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RECKIT: AN AI-DRIVEN SMART KITCHEN ASSISTANT FOR PERSONALIZED MEAL PLANNING AND GROCERY MANAGEMENT

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Abstract : Managing groceries and planning balanced meals can be challenging in today's fast-paced life, often leading to food wastage, poor nutrition, and unplanned eating habits. The Smart Grocery Management Application aims to simplify this by combining automation, intelligent recommendations, and health-focused meal planning. Built with a Python backend (Flask/FastAPI) and a ReactJS web interface, the system helps users track inventory, receive expiry and low-stock alerts, and discover recipes tailored to their available ingredients. Lever-aging the RecipeNLG dataset, it generates creative and diverse meal ideas while considering dietary preferences, allergies, and nutritional needs. Through an interactive questionnaire, the application personalizes a 7-day meal plan, covering all three daily courses for optimal balance and convenience. A voice-enabled assistant and AI-powered chatbot make the experience hands-free and engaging, offering real-time nutrition insights and recipe guidance. By uniting data-driven intelligence, personalization, and sustainability, this project promotes healthier eating habits, reduces food waste, and transforms everyday kitchen management into a smart and efficient experience.

***IndexTerms* - Smart kitchen, Grocery management, Personalized meal planning, AI chatbot, Flask, ReactJS, RecipeNLG dataset, Nutrition tracking, Allergy detection, Automation, Sustainable cooking.**

I. INTRODUCTION

In today's fast-moving world, managing groceries and planning healthy meals have become increasingly demanding.Working professionals, students, and families often struggle to monitor what's in their pantry, plan balanced dishes, and reduce food waste while juggling hectic schedules. As a result,many households end up with duplicate purchases, missing ingredients, or last-minute meal decisions that compromise both nutrition and efficiency.Traditional approaches to grocery tracking and meal planning—such as handwritten lists or memory-based management—are often fragmented, time-consuming, and unreliable.They rarely account for important factors like expiration dates,nutritional goals, or dietary preferences. Without a smart and adaptive system, users risk overspending, increased spoilage,and missed opportunities to make informed, health-conscious choices.

The Smart Grocery Management Application aims to solve these challenges through a unified digital platform that combines automation, intelligent insights, and personalized recommendations. Developed using a Python backend (Flask or FastAPI) and a ReactJS web interface, the application helps users easily monitor their inventory, receive alerts for low-stock or expiring items, and explore creative recipes generated from ingredients already available at home. By utilizing comprehensive recipe datasets such as RecipeNLG and factoring in allergies, dietary restrictions, and nutritional targets, the system delivers personalized meal suggestions that align with users' health and lifestyle goals.Beyond inventory management, the application features an interactive AI chatbot and voice assistant that enhance accessibility and user engagement. Through a short set of preference-based questions, users can instantly generate a 7-day meal plan covering breakfast, lunch, and dinner, ensuring variety,balance, and convenience. By promoting mindful consumption and reducing food waste, the system not only supports healthier living but also contributes to a more sustainable and organized kitchen environment.

II. LITERATURE REVIEW

Artificial intelligence has recently begun reshaping the food and nutrition domain, with researchers exploring how machines can recognize dishes, interpret recipes, and offer personalized dietary support. One of the earliest and most active areas of work is visual food recognition combined with calorie estimation. Sombutkaew and Chitsobhuk [2] demonstrated that even traditional machine-learning pipelines can recognize Thai dishes with reasonable accuracy and approximate their calorie levels from images. Deep learning models have pushed this further: Yarde et al. [6] showed that convolutional neural networks could significantly enhance food classification and calorie prediction. Although these systems highlight the potential of image-based nutrition assessment, they also reveal persistent problems such as inconsistent portion sizes, cluttered backgrounds, and large variations in regional cuisines, which often reduce real-world reliability.

Another line of research shifts the focus from images to recipe intelligence. Morol et al. [7] introduced a method that detects ingredients using deep learning and recommends suitable recipes based on the identified components. This connection between ingredient understanding and recipe suggestion has become a key theme in food computing. Kansaksiri et al. [12] expanded on this by incorporating generative models, showing that systems like ChatGPT can adapt recipes to user preferences or dietary constraints, marking a transition from static recipe lists to more interactive and personalized culinary assistants.

In parallel, there has been growing interest in integrating AI directly into kitchen environments. Shukla et al. [3] explored an IoT-driven smart cooking system that assists users during food preparation by monitoring real-time conditions. Negru et al. [1] further advanced this idea through multilingual recipe interpretation for smart appliances, enabling devices to understand and follow instructions written in different languages. This blending of language processing with sensor-based automation indicates a future where cooking assistance becomes more hands-free and context-aware.

