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A Study on the Development of a Chatbot Using Generative AI to Provide Diets for Diabetic Patients

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Abstract

The purpose of this study is to develop a sophisticated web-based artificial intelligence chatbot system designed to provide personalized dietary service for diabetic patients. According to a 2022 study, the prevalence of diabetes among individuals over 30 years old was 15.6% in 2020, identifying it as a significant societal issue with an increasing patient population. This study uses generative AI algorithms to tailor dietary recommendations for the elderly and various social classes, contributing to the maintenance of healthy eating habits and disease prevention. Through meticulous fine-tuning, the learning loss of the AI model was significantly reduced, nearing zero, demonstrating the chatbot's potential to offer precise dietary suggestions based on calorie intake and seasonal variations. As this technology adapts to diverse health conditions, ongoing research is crucial to enhance the accessibility of dietary information for the elderly, thereby promoting healthy eating practices and supporting disease prevention.

Keywords : Diebetic, AI Chatbot, Fine-tuning, Diet management system, Learning Data

Major Classification Code : Artificial Intelligence

1. Introduction

In today's society, the correlation between diet and health is unmistakably significant, especially as the elderly population expands, leading to an increased prevalence of major diseases among this demographic. Metabolic diseases, such as diabetes and hypertension, have emerged as significant health concerns for the elderly. Specifically, in Korea, the diabetic population has surpassed the 6 million marks. Despite this growing number, the availability of services and information tailored to meet the needs of individuals managing these conditions remains insufficient. Proper nutrition plays a crucial role in the management and prevention of diseases, yet the practical application of such diets faces significant hurdles in contemporary society. The surge in dietary diversity, along with the enhanced

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accessibility and convenience of foods, has inadvertently led to a rise in the consumption of items rich in calories, fats, and sugars. This shift in dietary behavior stands as a key contributor to the health challenges confronting older adults, fostering the onset of various diseases. The current applications of personalized diet recommendation systems tend to focus on specific conditions, often overlooking the diverse health and dietary needs of older adults. Seniors may experience multiple conditions simultaneously, making the task of planning an inclusive diet that accommodates all their health issues a complex challenge.

In this study, we concentrated on developing an AI chatbot service capable of offering dietary recommendations for all significant diseases affecting the elderly. To address the myriad of diseases and dietary needs, we initially trained a specialized AI model using data pertinent to diabetes and subsequently developed a model predicated on this training. Through this approach, our aim is to assist the elderly in sustaining healthy eating habits and in the effective prevention of diseases.

2. Related Research

2.1. Prior Studies Related to Diabetes Patient Chatbot

A study on the prevalence of diabetes and hypertension highlighted a marked increase in diabetes incidence among individuals aged 30 and above between 2018 and 2019-2020 (Bae, 2022). In 2018, the diabetes prevalence rate among this age group was 13.8%, which escalated to 15.6% in the period of 2019-2020, underscoring an increasing trend in the disease's prevalence over time. The investigation into hypertension presented equally significant findings. By 2021, the prevalence rates of hypertension in individuals aged 70 and above were 61.4% for men and 69.9% for women, revealing that hypertension risk factors augment with age. Moreover, a staggering 95.3% of those aged 65 and above suffer from a chronic condition, with 71% experiencing two or more comorbidities and an average of 4.1 chronic conditions (Jeong, 2013).

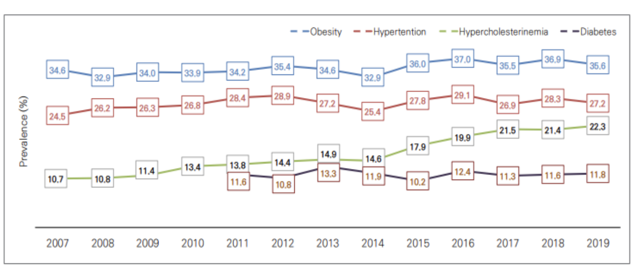


Figure 1: Prevalence of major comorbidities(Cho, Kyung Sook., 2021)

