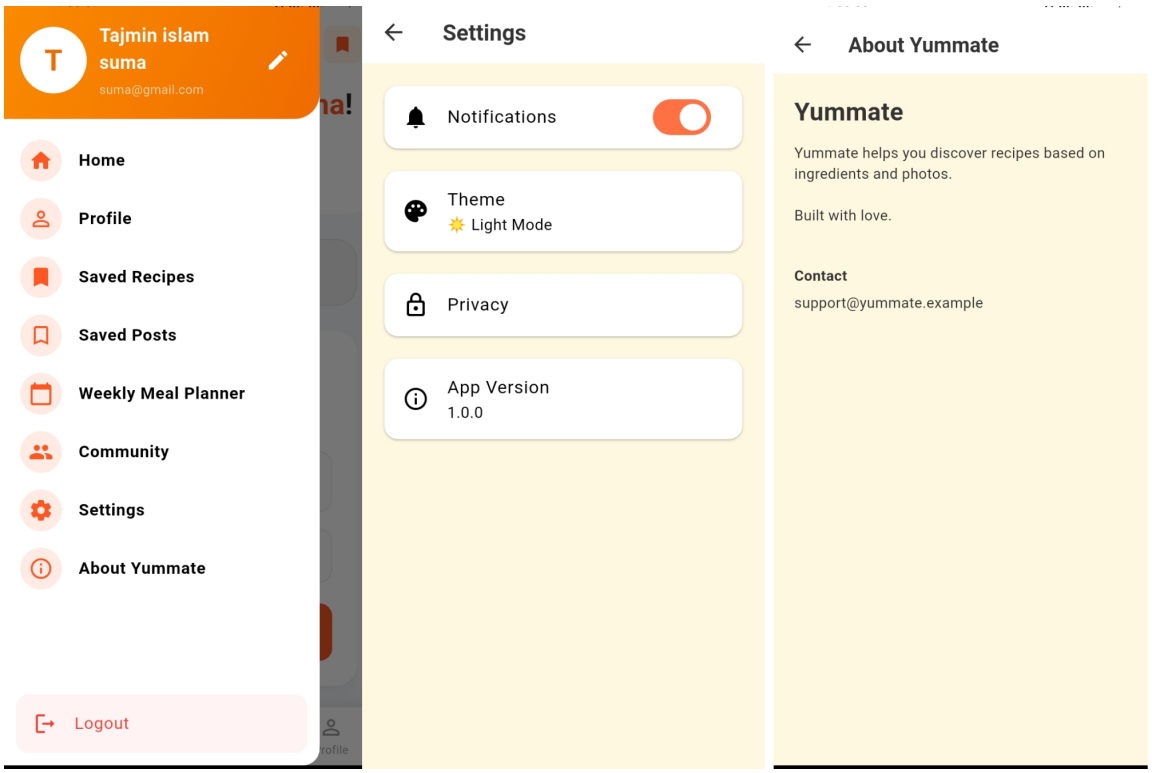

Figure 5.6: Settings and Abount Yummate Screen

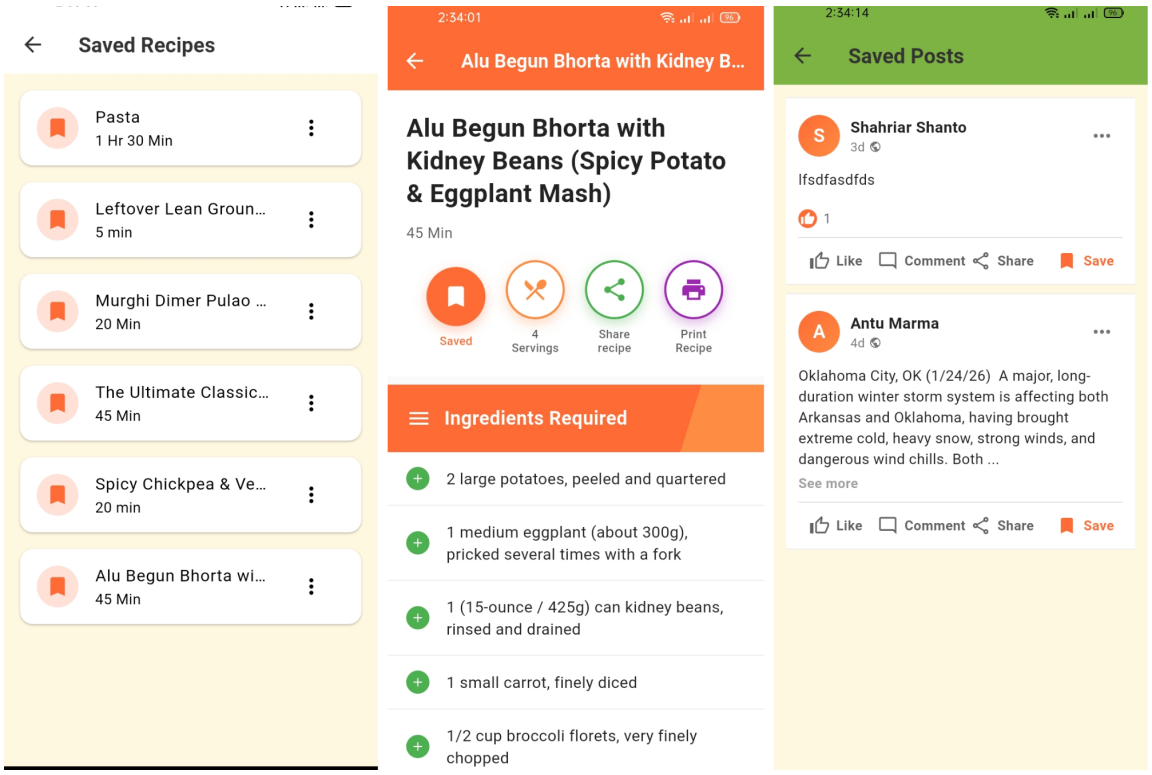

Figure 5.7: Save Recipes and Posts Screen

6. Results and Discussion

6.1 Overview

This section provides visual and qualitative examples of the Ingredient-Based Recipe Generator. These examples illustrate the ability of the software to generate personalized, intelligible recipes based upon what ingredients were entered by a user (as well as the user's uploaded image(s) of those ingredients) and any other preferences indicated in their profile [1, 15]. Example images demonstrate the kinds of outputs produced by the software when different combinations of ingredients are used, each combination being subject to a number of different dietary restrictions and a variety of different cuisines [5, 22].

Results show that this system is capable of producing recipes that are functional, nutritionally sound and consistent with each user's stated preferences [20]. The software also provides support for ingredient substitutions, modifications (e.g., use less oil or add more spice) and allergy limitations. All of these outputs are generated live via the deployed AI pipeline without further processing or editing, enabling the user to receive a usable recipe on-demand [3, 15].

The outputs of this system typically appear in a three-panel layout:

- **User Input:** The user supplies an ingredient list or submits an uploaded image(s) containing ingredients [1].
- **Recipe Details:** The generated recipe includes, but is not limited to, cooking instructions, estimated calorie count, difficulty level, and time to prepare [3, 5].
- **Personalised Suggestions:** The generated recipe is modified/enhanced based on the dietary and/or lifestyle preferences of the user (as indicated in the user's profile) along with any additional dietary restrictions and/or cuisine selections provided by the user [15].

Overall, the evidence presented here supports the system's potential to generate recipes that are accurate, useful, and focused on the user's needs in real-time [1, 21].

