

MEAL MASTER: AN INNOVATIVE AI SOLUTION FOR RECIPE GENERATION

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ABSTRACT

This paper aims to introduce Meal Master, a web platform driven by artificial intelligence, designed specifically to help with ideas on reducing household food waste and present quick and easy solutions for preparing meals, thereby reducing the time people usually spend preparing food. Artificial intelligence, algorithms, web-based systems, and modern web technologies have been implemented in this system. It provides professional and fast recipe suggestions based on photos or inputs provided by the user, considering any preferences and allergies in diets they have set in advance. By promoting healthy food consumption and minimising waste, Meal Master makes meal preparation faster, easier and more enjoyable.

KEYWORDS: *Artificial, Intelligence, Application, Cooking, Recipe.*

INTRODUCTION

Many people in the 21st century is professionally engaged and away from home during each working day. During these long periods, they often eat "raw food" or "fast food", which proves to be detrimental to their health (ANTRUM, C., WARING, M., COHEN, J. and STOWERS, K., 2023) [1], or in the slightly better case - in restaurants and canteens where the food does not always meet high health standards (CLAESSENS, I., GILLEBAART, M. and RIDDER, D., 2023) [3]. However, a large part of people desires to eat healthy and tasty food at home (BAUER, J., NIELSEN, K., HOFMANN, W. and REISCH, L., 2022) [2]. Coming home after work every day, they could prepare healthy meals for themselves, and their families based on the food items available at the time. In most cases, however, this will require the creation of a new recipe. Therefore, another obstacle appears: most people do not have the time and energy to create recipes themselves, let alone put research and creativity into this activity. This provoked the launch of a scientific study that would provide a quick, easy and effective solution to the problem. The developed solution is going to help with ideas on reducing household food waste and give quick and easy offers for preparing meals, thereby reducing the time people usually spend preparing food. The application can consider any preferences and allergies in diets users have set in advance. The result of the conducted research and the implementation of the solution in a real working system is already the basis for the activity of a progressive startup.

With the proliferation of readily available artificial intelligence (AI) models and systems (RUSSELL, S. and NORVIG, P., 2010) [19] providing APIs for developing software with broad applicability, great opportunities have opened for software engineers to develop applications that solve a very wide range of tasks, related to text and image analysis [9,19,14,18]. Therefore, it is logical to assume that an application can be designed and created that uses an AI system for text understanding and generation to analyse recipes and create new ones according to set criteria. But the problem posed suggests a study of existing scientific approaches through which a reliable solution can be reached. For this purpose, the work referred to modern, but also relatively extensive, scientific and scientific-applied publications that are closely related to the issue.

The present research aims to create an AI Web application that assists people in creating new recipes from currently available products. To achieve the intended goal, the following tasks have been set out: research to be conducted, appropriate software technologies to be selected, a model of the system to be created, the AI Web-based solution to be implemented and its work to be evaluated.

1. AI MODELS

An AI model for text understanding and generation is an artificial intelligence system specifically designed to process, comprehend, and produce human language text (RUSSELL, S. and NORVIG, P., 2010) [19]. These models are built using natural language processing (NLP) and machine learning techniques. Such modern models are, for example: GPT-4, Gemini 1.5, Claude 3.5, Mistral Large 2, Llama 3.2, Jamba 1.5, Mistral NeMo (Artificialanalysis, 2024) [5].

GPT-4 (Generative Pre-trained Transformer 4) (OpenAI, 2024) [11] is the fourth iteration of OpenAI's large language model in the GPT series, designed for natural language understanding and generation. It's built on the transformer architecture and trained on vast amounts of text data to understand and generate human-like language. Here are some key points about GPT-4: language understanding and text generation (handling complex instructions, and engaging in more nuanced conversations); multimodal capabilities (capable of understanding both text and images, allowing it to process and respond to image-based queries in addition to text); large model (powerful and capable of handling complex tasks with greater accuracy); good contextual understanding (it has an enhanced ability to follow and maintain the context of a conversation over longer interactions, leading to more coherent and relevant responses in longer discussions); improved safety and ethics (it possesses advanced safety mechanisms and follows stricter guidelines for ethical AI use). GPT-4 enhances the ability to interact with humans in natural and intuitive ways. OpenAI has developed the GPT-4 API. The API allows developers to integrate GPT-4 into their applications and projects, enabling them to leverage its advanced language understanding and generation abilities.