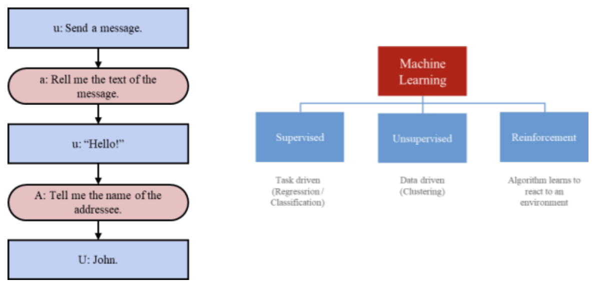
Figure 1 additionally reveals that the prevalence of hypercholesterolemia has consistently risen from 10.7% to 22.3% between 2007 and 2019, with obesity rates at 35.6%, surpassing those of hypertension and diabetes. In light of these trends, this study primarily concentrates on dietary recommendations for individuals with diabetes. A pioneering smartphone-based personalized diet management system, introduced in 2010, offered a more comprehensive and individualized approach. This application enabled users to fill out a dietary checklist tailored to their personal energy source ratios, subsequently generating customized dietary recommendations for breakfast, lunch, and dinner (Lee, Y.-H., 2010). The U-Health Self-Nutrition Programme, a web-based initiative launched in 2014, offers users the functionality to input their gender, height, and level of activity. Based on these inputs, the programme calculates their standard weight, adjusted weight, and daily caloric needs. To aid users, especially those managing diabetes, it provides one or two sample diets in 100-calorie increments, with total daily calories ranging from 1,400 to 2,300 (Ahn et al., 2014).

Figure 2: Prior Studies service model2

Drawing upon prior research and leveraging recent advancements in artificial intelligence, we have engineered a service model that integrates real-time health data to deliver personalized health recommendations.

2.2. Technical Background

A chatbot, functioning as a computer program or robot, utilizes artificial intelligence to facilitate natural language interactions with users. These interactions can manifest through various modalities, including text-based chat, speech recognition, speech synthesis, and image recognition. Commonly employed across diverse domains such as daily chores, customer service, medical consultation, and entertainment, chatbots serve to answer inquiries, execute commands, or disseminate information. Chatbots are categorized into two distinct types: rule-based and AI-based. Figure 3 illustrates examples of both a rule-based chatbot and an AI-based chatbot (Kim, 2018).



(a) Rule-based chatbot (b) AI-based chatbot

Figure 3: Two types of chatbot

ChatGPT, an advanced natural language processing model developed by OpenAI, excels in a wide range of linguistic tasks. This model represents a combination of "Chat" and "Pre-trained Transformer" (GPT), utilizing a transformer architecture that has been pre-trained on a vast database to facilitate conversation. Unlike traditional AI, which relies on learning from data and patterns, ChatGPT stands out as a generative AI. It generates or synthesizes outcomes through comparative learning with existing data, a method highlighted by Lee, S. (Lee, 2023). Moreover, ChatGPT inherently possesses extensive language understanding abilities but undergoes a fine-tuning process to incorporate specialized knowledge on specific topics or domains. This fine-tuning is crucial for enhancing the model's performance, enabling it to reach a high degree of expertise and understanding within a given area. For instance, the fine-tuning of ChatGPT has been applied to develop an AI chatbot offering personalized dietary advice to patients, demonstrating the process's significance in elevating the model to an expert level for improved support and guidance.

In this study, we enhanced ChatGPT by fine-tuning it into an AI chatbot capable of offering personalized dietary advice to individuals with diabetes. By integrating diabetes-specific data and domain expertise into the ChatGPT framework, we enabled the model to deliver more precise and valuable information during interactions with diabetic patients. This adaptation ensures that the advice provided is tailored to the unique needs and health considerations of each patient, reflecting the potential of fine-tuned AI in specialized healthcare applications.

3. Research Methods

3.1. Calculating Individual Energy Source Ratios

In this study, we determined the diagnostic criteria for diabetes, daily caloric needs, and individual energy source ratios to facilitate personalized diet management services. Body weight control and caloric intake are crucial in both the prevention and management of diabetes, highlighting the significance of blood glucose regulation. The diagnosis of diabetes relies on blood glucose measurements, with the diagnostic criteria detailed in Table 1 (Kang, 2011). This approach underscores the importance of tailored dietary plans that consider the unique nutritional requirements and health goals of individuals with diabetes.

Table 1: Example of a Table Caption

Classification	Criteria
A normal person	Less than 110mg/dl of fasting blood sugar or Blood sugar at least 126mg/dl for 2 hours after meals
Fasting blood glucose disorder	110mg/dl or more or less than 126mg/dl
Impaired glucose tolerance	140mg/dl or more or less than 200mg/dl
A diabetic	Fasting blood sugar of 126 mg/dl or more or 2 hours of blood sugar above 200mg/dl

The theoretical foundation concerning body weight and dietary caloric intake is acknowledged as a pivotal aspect of this research. Body weight standards fluctuate based on gender and height dimensions. Furthermore, daily caloric necessities adjust in accordance with varying degrees of physical activity, employing these attributes as a basis for data collection and analysis within the study. The fundamental daily caloric needs are precisely determined through the application of the Tokunaga-Matsuzawa index formula, as meticulously outlined in Table 2(10).