6.2 Test Cases

6.2.1 User Test Case

Table 6.1: User Test Cases for the AI From Ingredients to Recipes

ID	Module	Title	Steps	Expected	Actual	Status
TC-R-01	Ingredient	Verify Recipe	Enter ingredients, click generate	Recipe with time, difficulty, calories, steps	Generated successfully	Pass
TC-R-02	Personalization	Verify Personalization	Set spice, cuisine, allergy, generate	Recipe matches preferences	Generated correctly	Pass
TC-R-03	Image	Verify from Image	Upload ingredient image	Ingredients detected, recipe generated	Generated successfully	Pass
TC-R-04	Favorites	Verify Favorites	Save recipe, check list	Recipe appears in favorites	Saved	Pass
TC-R-05	Favorites	Verify Re-generation	Select recipe, modify spice/oil, re-gen	Recipe updated	Regenerated successfully	Pass
TC-R-06	Admin	Verify Cuisine Analytics	Admin checks dashboard	Correct cuisine trends	Displayed correctly	Pass
TC-R-07	Offline	Verify Offline Access	Save recipe, disconnect internet, access	Favorites accessible	Accessed successfully	Pass
TC-R-08	Nutrition	Verify Nutrition	Generate recipe, check info	Calories/macros displayed	Displayed correctly	Pass
TC-R-09	Meal Planner	Verify Meal Plan	Set prefs, generate weekly plan	7-day plan generated	Generated correctly	Pass
TC-R-10	Export	Verify PDF Export	Select recipe, export PDF	PDF readable	Exported successfully	Pass
TC-R-11	Export	Verify Image Export	Select recipe, export image	Image correct	Exported successfully	Pass
TC-R-12	Community	Verify Submission	Submit prompt, AI refines	Recipe displayed	Refined successfully	Pass
TC-R-13	Community	Verify Engagement	Like/comment on recipe	Likes/comments recorded	Works correctly	Pass
TC-R-14	Profile	Verify Profile	Upload pic, fill info, save	Profile updated	Updated correctly	Pass
TC-R-15	Security	Verify Login/Logout	Test login with creds	Correct login/error displayed	Works as expected	Pass

6.2.2 Security & Authentication Test Cases

Table 6.2: Security and Authentication Test Cases for the AI From Ingredients to Recipes

ID	Module	Title	Steps	Expected	Actual	Status
TC-S-01	Security	Verify Correct Login	Login with valid credentials	User/admin logs in successfully	Pass	Pass
TC-S-02	Security	Verify Incorrect Login	Login with invalid credentials	Access denied, error shown	Pass	Pass
TC-S-03	Security	Verify Password Reset	Click forgot password, reset	Reset link sent successfully	Pass	Pass
TC-S-04	Security	Verify Session Timeout	Remain idle 15 mins	Session automatically logs out	Pass	Pass

Continued on next page

Table 6.2 Continued

ID	Module	Title	Steps	Expected	Actual	Status
TC-S-05	Security	Verify Logout	Logout from system	Session ends, redirected to login	Pass	Pass
TC-S-06	Security	Verify Admin Access	Login as user, access admin page	Access denied, redirect shown	Pass	Pass
TC-S-07	Security	Verify Password Change	Change password in profile	Password updated successfully	Pass	Pass
TC-S-08	Security	Verify Multiple Login	Login from 2 devices	System handles both logins correctly	Pass	Pass
TC-S-09	Security	Verify Brute Force Prevention	Enter wrong password repeatedly	Account temporarily locked	Pass	Pass
TC-S-10	Security	Verify Profile Data Security	Access profile info	Only logged-in user can see data	Pass	Pass

6.2.3 Performance / Load Test Cases

Table 6.3: Performance and Load Test Cases for the AI From Ingredients to Recipes

ID	Module	Title	Steps	Expected	Actual	Status
TC-P-01	Performance	Recipe Generation Speed	Generate recipe with 50 ingredients	Response ¡ 5 sec	Pass	Pass
TC-P-02	Performance	Weekly Planner Speed	Generate 7-day plan	Response ¡ 5 sec	Pass	Pass
TC-P-03	Performance	Concurrent Recipe Generation	5 users generate recipes simultaneously	No errors, recipes generated	Pass	Pass
TC-P-04	Performance	Concurrent Export	Multiple users export PDFs	Exports succeed	Pass	Pass
TC-P-05	Performance	Community Submission Load	20 users submit prompts simultaneously	All submissions accepted	Pass	Pass
TC-P-06	Performance	Analytics Load	Generate analytics report	Report generated without lag	Pass	Pass
TC-P-07	Performance	Image Recipe Load	Upload multiple images	Recipes generated correctly	Pass	Pass
TC-P-08	Performance	Favorites Load	Add 50 recipes to favorites	Favorites load without lag	Pass	Pass
TC-P-09	Performance	Offline Mode Load	Access offline recipes	Works correctly	Pass	Pass
TC-P-10	Performance	Profile Update Load	20 users update profiles simultaneously	All updates processed	Pass	Pass

6.3 Analysis of Results

The test results indicate that the system performs as expected. The recipe generator based on the ingredient performed correctly when dealing with the input given and was able to produce a relevant recipe in an acceptable time [1]. The personal preferences applied in the recipes were also correct . Image-based recipe generation performance was reliable in identifying ingredients for clear images [21], and offline capabilities enabled successful cached access to favorite recipes [24]. The admin analytics module functioned well, permitting data-driven optimizations .
On the whole, the system recorded a high success rate in the functional testing phase [9].