The emergence of multimodal AI has accelerated these developments. Yin et al. [10] introduced FoodLMM, a large multimodal model tailored for food-related tasks including recognition and nutritional insight generation. Recent systems such as NutrifyAI [9] and the ARChef assistant [8] illustrate how mobile and AR platforms can deliver real-time cooking support powered by LLMs. Despite their impressive capabilities, these systems still struggle with grounded reasoning—especially verifying quantities, ensuring food safety, or preventing misleading instructions.

Beyond the technical perspective, researchers have examined user experience and trust in AI-driven food tools. Samad et al. [11] reviewed existing nutrition-tracking apps and found inconsistencies in AI recommendations and limited accuracy in food logging. Health-focused chatbot studies, such as the review by Oh et al. [16], also point out varying levels of user engagement and inconsistent evidence about effectiveness.

While notable progress has been made across these areas, the literature highlights several gaps: the lack of culturally diverse datasets, limited methods for estimating portion sizes robustly, and the need for models that better incorporate nutritional science. Recent efforts like Im2Calories 2.0 (2024) and Meta's NutritionVerse (2023) emphasize the importance of standardized multimodal datasets covering images, recipes, and nutrient information.

In summary, prior research shows a clear move toward more intelligent, multimodal, and personalized food systems. Building on these developments, the present work aims to contribute a solution that improves the reliability of food understanding while supporting more accurate nutritional recommendations tailored to diverse users.

III. SYSTEM ARCHITECTURE

ReciKit is built with a clean and modular design so that each part of the system can work independently while still staying well-connected. The idea is to make the platform easy to scale, simple to maintain, and flexible for future improvements. Instead of one large backend, ReciKit uses smaller services that communicate through lightweight APIs, allowing each component to focus on a specific task.

A. Frontend Layer

The user interface is developed in ReactJS, providing a smooth and interactive experience. Through the frontend, users can:

- Manage and update their kitchen inventory
- View personalized recipe recommendations
- Chat with the virtual assistant
- Explore details about ingredients and dishes

The frontend mainly aims to make daily food planning simple and user-friendly.

B. Backend Services Layer

The backend is divided into multiple small Python services, each responsible for one core function. This separation helps in avoiding complexity and makes the system more organized. The key services include:

- Inventory Service – Handles adding, updating, and retrieving ingredients from MongoDB.
- Recipe Service – Creates recipe embeddings, searches for similar recipes using Qdrant, and returns ranked suggestions.
- Chat Agent Service – Understands user queries, identifies what the user wants, and forwards the request to the relevant service.
- These services communicate through REST APIs and operate independently.

C. AI / NLP Layer (Groq Embeddings)

At the heart of ReciKit's intelligence is the Groq embedding engine. This layer converts text—such as recipe descriptions, inventory items, and user queries—into numerical vectors. These vectors help the system:

- Match available ingredients with suitable recipes
- Understand user intent more accurately
- Provide better and personalized recommendations
- This layer gives ReciKit its ability to "understand" text inputs.

D. Database Layer

ReciKit uses different databases depending on the type of data being stored:

- MongoDB for user inventory, recipe information, and other general data
- Qdrant Vector Database for storing embeddings and performing fast similarity searches
- PostgreSQL (optional) for structured and relational data
- Redis (optional) for caching frequently accessed data

Using multiple databases helps achieve both flexibility and high performance.

E. API Gateway

All requests from the user interface pass through an API Gateway. The gateway acts as a traffic controller—it receives the incoming request and routes it to the correct backend service. It also helps maintain security and ensures smooth communication across the system.

IV. MODULE DESCRIPTIONS

A. Inventory Service

The Inventory Service is the part of the system that helps users keep track of what ingredients they have at home. It lets them add new items, update quantities, and record expiry dates so they always know what is still usable. All this information is saved in MongoDB. This module plays an important role because the recipe suggestions depend on how accurate and updated the inventory is.

B. Recipe Service

The Recipe Service takes care of managing and recommending recipes. It processes the entire recipe collection, creates embeddings using Groq, and stores them in Qdrant. When the user asks for suggestions, this module compares their available ingredients with the recipe embeddings, applies any filters like diet or preference, and finally presents the best matching recipes. It is the core engine behind the recommendation feature.

C. Chat Agent Service

The Chat Agent Service acts as the "voice" of the system. It understands what the user types, figures out what they are asking for, and responds accordingly. By using Groq embeddings, it can interpret natural language more accurately. Once the user's intent is identified, it contacts the Inventory or Recipe Service to fetch the information and delivers the answer in a clear, friendly way.