GPT-4o, also known as GPT-4 Omni, is an upgrade from previous models and supports text, image, and voice inputs, with a focus on text-to-text and speech-to-speech capabilities. This version has extended features, including advanced voice interaction. GPT-4o can generate and interpret audio, expanding its usability beyond just text and image modalities.

Gemini 1.5 (Google, 2024) [8] is a large language model developed by Google AI. It is a multi-modal and foundation model. API is available through the Google AI Studio platform. Mistral Large (Mistral AI, 2024) [16] is a large language model developed by Mistral AI, designed to assist with a wide range of tasks, from answering questions to generating creative content. Its capabilities include understanding and generating human-like text, making it a versatile tool for various applications. Mistral AI has developed an API. Llama 3.2 (Meta, 2024) [13] is a collection of large language models (LLMs). Developers can access an API. Jamba (Jamba, 2024) [12] is a Large Language Model created by AI21, trained in early 2024. With a knowledge cutoff of February 2024, Jamba is designed to provide helpful and professional responses, assisting users with a wide range of inquiries and tasks. Developers can access an API. Claude (Anthropic, 2024) [4] is an AI assistant created by Anthropic. It has a broad knowledge base that allows users to engage in conversations and assist with tasks on a wide variety of topics. Anthropic does not provide an API. Mistral NeMo (Mistral, 2024) [17] is a text-based AI model designed to understand and generate human-like text based on the input it receives. It can answer questions, provide explanations, or engage in conversation. Developers cannot access an API.

An AI model for text-to-image creation is a type of artificial intelligence model that can generate images from textual descriptions (RUSSELL, S. and NORVIG, P., 2010) [19]. These models use deep learning techniques, typically involving a combination of NLP and computer vision, to understand the text and then create a corresponding image. The most well-known text-to-image models (Artificialanalysis, 2024) [5] are DALL-E, developed by OpenAI (OpenAI, 2024) [11], Stable Diffusion - by Stability AI (Stable Diffusion, 2024) [20] and Midjourney - by Midjourney lab (Midjourney,

2024) [15]. They can generate high-quality, highly detailed, photorealistic and creative images from textual prompts.

2. EXISTING AI MODELS AND APPLICATIONS IN RECIPE GENERATION

Ahmet Değerli and Nevruz Tatlisu, the authors of (DEĞERLİ, A. and TATLISU, N., 2023) [7], investigate the capabilities of AI tools, specifically ChatGPT (versions 3.5 and 4) and Bard, in the context of food recipe generation. The research explores their competency in various tasks including recipe correction, adaptation, detailing, time management, and presentation. The study aims to determine the strengths and limitations of these AI tools in comparison to a professional chef, highlighting their potential as supportive assets within the gastronomy field. Overall, ChatGPT 4 demonstrated superior performance in recipe correction, time management, and presentation tasks compared to the other AI tools. ChatGPT 4 achieved an 80% accuracy rate in identifying and correcting errors in recipes, while ChatGPT 3.5 achieved around 50%. Bard's performance was inconsistent, ranging from 30% to 80% accuracy. Both ChatGPT versions successfully provided detailed and understandable instructions for a given brief recipe. ChatGPT versions effectively adapted recipes to meet specific dietary restrictions (vegan, vegetarian, gluten-free, keto). ChatGPT 4 excelled in creating efficient time management plans, effectively utilising passive cooking times. ChatGPT 4 generated the most detailed and aesthetically pleasing presentations, along with corresponding SVG code. Bard exhibited inconsistencies and unsolicited actions in its responses, making unnecessary substitutions, omissions, and revisions in recipes. The study highlights that although AI tools cannot currently replace human chefs or dietitians, they hold significant potential as supplementary tools to facilitate tasks, enhance performance, and generate creative ideas.

The author of (GEORGE, A., 2024) [9], A. George, explores the relationship between human bartenders and AI in cocktail creation. It examines consumer preferences for cocktails made by humans versus AI systems, finding that most participants prefer the bartender's creations, valuing the human touch, creativity, and personalization. The study also suggests potential opportunities for human-AI collaboration, proposing models where AI could serve as a creative tool to enhance the bartender's skills rather than replace them.