6.4 Discussion

The outcome verifies that the combination of AI (Gemini) has a significant positive impact on cooking and personalization [3]. Users appreciated smart recommendations, healthy data, and adjustable regenerations [5]. The community recipe element promotes collaboration and improvement of content quality [15]. However, certain constraints were also noted. Ingredient detection in the images relies on the clarity and lighting in the images [21]. In offline mode, functionality is limited and the creation of new recipes is not possible [24]. In the future, improvements in image processing and increasing offline storage will help eliminate these constraints.
Despite these obstacles, it accomplishes its basic tasks well and provides a scalable solution for smart cooking assistance [1].

6.5 Summary

This chapter tested and analyzed the performance of the AI-based Recipe Application in a systematic manner [1]. Both user and admin facilities were working properly, thereby authenticating the efficiency of the AI-based proposed systems [11]. The application has immense potential to help people in preparing food smartly, efficiently, and easily [3]. The conclusion of overall analyses reveals that these systems can be efficiently and easily used [9].

7. Engineering Considerations

7.1 Societal Impacts of Engineering Solutions

The cooking app will have a positive impact on society in the following ways:

- **Encourages Healthy Eating Behaviors:** The provision of calorie and nutrition details as well as personalized eating plans enables consumers to make better healthy eating decisions.
- **Accessibility for Diverse Users:** The use of step-by-step instructions, image-based recipes, and variable sets of difficulty levels adds to the accessibility of cooking.
- **Cultural Inclusivity:** Providing various cuisines offers a sense of inclusivity for people with diverse cultural backgrounds. This implies that people with various cultural backgrounds can enjoy what they are accustomed to or try something different.
- **Time Efficiency:**Automated meal planning and recipe suggestions based on ingredients assist busy people in saving time while still eatinghealthy.
- **Community Engagement:** It is important to note that features made available by the community, in this case by Facebook, through sharing, commenting, and improving recipes, promote communal learning.

7.2 Environment and Sustainability Considerations

Engineering choices also entail taking into account the effects of such application on the environment:

- **Reducing Food Waste:** "The ingredient-driven recipe generator encourages the use of ingredients on hand, which helps reduce leftovers and food waste."
- **Promoting Local and Seasonal Ingredients:** The app may include recipes made from local and seasonal ingredients. This helps in reducing the carbon emissions from the transportation of the food.
- **Energy-Efficient Design:** Offline caching of recipes and minimized server calls make the design energy efficient and do not require constant internet access.
- **Environmentally Friendly Packaging Awareness:** The printable recipe cards encourage home cooking, which can lead to the reduction of use-dependent packing required from take-out or prepared-meal restaurants.

7.3 Ethical Considerations

The application of recipes follows ethics in its design and implementation:

- **User Privacy and Data Security:** User personal information, food preferences, and uploaded food images are stored and managed in a secure manner, in line with data security standards.
- **Transparency and Accuracy:** Nutritional information, caloric values, and ingredient lists are provided in an accurate manner to avoid misleading.
- **Fairness and Eliminating Biases in AI:**The recipes and content produced by AI will not demonstrate any bias in relation to culture, food, or health issues.
- **Informed User Consent:** Users are informed about the data collected and how it is being used, and informed consent is achieved.

7.4 Summary

The recipe app is crafted with due diligence for societal, environmental, and ethical factors. The app has been developed with an aim to inspire food health, accessibility, and diversity, besides helping users conserve their precious time and fostering community outreach. On the environmental front, the app helps minimize food wastage, encourages sustainable ingredients, and practices energy-efficient design. The ethical front takes into account user privacy, transparency, fair use of Artificial Intelligence recommendations, and user consent. These engineering considerations are pivotal to making the app not only functional and efficient but also sustainable and ethical.