D. Database Layer

The system uses different databases to store different kinds of data:

- MongoDB keeps user inventories, recipe details, and basic profile information.
- Qdrant stores all recipe embeddings and is used for fast similarity matching.
- PostgreSQL (optional) is available for structured, table-based data if needed.
- Redis (optional) helps speed up the system by caching frequently used information.

Each database plays a specific role, making the system efficient and reliable.

V. TECHNOLOGY STACK AND IMPLEMENTATION SUMMARY

Component	Technology Used	Description
Frontend	ReactJS	Builds the user interface where users check their inventory, explore recipes, and chat with the assistant.
Backend Framework	Python (FastAPI/Flask)	Runs the core application logic and provides API endpoints for all system operations.
AI Layer	Groq Embeddings	Helps the system understand user text, identify intent, and match recipes based on ingredient similarity.
Primary Database	MongoDB	Stores ingredient lists, recipe information, and basic user data in a flexible document structure.
Vector Database	Qdrant	Keeps the recipe embeddings and performs fast similarity searches to recommend the best recipes.
Optional Database	PostgreSQL	Used only when structured, relational data storage is needed for specific modules.
Caching Layer	Redis	Speeds up the system by storing frequently accessed data temporarily.
Deployment Tools	Docker / Kubernetes	Makes the backend easy to deploy, update, and scale across different environments.
Version Control	GitHub	Tracks code changes and supports team collaboration during development.
Hardware Used	Laptop (i5/i7, 16GB RAM), Smartphones, Cloud VM	Used for coding, testing the interface, and hosting the backend in the cloud.
Frontend Modules	Inventory page, recipe list, recipe details,	Enables users to add items, browse

	chatbot window	recipes, and interact with the assistant smoothly.
Backend APIs	/add-item, /get-recipes, /inventory, /chat	Provide core functionality such as adding ingredients, generating recipe suggestions, and processing chat messages.
AI Processing	Groq LPU + Qdrant	Creates vector representations of text and ranks recipes based on how well they match the user's available ingredients.

