A CONVENIENT MOBILE APPLICATION TO MODIFY HIGH-SUGAR BAKING RECIPES TO DIABETIC-FRIENDLY USING TEXT RECOGNITION AND ARTIFICIAL INTELLIGENCE

Julia Yili Shang[1] and Julian Avellaneda[2]

[1]Diamond Bar High School, 21400 Pathfinder Rd, Diamond Bar, CA 91765
[2]Computer Science Department, California State Polytechnic University, Pomona, CA 91768

ABSTRACT

Previous research demonstrated that an average American adult could easily over consume the daily suggested amount of added sugar. Our team realized that a typical dessert contains way more sugar than suggested amount, which can be potentially harmful to obese and diabetic patients. We decided to develop a mobile application scans conventional baking recipe, recognize the and generates a healthier recipe reduced in sugar using AI to replace some of the ingredients to healthier ones.

The three major technical components are authentication service, AI, and text recognition and matching function. We integrated OpenAI to build the template, Spacy function and image.scan for text recognition, and firebase authentication for login functions.

Two experiments were conducted to test the accuracy of AI and text recognition. All the testing's suggested that the app is able to adjust any baking recipe to a healthier alternative, while guaranteeing the basic tastes.

KEYWORDS

Diabetes, Baking, Mobile Application, Health

1. INTRODUCTION

Diabetes and Obesity are both common chronic diseases that significantly impact people's health. While diabetes is ranked the 7th leading cause of death [1], obesity result in an annual 2.8 million deaths domestically[2].

Diabetes is a common chronic disease defined as high blood glucose levels resulting from abnormal insulin action [3]. Insulin is responsible for converting food to energy to control the glucose levels.4 Insufficient production of insulin or insulin deficiency can lead to hyperglycemia, or high glucose [4]. Between 1958 and 2015, the percentage of diabetic prevalence increased from 0.93% to 7.40%, which is an increase of 21.77 million domestic diabetic patients [5]. The significant increase in diabetic prevalence highlights the importance of preventing further development of this disease.

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Abnormal accumulation of fat characterizes obesity [6].A body mass index (BMI) indicates a person's body fat based on height and weight. A BMI of over 30 is classified as obese [7]. Since 1980, obesity and overweight prevalence nearly doubled. Nowadays, almost ⅓ of the world population is identified as obese or overweight [8].

Both diseases require dietary constraints, especially limitations on consuming added sugar [9]. The daily suggested sugar intake is 24 grams for males and 36 grams for females [10], but the average amount of daily sugar consumption already reached 77 grams for adults in 2016 [11]. A typical dessert usually has high sugar content. For example, a basic 6-inch sponge cake made with 3 eggs contains approximately 50 grams of added sugar [12].

Problem: This highlights the potential risk factor in desserts – containing too much sugar. Healthy desserts are both crucial for preventing obese and diabetic development and maintaining patients' health conditions.

Solution: We proposed an App that can scan a baking recipe to acquire its ingredients and utilize Artificial Intelligence (AI) to modify the high-sugar recipe to a healthier and diabetic friendly version by replacing ingredients with healthier alternatives. This app allows effective reduction in unhealthy ingredients such as all-purpose flour, cane sugar and animal fat that might potentially contribute to negative development relating to human health, thus either preventing or maintaining normal health conditions for obesity and diabetes [10]. By calculating the added sugar amount for both conventional recipes and healthier alternative recipes, the users can also clearly see the reduction in sugar. Besides, users can also save the alternative recipe into the app, allowing them to access their favored healthy recipes conveniently.

The scanning function enables the users to simply upload a picture of their recipe instead of manually typing in all the ingredients. Automatically replaces some ingredients to healthier versions, the AI gives specific amounts of each alternative, ensuring that each recipe is specified and easy to follow.

We chose to develop a mobile app since it is easily accessible for users and that users can easily upload pictures of their recipes in the photo library.

Overall, the concept is simple yet powerful, which makes this solution potentially better than others as it is very accessible, easy to follow, and applicable to every baking recipe. People already diagnosed with those diseases or those at the boundaries of diagnosis both could use it as a means to prevent further deterioration or prevalence of diabetes and obesity.

2. CHALLENGES

In order to build the project, a few challenges have been identified as follows.