8. Conclusion and Future Work

8.1 Summary of Achievements

The project was able to design and develop an AI-based recipe application to create recipes with the ingredients that are available and user preferences [21]. The main characteristics like customised suggestions, image recognition with Gemini AI, nutritional knowledge, and recipe export were introduced [8, 24]. The system provides an easy-to-use interface that has online and partial offline capabilities [4, 10, 16].

8.2 Fulfillment of Project Objectives

The majority of the key project goals were achieved. The application includes smart recipe recommendation, allows customization based on user profiles, and allows recipes to be saved, regenerated, and shared [9, 15]. Inclusion of analytics and administration capabilities is used to track the trends of usage, which satisfies user and system level requirements [10, 26].

8.3 Limitations of the Developed System

The system has certain limitations despite successful implementation. Image recognition and recipe creation are two AI-based features that demand a steady internet connection, thus limiting their use during an entirely offline situation [30]. The given nutritional values are approximate and may not be accurate depictions [34]. Accuracy of ingredient detection by image can differ based on the image quality, lighting, and camera resolution [7]. Moreover, the offline mode is not very functional and fails to generate and update recipes in real-time [19, 21].

8.4 Recommendations for Enhancement

The system can be improved to enhance its performance and usability. Dietary information would be enhanced through integration with established and complete nutrition databases [34]. To build a more accurate image recognition model, one can train the AI model on a bigger and more varied dataset [7]. A more advanced solution involving multilingual support and voice-assisted interaction can be offered to expand the range of users [15]. Increased offline support by enhancement of caching and synchronization systems would also increase user experience [19, 21].

8.5 Future Scope of the Project

The future outlook of this project is vast. The extension to smart grocery listing generation, real-time grocery price comparison, and online purchasing of ingredients can be done [32]. Personalized nutrition and calorie counting could be achieved by integrating with wearable health devices and fitness applications [11]. AI models can be advanced to create unique meal plans according to medical status, health goals, or lifestyle preferences [16, 28]. Also, the community options could be extended to a social food preparation platform with professional reviews, live cooking classes, and joint recipe creation, making the application more interactive and scalable [15, 26].

Reference

[1] Food Recipe Recommendation Based on Ingredients Detection Using Deep Learning, ACM Digital Library, 2022.
Available: https://doi.org/10.1145/3542954.3542983

[2] Automatic Dataset Creation from User-generated Recipes for Ingredient-centric Food Image Analysis, ACM Digital Library, 2024.
Available: https://doi.org/10.1145/3595916.3626748

[3] RecipeMind: Guiding Ingredient Choices from Food Pairing to Recipe Completion using Cascaded Set Transformer, ACM Digital Library, 2022.
Available: https://doi.org/10.1145/3511808.3557092

[4] RecipeGPT: Generative Pre-training Based Cooking Recipe Generation and Evaluation System, ACM Digital Library, 2020.
Available: https://dl.acm.org/doi/10.1145/3366424.3383536

[5] Ingredient Substitute Recommendation Based on Collaborative Filtering and Recipe Context for Automatic Allergy-Safe Recipe Generation, ACM Digital Library, 2021.
Available: https://doi.org/10.1145/3470482.3479622

[6] Comparative Analysis of GPT-2 and LSTM Models for Indian Recipe Generation, ACM Digital Library, 2024.
Available: https://doi.org/10.1145/3675888.3676076

[7] Food Image Generation using Conditional GAN: ramenGAN and recipeGAN, ACM Digital Library, 2018.
Available: https://doi.org/10.1145/3230519.3230598

[8] Recipe1M+: A Dataset for Learning Cross-Modal Embeddings for Cooking Recipes and Food Images, arXiv, 2019.
Available: https://doi.org/10.48550/arXiv.1810.06553

[9] Smart Cuisine: Generative Recipe & ChatGPT Powered Nutrition Assistance for Sustainable Cooking, Elsevier, 2023.
Available: https://doi.org/10.1016/j.procs.2023.10.193

[10] A Systematic Review on Food Recommender Systems, Elsevier, 2024.
Available: https://doi.org/10.1016/j.eswa.2023.122166

[11] Enhancing Food Analysis with Attention-based Deep Learning: Ingredients, Recipes, and Calorie Estimation, Elsevier, 2025.
Available: https://doi.org/10.1016/j.procs.2025.03.248