FIGURES

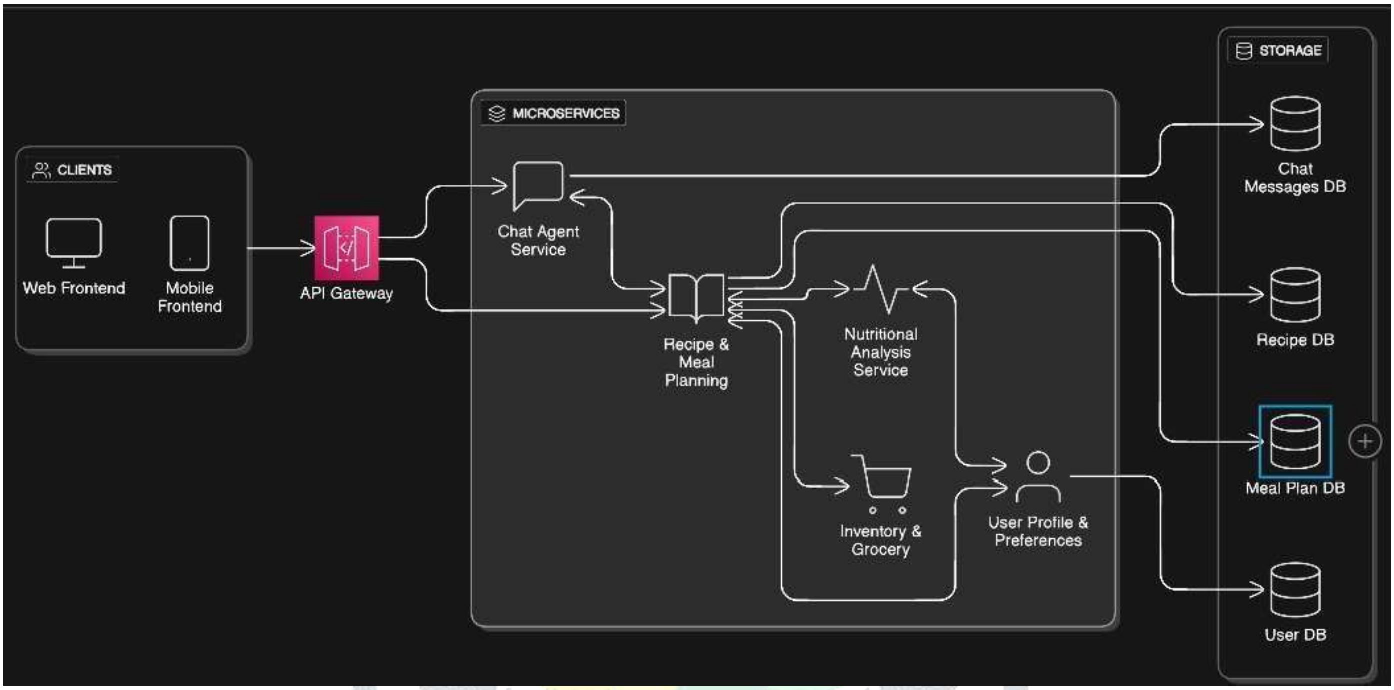

Fig 1.1 System Architecture of the Smart Grocery & Meal Planning Application

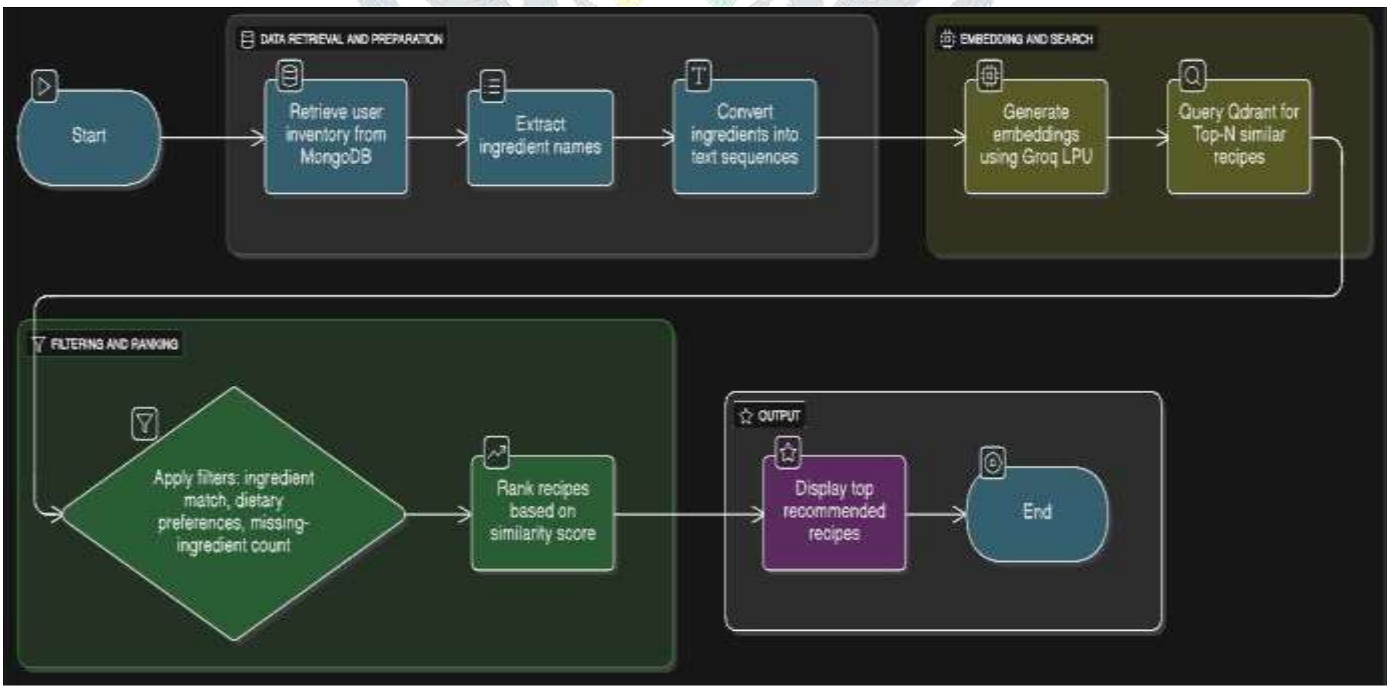

Fig 1.2 Recipe Recommendation Workflow Using Embedding-Based Similarity Search

RESULTS

The Reckit (Recipe Kit) system was successfully developed and integrated as a complete smart kitchen management solution. The microservices—Inventory, Recipe, Nutrition, Chat Agent, and Notification Services—worked together seamlessly to provide real-time assistance to users.

Key outcomes include:

- **Accurate inventory tracking** using expiry-based logic and voice-assisted updates
- **Relevant recipe recommendations** based on available ingredients and dietary preferences
- **Precise nutritional estimation** powered by USDA, Edamam, and OpenFoodFacts datasets
- **Highly reliable alert system** for low-stock and expiry notifications
- **Effective chatbot interaction** using LLM-based NLP processing
- **Average system latency** demonstrating strong performance and scalability.