2.1. AI Integration

As mentioned before, AI is a crucial tool in the designed program as it generates an alternative recipe by replacing high-sugar ingredients with healthier ones. However, directly integrating this tool in Flutter (the language for app development) could be a challenge. To overcome this issue, we planned to develop AI using Python, then connected the python server with Flutter. Our initial attempt wasn't successful though: the integration of AI model "Google-flan-xxl" did not give enough creative replacement of the ingredients, sometimes even returning the same input recipe without any changes. Revising the prompt template, as well as increasing the temperature, did not

help with this problem. We eventually ended up integrating OPENAI as the primary model, which turned out to be effective in ingredient replacement and reduction in sugar content. However, future improvement could be made to specify the level of sweetness based on personal preference by specifying in the prompt template.

2.2. Text Recognition and Matching with ingredients

Recognizing the ingredients and their amounts in the recipe that users upload was the base of this entire program. Only after precise text recognition, the sugar could be calculated and the AI could correctly identify the original ingredients and replace them with healthier alternatives. However, in our first several tries, the code did not scan the text correctly and thus returned the inaccurate scanned information to the server.

We noted that sometimes the program does not recognize fractions, missing the division line (e.g., 1/2). To solve this, we could change the regular expression, a pattern in string that takes out irregular symbols. By doing so, we could make the program not take out the division sign.

Just in case, we could implement the Matcher function in Spacy library, which allowed it to scan the ingredients even with some slight spelling deviations or formatting errors (e.g. misspelling such as “butter” to “buter” and “yogurt” to “yougurt”). The amount of each ingredient also matched with the original recipe. With this function implemented, the program executed with correct scanned information, enabling the AI to work as expected.

3. SOLUTION

The app consists of 3 major components: an authentication service, a text recognition program and AI. Authentication enabled users to sign into their account using email and password. By doing so, they can access their saved baking recipes on the HomeScreen. It was built through Flutter codebase, Firestore and database.

On the scanning screen, users could upload conventional baking recipes and the text recognition would recognize ingredients of the conventional baking recipe and send the information to the backend server. We chose to use the Matcher function in Spacy library. This allowed some slight spelling errors in the uploaded recipes (e.g., misspelling such as “butter” to “buter” and “yogurt” to “yougurt”). After acquiring the original ingredients in the uploaded recipe, the backend would use the “matcher” function to match them with a list (formatted in csv file) of ingredients and their corresponding added sugar per 100 grams, returning the total added sugar of that recipe.

If the users want to modify the conventional recipe to a healthier one, then they could press on the “Get a healthier alternative” button. The backend is integrated with OpenAI, and a paid API key is implemented for execution. Receiving the original ingredients and users’ request, AI would execute the specific prompt that asked for modifications to the conventional baking recipe. It would eventually return with an adjusted recipe by replacing some ingredients with healthier alternatives. The users can also see the sugar content in the returned recipe by clicking on the “Analyze Sugar” button, which the backend would execute the matcher function again and show the amount of added sugar in grams.