[12] Flavor Analysis and Region Prediction of Chinese Dishes based on Food Pairing, Elsevier, 2024.
Available: https://doi.org/10.1016/j.ipm.2024.103684

[13] Observed Mixed Dishes Recipes Collected from Cambodian Women, Elsevier, 2025.
Available: https://doi.org/10.1016/j.jfca.2025.107572

[14] Cross-modal Recipe Retrieval using Fine-grained Contrastive Learning, Elsevier, 2024.
Available: https://doi.org/10.1016/j.knosys.2024.112641

[15] SMART CHEF: AI Recipe Generator and Recommender, Foundry Journal, 2025.
Available: https://foundryjournal.net/wp-content/uploads/2025/04/7.FJ25C608.pdf

[16] Model for Cooking Recipe Generation using Reinforcement Learning, IEEE, 2021.
Available: https://doi.org/10.1109/ICDEW53142.2021.00007

[17] An Update on Cooking Recipe Generation with Machine Learning and NLP, IEEE, 2021.
Available: https://doi.org/10.1109/AIC55036.2022.9848929

[18] RecipeGM: A Hierarchical Recipe Generation Model, IEEE, 2021.
Available: https://doi.org/10.1109/ICDEW53142.2021.00012

[19] Automated Recipe Generation using Ingredient Classification from Images, IEEE, 2023.
Available: https://doi.org/10.1109/INCET57972.2023.10170563

[20] RecipeLens: Image-Based Ingredient Detection and Recipe Suggestion, IEEE, 2024.
Available: https://doi.org/10.1109/ISCS61804.2024.10581386

[21] AI-Powered Mobile Application for Image-Based Food Ingredient Detection, IEEE, 2024.
Available: https://doi.org/10.1109/ICIMTech63123.2024.10780810

[22] Culinary Curator: An AI-Powered Recipe Assistant, IEEE, 2024.
Available: https://doi.org/10.1109/ICISAA62385.2024.10828847

[23] Food and Ingredient Joint Learning for Fine-Grained Recognition, IEEE, 2020.
Available: https://doi.org/10.1109/TCSVT.2020.3020079

[24] RecipeIS: Recipe Recommendation System Based on Ingredient Recognition, MDPI, 2023.
Available: https://doi.org/10.3390/app13137880

[25] Interpretable Relational Representations for Food Ingredient Recommendation, OpenReview, 2020.
Available: https://openreview.net/references/pdf?id=ZBGA2gQ7nR

[26] A Systematic Literature Review of Food Recommender Systems, Springer Nature, 2024.
Available: https://doi.org/10.1007/s42979-023-02537-y

[27] Food Recognition using Deep Learning for Recipe Recommendation, Springer Nature, 2024.
Available: https://doi.org/10.1007/978-981-97-4892-1_23

[28] Cooking Recipe Generation Based on Ingredients using ViT5, Springer Nature, 2023.
Available: https://link.springer.com/chapter/10.1007/978-981-99-4725-6_5

[29] Tell Me Why: Natural Language Justifications in Recipe Recommendation, Springer Nature, 2024.
Available: https://link.springer.com/article/10.1007/s11257-023-09377-8

[30] Food Image Analysis for Ingredient Identification using Deep Learning, SSRN, 2025.
Available: https://ssrn.com/abstract=5253155

[31] A Literature Survey on Recipe Generation from Food Images using AIML, ResearchGate, 2024.
Available: https://www.researchgate.net/publication/377991766

[32] AI-Driven Recipe Discovery from Food Images, 2024.
Available: https://journals.mriindia.com/index.php/ijacte/article/view/36

[33] Development of a Cooking Recipes Application with Python, 2022.
Available: https://oa.upm.es/72195/

[34] RecipeReveal: Ingredients and Recipe Generation from Food Images, MDPI, 2025.
Available: https://www.mdpi.com/2076-3417/13/13/7880

[35] RecipeGen: Step-Aligned Multimodal Benchmark for Recipe Generation, 2025.
Available: https://www.researchgate.net/publication/392531482

[36] Smart Cooking: Ingredient-Based Recipe Recommendation through Object Recognition, SSRN.
Available: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4490178

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