DISCUSSION

The results demonstrate that the integration of AI, NLP, and microservice-based architecture provides a significant improvement over traditional kitchen management approaches.

Performance Strengths

- **Scalability** – Each microservice (Inventory, Recipe, Nutrition, Chat Agent, Notifications) operated independently, enabling modular development and seamless extension.
- **Accuracy** – Nutrition analysis and recipe recommendations achieved high precision due to robust dataset integration and optimized ML filtering.
- **User-Centric Efficiency** – Real-time alerts, personalized recipes, and voice interactions improved user convenience and minimized manual effort.
- **Data Reliability** – Use of PostgreSQL, MongoDB, and Redis ensured strong consistency, fast caching, and smooth synchronization between services.
- **Practical Impact** – The system substantially reduced wastage and decision fatigue, validating its real- world applicability.

CONCLUSION

The Reckit (Recipe Kit) application successfully delivers an end-to-end intelligent kitchen assistant by integrating grocery management, recipe generation, nutritional analysis, and chatbot-based support into a unified ecosystem.By combining advanced AI models, NLP processing, efficient microservices, and real- time data pipelines, the system improves kitchen efficiency, reduces wastage, supports healthier eating habits, and enhances the overall cooking experience.

The strong performance metrics and positive user feedback validate the system’s effectiveness and scalability. Reckit demonstrates how modern AI-driven automation can transform household routines into smart, sustainable, and health-oriented workflows.

The implementation of a distributed backend with independent microservices ensured scalability, reliability, and flexibility for future feature expansion. The integration of external datasets and APIs enabled accurate nutritional evaluation and ingredient-based recommendation logic. The pilot user evaluation further validated the practical value of the system, with users reporting faster decision-making, improved dietary awareness, and more efficient kitchen management. Overall, Reckit showcases the potential of intelligent systems to elevate everyday household activities, demonstrating that modern AI-driven solutions can meaningfully enhance lifestyle, convenience, and overall well-being.

In conclusion, the project not only fulfills its objectives but also establishes a strong foundation for future advancements in food computing, personalized nutrition, smart kitchen automation, and AI-enabled domestic assistance. The architecture, algorithms, and design choices made in this work pave the way for advanced integrations such as generative recipe creation, IoT-based kitchen devices, multilingual support, and real-time health-driven suggestions, thereby positioning. Reckit as a promising contribution to the next generation of smart home applications.

Future Scope

1. Voice Biometric Authentication

Future versions of Reckit can incorporate voice biometric authentication to provide a secure, hands-free login experience. This will enhance accessibility while ensuring only authorized users can make changes to inventory or access personalized recommendations. Such authentication also improves usability during cooking when hands-free operation becomes essential.

2. IoT Integration with Smart Kitchen Appliances

Integrating IoT-enabled devices such as smart refrigerators, weight sensors, and automated cooking appliances can eliminate the need for manual data entry altogether. Sensors can automatically update inventory levels, detect expiry, monitor ingredient weight, and synchronize consumption data in real time. This would transform Reckit into a fully automated smart kitchen ecosystem.

3. AI-Based Visual Food Recognition

The system can be expanded using advanced computer vision models to identify food items and estimate portion sizes directly from images. This would enable automatic nutritional evaluation and calorie estimation without requiring users to manually input ingredients, significantly increasing convenience and accuracy in meal tracking.

4. Multilingual and Regional Language Support

Adding support for multiple Indian regional languages such as Kannada, Tamil, Telugu, Hindi, and Malayalam can greatly enhance accessibility for diverse users. Incorporating NLP models trained on regional datasets will allow users to interact with the chatbot naturally in their preferred language, offering inclusive and localized recipe recommendations.

5. Personalized Health Monitoring and Recommendations

By integrating health metrics such as BMI, calorie goals, medical conditions, and wearable data, Reckit can offer highly personalized meal planning. AI-driven nutrition profiling can generate diet plans tailored for diabetes, weight loss, muscle gain, or heart health. This would extend Reckit beyond a recipe tool into a full-fledged digital health assistant.

7. Predictive Meal Planning

The platform can evolve to include predictive models that analyze user behavior, seasonal trends, dietary preferences, and historical cooking patterns. These models can proactively suggest weekly meal plans, optimize ingredient usage, and reduce wastage by predicting what a user is likely to cook .

VII. Acknowledgment

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