In (SWAN, M., KIDO, T., ROLAND, E. and SANTOS, R., 2024) [21] the authors explore the potential of AI in revolutionising healthcare and promoting healthy longevity. The development of AI infrastructure is happening rapidly, which is making it easier to study biology. The use of AI is encouraging in the third wave of digitisation, where lots of processes are becoming digital.

The authors of (RAZZAQ, M., MAQBOOL, F., ILYAS., M. and JABEEN, H., 2023) [18] propose Evo Recipes, a novel framework for generating new culinary recipes using a combination of evolutionary algorithms and generative AI. Evo Recipes uses a large knowledge graph, Recipe KG, and an ontology, Recipe On, to represent recipes in a machine-understandable format. Evolutionary operators, including mutation and crossover, are applied to recipes encoded in this format to introduce novelty and diversity. The generated recipes are then transformed into human-readable text using OpenAI's GPT API. The framework is evaluated through quantitative metrics, measuring novelty, simplicity, visual appeal, and feasibility, as well as through a qualitative survey that assesses the subjective aspects of the generated recipes. The authors conclude that Evo Recipes-generated recipes are novel, simple, visually appealing, and valid. Evo Recipes, however, cannot generate suggestions of what the finished dishes will look like (as images of the created recipes).

This research paper (VENKATARAMANAN, R., ROY, K., RAJ, K., PRASAD, R. and ZI, Y., 2023) [24] explores the creation of a novel generative AI model called Cook-Gen that is designed to

extract cooking actions from recipe text. The paper tackles the challenge of irregular data patterns in recipes, such as variations in language descriptions for the same action and infrequent occurrences of certain actions. The authors propose aggregation-based generative methods to overcome these challenges and compare Cook-Gen to other generative and discriminative models, finding that it significantly outperforms them while requiring fewer computational resources. Cook-Gen does not create new recipes from a list of ingredients, nor does it create images of dishes.

In (GIM, M., PARK, D., SPRANGER, M., MARUYAMA, K. and KANG, J., 2021) [10] Recipe Bowl is presented, a novel cooking recommendation system that uses a Set Transformer to learn meaningful representations of ingredients and recipes. The system takes a set of ingredients and cooking tags as input and suggests possible ingredient and recipe choices. The paper describes the dataset used to train Recipe Bowl, including a method for selecting target ingredients based on their Tf-Idf scores. It also details the model architecture, which consists of a Set Encoder and a 2-way Decoder and explains the loss objective function used for training. The authors present quantitative and qualitative analyses of Recipe Bowl's performance, highlighting its ability to suggest relevant and plausible ingredient and recipe recommendations based on recipe context and ingredient relations. Recipe Bowl's primary function is to recommend ingredients and recipes based on existing culinary knowledge, rather than generating completely new recipes.

While the reviewed works demonstrate significant advancements in the application of AI within the culinary domain, they do not fully encompass the comprehensive functionality of the goal of the present research. Specifically, these studies primarily focus on recipe correction, adaptation, ingredient recommendation, and, in some cases, the extraction of cooking actions from text. Notably, none of the reviewed works integrates the capability to generate new recipes from a given set of ingredients and suggests corresponding images of the finished dishes, which is going to be the core innovation of the present solution.

3. SELECTION OF AI MODELS FOR IMPLEMENTATION

Several main criteria should be considered when choosing the most suitable AI model. The chosen model should be as fast as possible, because the structure of the application is made so that the result returned from the request to the AI model, first passes through the API of the application, then at the same time it is sent to the user (owner of the request) as well as the database so that everything can be stored. From (Artificialanalysis, 2024) [22], we can see that the Meta and OpenAI models achieve the best results for Throughput. In the context of a culinary web and mobile application, AI models should be able to generate recipes based on available products and user preferences, as well as a photo of random culinary products. They should then be able to generate high-quality images in a similar style. The best AI text models according to (Artificialanalysis, 2024) [5] that can meet these requirements are GPT-4, GPT-4o, Gemini, Llama 3, Claude Sonnet 3.5 and Opus. The best AI models for image generation according to (Harry Guinness, 2024) [23] are Dall-E 3, Stable Diffusion 3 and Midjourney.