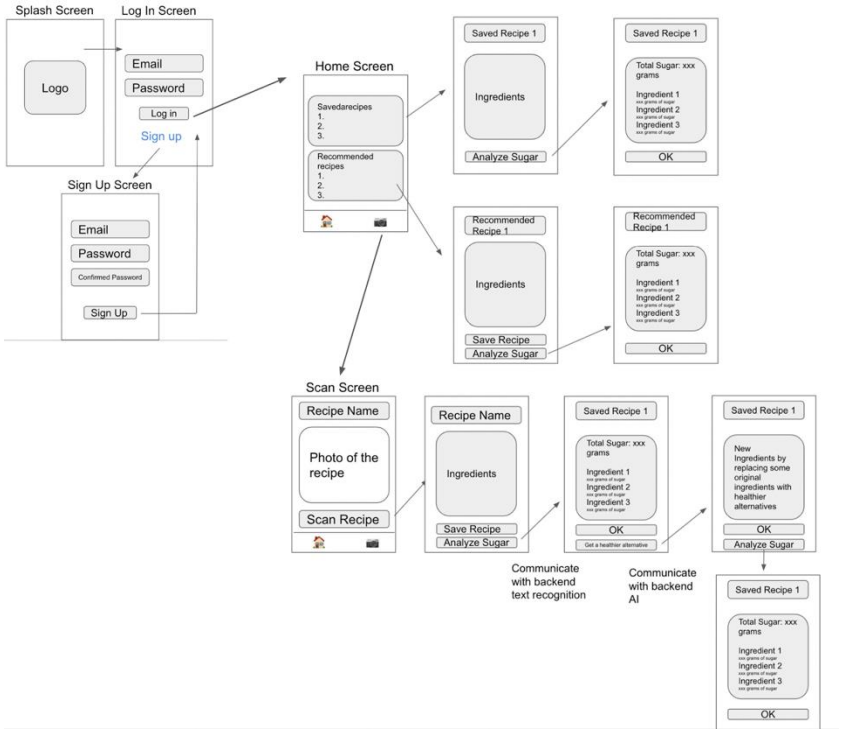

Figure 1. Overview of the solution

Component A: One component of the program is an authentication service. The firebase oversees logging in and signing up for the app. Besides, a Firestore is also used to save users' information. Thanks to the Firestore, by signing in using their authentication information (email and password), the users can save their favored baking recipes and directly access it on the Home Screen.

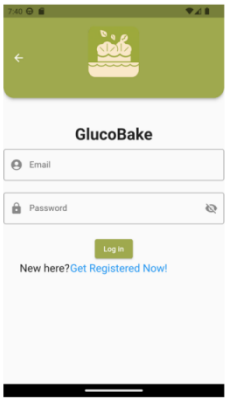

Figure 2. Login page

In order to create basic signing in and signing up functions, we created a class called Authentication Functions. It created a firebase object using firebaseauth. instance. Then, the program gets the current users' emails and passwords for identity confirmation. Both the sign up and sign in functions require 2 parameters – email and password, the way how the account is established and access in the app. To be noted, we implemented the catching error features in both sign in and sign up functions. This is useful in 3 situations: 1. The information required to sign in or sign up is left blank. 2. The registered users did not enter the correct email or password

when signing in. 3. The new user failed to correctly register for a new account. Some of the functions are coded with Future to ensure that information would be returned later. The async feature enables functions to execute at the same time.

Component B: Another major component of the app is text recognition. Its purpose is to recognize the ingredients in the uploaded recipe for sugar calculation and healthier modification. The scanned ingredients are then displayed on the result screen for users to decide on either saving the recipe or analyzing the sugar amounts. Based on the sugar amounts, the users can choose to have a healthier alternative recipe.

Figure 3. Scanned Recipe Page

The function scanImage is in charge of acquiring all the ingredients in the uploaded baking recipe. The inputImage is the uploaded image and is acquired with InputImage.fromFile() widget. The text recognizer processes the image and gets all the texts. It then sends and displays the recognized text with recipe title to the next page with Navigator.push() widget.

Figure 4. Alternate Recipe Page

The program pushes to the results screen which displays all the ingredients and corresponding amount obtained from the uploaded recipe. Same as the authentication service, we implemented a catch error feature. This is because sometimes the users could upload an unclear recipe or accidentally upload a random picture to the app, resulting in the text recognition not working properly. If that happens, a SnackBar would jump out from the bottom of the screen, notifying the users to reupload a better recipe. Future allows the function to return a certain value later, whereas the async enables the function to execute with other functions.

Component C: The last component of the app is AI. AI is essential for automatic replacement of ingredients from conventional baking recipes with healthier alternatives. After trying out different AI, we found OpenAI is the best for recipe modification. We integrated it in the backend of the app in Visual Studio Code with python.

On the backend, we created a new file to program AI replacement of unhealthy ingredients. The template is the prompt, or our request, for the AI to execute. At this point, we wanted to modify the input recipe by changing some ingredients to healthier alternatives. However, considering the texture and overall taste of the desserts, we also wanted to keep some of the cane sugar. After detailed testing, we eventually came up with the template as shown above. With the input variables "title" and "recipe", AI will automatically replace the ingredients in the "recipe", changing it to a healthier version. Using llm, the paid OpenAI token was integrated into the code for proper execution. llm_chain combines the AI model with the variables to allow llm_chain.run to work. It gets the "title" and "recipe" from the uploaded conventional baking recipe, inputs those into the prompt and generates the modified recipe. The adjusted recipe is then saved to results and returned to the server.