Table 2: Method for calculating daily calorie requirements

Classification	Criteria
A normal person	Less than 110mg/dl of fasting blood sugar or Blood sugar at least 126mg/dl for 2 hours after meals
Fasting blood glucose disorder	110mg/dl or more or less than 126mg/dl
Impaired glucose tolerance	140mg/dl or more or less than 200mg/dl

A diabetic	Fasting blood sugar of 126 mg/dl or more or 2 hours of blood sugar above 200mg/dl

Light activity primarily encompasses sedentary tasks, such as office work and typing, prevalent in daily routines. In contrast, moderate activity typically involves actions like walking, washing, cleaning, childcare, light industrial tasks, and domestic chores, encapsulating the standard level of daily exertion. Conversely, vigorous activities demand significantly more effort and energy, including endeavors such as climbing, transporting heavy loads, swift running, engaging in agricultural or mining operations, athletic training, and labor in steel manufacturing environments (11). To ensure the provision of adequate energy within a diabetic diet, it is crucial to focus on the integration of energy sources and dietary selections. The interconnections among these elements are concisely delineated in Table 3(Y.-H. Lee., 2010).

Table 3: Percentage of energy sources for people with diabetes

Classification	Energy per gram	Composition ratio	Type of food
Sugar content	4Kcal	50~60%	Fiber that does not produce calories such as sugar and starch
Protein	4Kcal	15~20%	Meat, Fish, Eggs, Dairy, Beans, Tofu
Fat	9Kcal	25% Less than	Cooking oil, Margarine, Nuts, Stalks

Based on the above criteria, we derived a suitable diet for diabetic patients and used it as training data in this paper. The data was used as a resource for fine-tuning the ChatGPT model.

3.2. Data Collection and Model Design

Individuals with diabetes require diets tailored to their unique caloric needs, reflecting their physical demands. To accommodate this variability, distinct caloric levels have been designated, including 1400 kcal, 1500 kcal, 1600 kcal, 1700 kcal, 1800 kcal, and 1900 kcal. These dietary plans data were devised adhering to the guidelines set forth by the Korean Diabetes Association. In consideration of the changing seasons—spring, summer, autumn, and winter—our approach was to choose nutrients and foods best suited to each period. Consequently, we diversified the data into 10 dietary guidelines to effectively accommodate the individual nutritional compositions of patients according to the seasons and to provide tailored solutions. To facilitate the development of a flowchart for the patient nutrition web service, we devised a user-centered scenario, as illustrated in Figure 4.

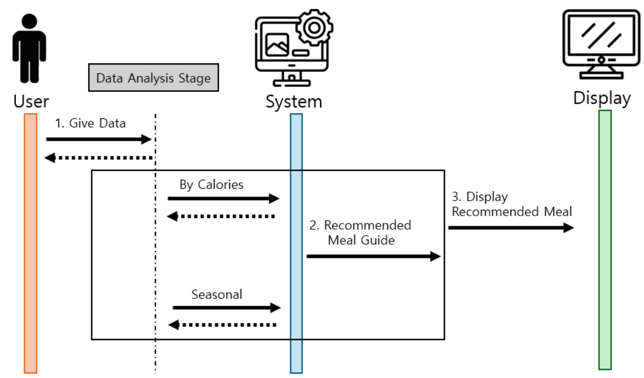


Figure 4: Workflow of chat bot model

Upon activation via the designated procedure, the service operates predicated on two principal criteria: caloric intake and seasonal factors, aiming to recommend a diet that aligns with the user's needs. It adjusts to either establish a specific calorie target based on user preference or to recommend the ideal seasonal diet. The proposed dietary plans are subsequently displayed in a table, enabling users to easily comprehend and visualize their options. Upon successful execution, the service concludes by offering personalized advice on dietary enhancement, tailored to the recommendations made, thereby equipping users with the knowledge to improve their nutritional habits.

JavaScript scripts played a pivotal role in crafting dialogue interfaces and behaviors, facilitating data processing and the interaction dynamics between the user and the model. To enhance the visual appeal, Cascading Style Sheets (CSS) were employed, introducing supplementary styles. The adjustment of web page layouts and designs was accomplished through the adept use of CSS, while the foundation of the web pages was established using HyperText Markup Language (HTML) files to delineate their structure and interface. By integrating HTML with JS scripts and CSS, we ensured a coherent and seamless user experience, effectively marrying the structural components with dynamic functionalities and aesthetic enhancements.