Meal Master uses OpenAI products, both to generate images and to generate text responses, dialogues, titles and internal AI operations. The following AI models have been chosen: GPT-4o and DALL-E 3. They are designed to work well together, ensuring a smooth integration process. GPT-4o generates the textual recipe, while DALL-E 3 creates corresponding images, providing a cohesive and comprehensive recipe generation and visualisation solution. The combination of GPT-4o and DALL-E 3 offers a superior user experience by delivering both detailed recipes and visually appealing images, catering to both the informational and visual needs of users.

4. DEVELOPMENT PHASES

The development process has been divided into the following four phases:

Phase 1: Planning and Research.

The first phase involves extensive planning and research to determine development challenges, followed by an analysis of existing solutions and market competitors.

Phase 2: Prototyping.

A basic prototype has been developed that includes key functionalities, mainly allowing users to enter available ingredients and generate recipe suggestions based on this data. The app introduces a chatbot powered by the OpenAI API that allows users to engage in text and image-based conversations. This chatbot not only provides recipe recommendations but also offers cooking tips and help, which makes preparing food an easy task. The app's recipe management feature allows users to save and manage their chat-generated recipes, and the chat history feature lets them go back to previous conversations for greater convenience.

Phase 3: AI models integration.

A notable innovation in the app is the image recognition feature by which users can take a picture of the ingredients available at that moment and then the app suggests recipes based on the image. This improves the overall user experience by making the process more intuitive and accessible. Additionally, an admin panel is included to monitor user activities and app metrics such as popular searches, user interactions, and subscription details. Subscription cost analysis can also be tracked to support the financial sustainability of the application.

Phase 4: Release Minimum Viable Product (MVP).

As the project progressed, AI models for recipe generation and ingredient management were developed and integrated into the platform. These models have undergone thorough testing and validation to ensure precision and reliability. After the testing phase, an MVP was released to gather user feedback.

5. CHOICE OF TECHNOLOGIES

To realise the Meal Master concept, modern web technologies have been carefully selected to ensure performance, scalability and ease of use. At the design stage, Figma and Canva are used to create an intuitive and visually appealing user interface. React with Vite.js has been chosen for building the frontend of the application for greater speed and dynamic visualisation in the web solution. For the mobile version, React Native is used to maintain a consistent user experience across devices. For design purposes, Tailwind CSS has been applied, ensuring that the app is both responsive and visually clean. For backend development, .NET Core is used to drive business logic and create a reliable API. The AI-powered recipe generation feature has been implemented using the OpenAI API integrated into the backend for seamless interaction. Payment management is handled by Stripe, enabling secure and efficient online transactions within the platform. Data storage is managed using MongoDB, chosen for its flexibility in handling user data, recipes and ingredient information. The hosting infrastructure is based on Azure, using services such as App Service, Static Web Apps and Cosmos DB to provide a scalable and reliable environment for both web and mobile applications. By using these technologies, Meal Master has been able to combine advanced AI functionality with a user-friendly interface, creating an innovative solution that simplifies meal preparation while reducing food waste.

6. APPLICATION MODEL, IMPLEMENTATION AND RESULTS

Two main output platforms have been built - a web-based one and a mobile one. This can be seen in the diagram of the created Meal Master model (Figure 2). For users to access the same data from both the internet and their mobile phone, Microsoft Entra ID has been integrated. After authorization and authentication, the user has access to the applications' functionalities. Every user action goes through the Meal Master API, which can be said to be the core of the application. This API implements OpenAI, Stripe, MongoDB, and Azure storage. Through Stripe, the application manages payments, subscription plans, as well as payment user accounts, invoices and statements. Through Azure Storage, user accounts are managed outside the application, and through OpenAI, chats, messages and photos are quickly and efficiently managed using their powerful AI models. All these technologies aim to achieve security and stability in the application and succeed in doing so.