4. EXPERIMENT

4.1. Experiment 1

It is important for the AI to works well since it is crucial for the main function of the app - modifying the conventional baking recipe to a healthier alternative.

To test whether the AI is working, we plan to input 3 different baking recipes to generate healthier alternative recipes respectively. The prompt of the AI is shown below:

Table 1: Sugar content of conventional baking recipe vs. modified baking recipe

Recipe	Original sugar	Sugar after modified	Reduction in sugar
Pancake	38.646	24.996	13.65
Chocolate Cake	243.12	100.92	142.2
Blueberry Pie	105.15	33.36	71.76

Change the {title}: {recipe} to a healthier one using healthier alternative ingredients. If there is sugar in the recipe, replace some of the sugar with sweetener. Please include only the ingredients and their amount.

With this template, we expected the app would reduce the sugar amount of the conventional baking recipes. The 3 recipes are recipes for pancake, chocolate cake and blueberry pie. The amounts of sugar in conventional baking recipes and modified recipe will be compared to prove the functioning of AI.

The table shows that the app can generate a healthier alternative recipe reduced in sugar. The pancake, originally containing 38.636 grams of sugar, is reduced to 24.996 grams of sugar. The sugar in chocolate cake is reduced from 243.12 grams to 100.92 grams, whereas the sugar of blueberry pie is reduced from 105.15 grams to 71.76 grams. By calculating the percentage of sugar reduced for each recipe respectively (amount of sugar reduced/total sugar in the recipe), we found that the app is able to reduce the sugar content from 35.32% (Pancake) to 68.09% (Blueberry Pie). This demonstrates that the template of the AI worked well since it was able to

replace some of the sugar, for example, cane sugar to a combination of artificial sweetener and honey. Overall, the results achieved our goal since we did not want all the sugar to be replaced in order to guarantee the taste and texture of the desserts.

4.2. Experiment 2

Another thing that we wanted to test out was the text recognition. It is in charge of recognizing each ingredient in the uploaded recipe and is crucial for generating modified recipes.

To test whether the text recognition is working appropriately, we prepared 5 different images, as described below:

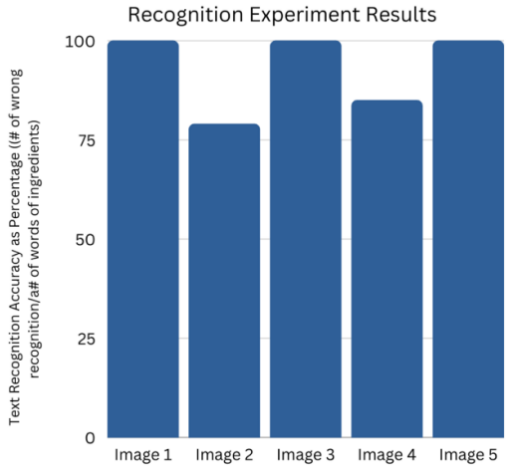

Figure 5: Text Recognition Accuracy as Percentage bar graph, created with Canva [13]

- Image 1: the same pancake recipe but with ingredients written in hand nicely
- Image 2: a basic pancake recipe with printed ingredients
- Image 3: a chocolate cake recipe with printed ingredients with units of grams
- Image 4: the same chocolate cake recipe but with ingredients written in hand nicely
- Image 5: a pure white background image without any word

The accuracy of text recognition will be calculated manually as a percent, with the number of wrongly recognized words as the numerator and total number of words in the recipe as the denominator. Numbers, units and fractions are each counted as one word.

It turned out that the text recognizer recognizes printed text better than handwritten texts. While it got all the printed text recognized perfectly, there were some deviations when recognizing the handwritten texts. For the handwritten pancake recipe, it recognized 5 out of 24 words wrong, resulting in an accuracy of 79% (19/24=0.79167). For the handwritten chocolate cake recipe, it recognized 3 texts wrong, resulting in an accuracy of 85% (17/20=0.85). However, we did notice that the recognizer tended to make mistakes when reading fractions, mistakenly recognizing the number 1 in the fraction as slashes. We found that if the ingredient units in the handwritten version are all in grams, it recognizes it more accurately.

The average percentage accuracy of two handwritten recipes is 82%, while it recognizes other printed recipes with 100% accuracy. However, with Spacy implemented as the matcher function, it is able to recognize the ingredients even with some slight deviations in spellings.