3.3 Chatbot Development Process

In this study, the chatbot is based on OpenAI's ChatGPT

AI model. By invoking the ChatGPT API, the model was utilized, and a subsequent refinement phase was undertaken to provide patients with accurate and satisfying solutions. In this phase, additional training was conducted using a dataset we developed. As a result, a chatbot system focused on dietary guidance for diabetic patients was developed, performing the role of a specialist in proposing appropriate dietary regimens. Particular emphasis was placed on providing precise caloric data to help users effectively manage their health conditions. The structure for invoking and utilizing the chatbot's API is illustrated in Algorithm 1.

Table 4: AI Chatbot Pseudo-code

Algorithm 1 Chatbot Handling

```
function GENERATERESPONSE(chatElement)
    messageElement ← select paragraph element
    from chatElement
    Create requestOptions object
        Set method to "POST"
        Add headers:
            "Content-Type" ← "application/json"
            "Authorization" ← "Bearer" + API_KEY
        Set body to JSON.stringify:
            Set messages to [role: "user", content:
            userMessage]
    Send request using fetch with API_URL and
    requestOptions
        Parse response as JSON and store as data
        Set text content of messageElement to
        trimmed content of first message in
data.choices
        If error, add "Sorry, an error occurred.
Please try again." to messageElement and add class
"error"
    Scroll chatbox to bottom
end function
function HANDLECHAT
    userMessage ← trim(chatInput.value)
    if userMessage is empty then
        return
    end if
        Set chatInput value to empty string
        Set height of chatInput to inputInitHeight
        Add outgoing message to chatbox using
CREATECHATLI(userMessage, "outgoing")
            GENERATERESPONSE
end function
```

For the fine-tuning process, we transformed the dataset into JSON format to retrain the model, enhancing its efficacy. As a result, the refined model demonstrated a heightened responsiveness to inquiries concerning dietary recommendations for diabetes, supplying users with precise and authoritative information. This meticulous fine-tuning process culminated in the evolution of an AI chatbot tailored to deliver dietary advice specifically designed for individuals managing diabetes, thereby augmenting the chatbot's utility and relevance in healthcare applications.

3.4 Fine-tuning Process

During the fine-tuning phase, dietary information was structured in JSON format, incorporating the 10 existing dietary guidelines. Each guideline included diets based on expert consensus, with 10 exemplar diets added per criterion. This approach of providing the model with detailed data significantly enhanced its ability to respond to user-specific dietary inquiries. During the fine-tuning process, training loss gradually decreased and reached a stable level, as shown in Figure 5. The x-axis of the graph represents epochs, while the y-axis represents the training loss values. With this meticulously fine-tuned AI integrated into the chatbot, its ability to offer personalized dietary recommendations, tailored to the user experience, will be further enhanced.

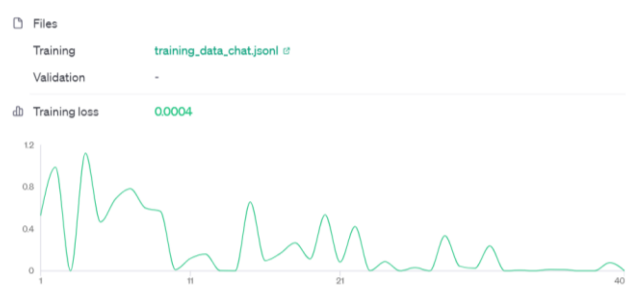


Figure 5: Fine-tuning Results

4. Results and Discussion

Figure 6 illustrates the operation of the meal delivery service as delineated by the flowchart in Chapter 3.