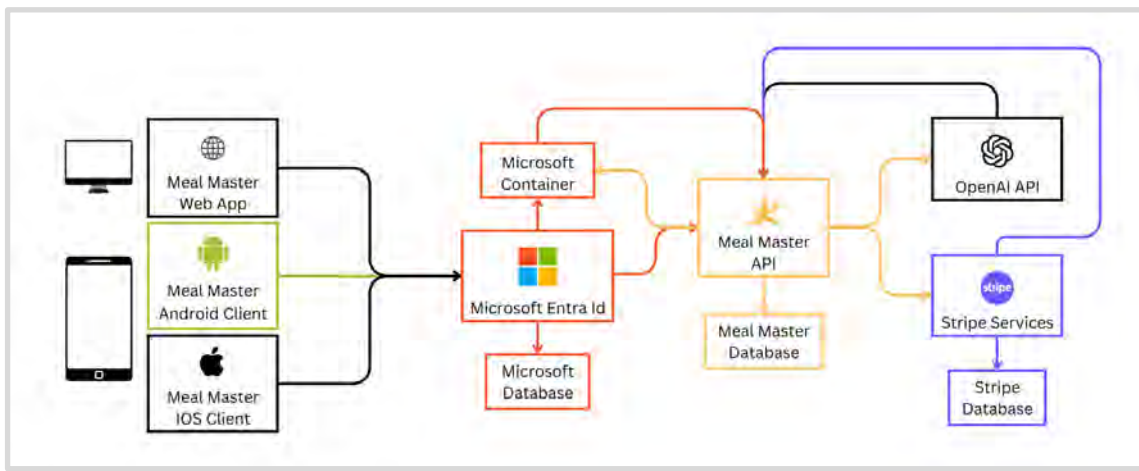


Figure 2. Application Model of the AI Solution

Source: Own elaboration

Using external sources to store important user information makes Meal Master as secure as possible for data storage. Absolutely no user information is stored on the database of the app itself, no emails, no location information, debit cards, names, etc. Only the chats and the access keys of each user to the external storage are stored. Even if these keys are stolen, it is still not possible to access the information since several more secret keys must be used, which only the isolated core of the application can access.

Figure 3 is a generated photo of a dish, demonstrating the AI's ability to analyse available ingredients and suggest a fully realised recipe. This preview serves as a proof of concept and the app's level of functionality, illustrating how it can take raw input such as an image of ingredients and create a detailed, appetising meal suggestion.



Figure 3. A meal suggestion generated by Meal Master

Source: Own elaboration

CONCLUSION

By leveraging cutting-edge AI technologies, Meal Master offers a comprehensive solution that not only generates personalised and contextually relevant recipes but also provides visually appealing images of the dishes. This capability sets Meal Master apart from existing solutions, which primarily focus on recipe correction, adaptation, and ingredient recommendation without integrating image generation. This combination of text and image generation capabilities addresses the limitations of current AI models, offering a more holistic and user-friendly approach to meal planning and preparation. Moreover, the use of modern web technologies and a robust API framework ensures that Meal Master is both scalable and efficient, capable of handling real-time interactions and providing quick responses to user inputs. The platform's ability to consider user preferences and dietary restrictions further enhances its practicality and appeal. Overall, Meal Master demonstrates the potential of AI to revolutionise everyday tasks, making meal preparation faster, easier, and more enjoyable while promoting healthy eating and reducing food waste.

Future developments in extending this AI solution may include extending personalised recommendations and integrating the app with IoT devices, such as smart refrigerators, to automatically track ingredient availability.

REFERENCES

1. ANTRUM, C., WARING, M., COHEN, J. and STOWERS, K. (2023) Within-store fast food marketing: The association between food swamps and unhealthy advertisement. *Preventive Medicine Reports*, Elsevier Journal, [Online] Volume 35. pp. 1-6. Available from: <https://doi.org/10.1016/j.pmedr.2023.102349> [Accessed 1/10/2024].
2. BAUER, J., NIELSEN, K., HOFMANN, W. and REISCH, L. (2022) Healthy eating in the wild: An experience-sampling study of how food environments and situational factors shape out-of-home dietary success. *Social Science & Medicine*, Elsevier Journal, [Online] Volume 299. pp. 1-11. Available from: <https://doi.org/10.1016/j.socscimed.2022.114869> [Accessed 1/10/2024].
3. CLAESSENS, I., GILLEBAART, M. and RIDDER, D. (2023) Personal values, motives, and healthy and sustainable food choices: Examining differences between home meals and restaurant meals. *Appetite*, Elsevier Journal, [Online] Volume 182. pp. 1-12. Available from: <https://doi.org/10.1016/j.appet.2022.106432> [Accessed 1/10/2024].
4. Claude 3.5. Available from: <https://claude.ai> [Accessed 1/10/2024]