5. RELATED WORK

The paper by Huang, Luk, Zhou and Sun titled An Intelligent Mobile System to Predict Blood Sugar Level for Gestational Diabetes Patients Using Machine Learning aimed to solve a major issue for diabetic patients – testing their blood sugar level too frequently, sometimes reaching 4 times a day[14]. They came up with a solution of using computing and machine learning to predict the blood sugar level based on the patients' diets and physical activities. According to their own paper, one limitation of their solution is the lack of suggested threshold of the training dataset.

Even though both our and Huang's team goal was to help diabetic patients, our approaches were completely different. While they helped them with blood sugar level testing, we aimed to maintain their blood sugar level when it comes to eating desserts.

The study by Velázquez, titled *Cross-modal interactions as a strategy for sugar reduction in products targeted at children: Case study with vanilla milk desserts*, also aimed to reduce sugar in the desserts especially for children [15]. They utilized cross-modal perception – taste, odor and texture – as means to reduce the cane sugar in milk desserts while guaranteeing the taste for desserts [15]. Their result suggested that kids' preferences for special sugar-reduced desserts and conventional desserts are not significantly different.

Their goal was like our goal in helping diabetic patients. However, their reduced-sugar desserts were designed through careful measurements and testing. Our app, on the other hand, can automatically generate healthier alternative baking recipes not limited to milk desserts, providing ordinary diabetic patients without baking experience a healthier dietary choice.

The study by Kibria, Nahiduzzaman, Ahsan and Haider, titled *An Ensemble Approach for the Prsediction of Diabetes Mellitus Using a Soft Voting Classifier with an Explainable AI*, aims to use AI to predict the possibility of diabetic prevalence for different people [16]. The team discovered that weighted ensembles were a powerful AI tool that can generate effective and accurate predictions. Indeed, it achieved an accuracy of 90%, which distinguished it significantly from other AI models.

Again, our approach to help diabetic or prediabetic patients was completely different. However, we both integrated AI as an important means. While they used AI for prediction, our app mainly used it for prompting. The prompting of the questions in the backend was essential in producing a healthier alternative baking recipe.

6. CONCLUSIONS

One limitation of the app is that it only generates one alternative recipe. It is possible that the users want to choose their preferred level of sweetness (e.g., very sweet, moderately sweet, not sweet), but they will not be able to choose their preference. Future study can be made by changing the prompt by adding another parameter to the AI about the sweetness selection of the users, allowing AI to generate a healthier recipe based on users' preference for sweetness.

Another limitation is the sugar amount calculation. Accurate sugar content can only be calculated if the ingredients in the conventional and alternative recipe include the csv file containing different ingredients with their corresponding amount of sugar per 100 grams [13]. Even though the csv file includes most of the common ingredients used in baking, there is a chance that the conventional or alternative recipes have uncommon ingredients not included in the file, resulting

in a potential inaccurate calculation of sugar. Although integrating another AI to acquire the sugar for each ingredient is a choice, considering that each acquirement of an individual ingredient costs money, it is better to just simply add more ingredients to the csv file.

The incapability of the app to generate different alternative recipes based on the users' preferences is one of the limitations of the app. This could be solved with adding another parameter to the AI and changing the prompt accordingly [14]. Another limitation is the sugar calculation of the baking recipes. Taking the costs of AI into consideration, addition of ingredients to the csv file could be a better solution.

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AUTHORS

Julia Yili Shang is a senior at Diamond Bar High School in California. High school diploma expected in May 2024. She interned and did research at SoftCom Lab in Computer Science Department of California State Polytechnic University, Pomona, developing a mobile application that integrates AI to modify conventional baking recipe. Julia is passionate about baking and has programming experiences in C++, python and R. Her passion in those two fields facilitated her to conduct this research and develop this app.

Julian Avellaneda is a software engineering student at California Baptist University, located in Riverside. With an innate passion for computers and a penchant for building innovative solutions, Julian's journey into the realm of software engineering was a seamless progression. His diverse skill set spans game development, app creation, AI/machine learning, and web design, reflecting his versatile and creative approach to coding. Julian's dream encapsulates his love for both basketball and programming, as he aspires to craft a revolutionary basketball video game that seamlessly merges his two greatest passions.