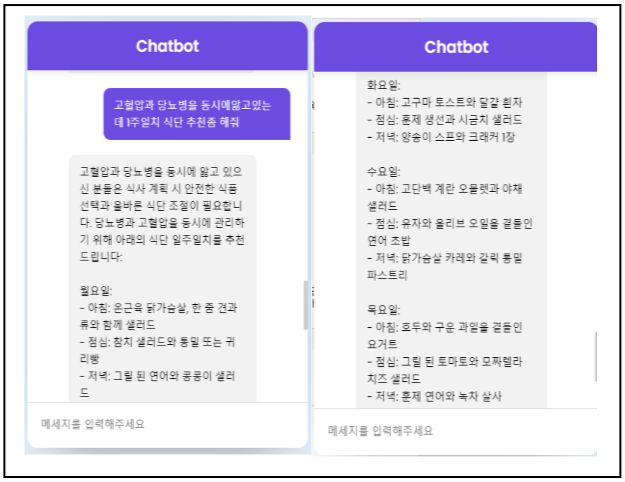


Figure 6: Recommended Diets and Explanations

Figure 6 demonstrates the capability of the system to offer dietary recommendations for multiple geriatric conditions simultaneously, rather than being restricted to a singular condition. This multi-condition approach enables the provision of tailored dietary advice for individuals with coexisting health issues. Specifically, for diabetes, a specialized model pre-trained with relevant data is employed, as depicted in Figure 6. This specialized approach ensures that the service delivers more precise and expert-driven recommendations, catering to the nuanced needs of individuals managing diabetes alongside other geriatric conditions. The interface showcases a week's average dietary plans tailored to specific health conditions, ascertained through interactions with the AI chatbot. At present, the focus is exclusively on diabetes, with the dietary visuals derived from the authoritative data provided by the Korean Diabetes Association. This ensures that the recommendations are not only personalized but also adhere to recognized dietary standards for diabetes management.

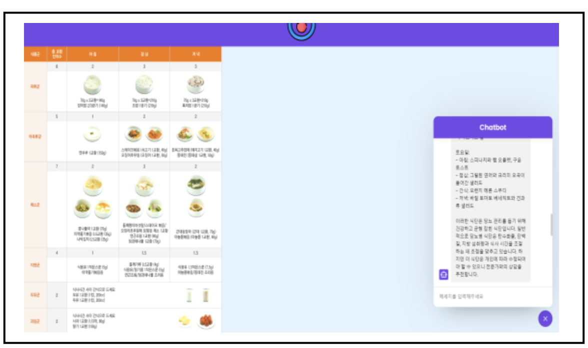


Figure 7: Diet Verification Through Photos

4.1 Comparison with Existing App Services

The innovation introduced in this research extends personalized diet plans across the spectrum of geriatric diseases, with an enhanced emphasis on diabetes management. As depicted in Table 4, a comprehensive comparison is made between the capabilities of current diabetes management and recipe applications against the system developed in this study. This comparison highlights that existing applications either do not fully accommodate the user's health condition or only partially integrate certain functionalities and supplementary information. Contrarily, the system proposed herein pioneers a diet recommendation protocol that acknowledges the prevalence of multiple coexisting conditions in the elderly. Furthermore, it augments the traditional chatbot interface by incorporating visual representations of suggested diets, thereby addressing the limitations of text-only information provision. This advancement not only facilitates a more engaging user experience but also aids in the comprehensive understanding and adherence to dietary recommendations.

Table 5: Comparison with Existing Applications

Classification	Diabetes App	Recipe App	A system of presentation
Reflect user health status	Reflection	Unreflected	Reflection
Whether specific services are provided	A diabetic logbook	Keep Recipe	Recommended diet based on diabetes judgment
Whether additional information is available	Unreflected	Partial reflection	Seasonal preference

5. Conclusions

In the contemporary era, the management of diet has gained paramount importance due to the escalating prevalence of geriatric diseases, propelled by the swift expansion of the elderly demographic. This paper introduces an AI chatbot system designed to address a broad spectrum of geriatric diseases, with a particular depth of expertise in diabetes management. The system's objective is to furnish users with customized dietary information tailored to specific health conditions and nutritional requirements. The enhancement of the ChatGPT model through fine-tuning, leveraging our specialized knowledge and diabetes-related data, has significantly sharpened the model's focus. This refinement process has elevated the model's interaction accuracy with diabetic patients, enabling the provision of pragmatic and beneficial patient support alongside dietary guidance.

The research further ventured into crafting user-centric service scenarios and curating training data that encapsulates dietary management across diverse diseases and nutritional needs. This approach empowers patients to access diets personalized to their physical requirements, including options that cater to seasonal variations. When juxtaposed with existing applications, our system demonstrates a superior capacity to mirror the health status of the elderly more accurately and offers an enhanced array of services and utilizations of supplementary data. These advancements are anticipated to aid the elderly in sustaining healthy dietary practices and in the effective prevention of diseases. Currently centered on diabetes, our research is poised to broaden its scope to encompass AI chatbots capable of addressing a multitude of other geriatric conditions, including hypertension. Recognizing the diverse needs and preferences of users, we aim to enhance personalization within our services by assigning greater significance to user preferences. Additionally, in the pursuit of offering more engaging and interactive content, we anticipate integrating a feature that delivers recipes through YouTube videos in the future.

The AI chatbot system delineated in this study is envisioned to serve as a pivotal instrument in bolstering the health and enhancing the quality of life for the elderly population. By supplying comprehensive dietary information tailored to address various diseases, this system underpins our commitment to fostering well-being and preventative health measures among the aging demographic.

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