5. Comparison of Models: Quality, Performance & Price Analysis. Artificial Analysis. Available from: <https://artificialanalysis.ai/models> [Accessed 1/10/2024]
6. DALL-E. Available from: <https://openai.com/index/dall-e> [Accessed 1/10/2024]
7. DEĞERLİ, A. and TATLISU, N. (2023) Cooking with ChatGPT and Bard: A Study on Competencies of AI Tools on Recipe Correction, Adaption, Time Management and Presentation. *Journal of Tourism and Gastronomy Studies*, 11 (4). pp. 2658-2673. Available from: <https://jotags.net/index.php/jotags/article/view/1974/3008> [Accessed 1/10/2024]
8. Gemini 1.5. Available from: <https://gemini.google.com> [Accessed 1/10/2024]
9. GEORGE, A. (2024) Human Touch: Exploring the Synergy Between Bartenders and AI in Cocktail Creation. *Partners Universal Innovative Research Publication*, 2 (2). pp. 106-118. Available from: <https://zenodo.org/records/10956977> [Accessed 1/10/2024]
10. GIM, M., PARK, D., SPRANGER, M., MARUYAMA, K. and KANG, J. (2021) RecipeBowl: A Cooking Recommender for Ingredients and Recipes Using Set Transformer, *IEEE Access*, vol. 9. pp. 143623-143633. Available from: <https://ieeexplore.ieee.org/document/9570315> [Accessed 1/10/2024]
11. GPT-4. Available from: <https://openai.com/index/gpt-4> [Accessed 1/10/2024]
12. Jamba. Available from: <https://www.ai21.com/jamba> [Accessed 1/10/2024]
13. Llama. Available from: <https://www.llama.com> [Accessed 1/10/2024]
14. MANOCHANDAR, S. (2024) AI-Enhanced Smart Cooking Pot: A Culinary Companion with Intelligent Sensing. *Data Analysis and Forecasting Journal*, 2 (2). Available from: <https://doi.org/10.3991/itdaf.v2i2.48757> [Accessed 1/10/2024]
15. Midjourney. Available from: <https://www.midjourney.com> [Accessed 1/10/2024]
16. Mistral Large 2. Available from: <https://mistral.ai> [Accessed 1/10/2024]
17. Mistral NeMo. Available from: <https://mistral.ai/news/mistral-nemo> [Accessed 1/10/2024]
18. RAZZAQ, M., MAQBOOL, F., ILYAS., M. and JABEEN, H. (2023) EvoRecipes: A Generative Approach for Evolving Context-Aware Recipes. *IEEE Access*, vol. 11. pp. 74148-74164. Available from: <http://dx.doi.org/10.1109/ACCESS.2023.3296144> [Accessed 1/10/2024]
19. RUSSELL, S. and NORVIG, P. (2010) *Artificial Intelligence - A Modern Approach*, Third Edition. Prentice Hall Series in Artificial Intelligence, Pearson Education, New Jersey.
20. Stable Diffusion. Available from: <https://stability.ai/stable-image> [Accessed 1/10/2024]
21. SWAN, M., KIDO, T., ROLAND, E. and SANTOS, R. (2024) AI Health Agents: Pathway2vec, ReflectE, Category Theory, and Longevity. *Proceedings of the AAAI 2024 Spring Symposium Series*, 3 (1). Available from: <https://doi.org/10.1609/aaais.v3i1.31249> [Accessed 1/10/2024]
22. Text to Image AI Model & Provider Leaderboard. Artificial Analysis. Available from: <https://artificialanalysis.ai/text-to-image> [Accessed 1/10/2024]
23. The 7 best AI image generators in 2024. Available from: <https://zapier.com/blog/best-ai-image-generator> [Accessed 1/10/2024]
24. VENKATARAMANAN, R., ROY, K., RAJ, K., PRASAD, R. and ZI, Y. (2023) Cook-Gen: Robust Generative Modeling of Cooking Actions from Recipes. *Cornell University, Computer science section*. Available from: <http://dx.doi.org/10.48550/arXiv.2306.01805> [Accessed 1/10/2024]