Nutrition on a Budget: Tailored Meal Planning for Health and Savings

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Abstract:

This report explores how to create personalized meal plans that are both healthy and affordable. By combining information on nutritional needs, food prices, and individual health profiles, we developed a method to design meal plans that meet dietary guidelines without costing too much. Using a mathematical model, we can suggest meals that are both nutritious and budget-friendly, even considering specific dietary restrictions. Our findings show that it's possible to eat healthily without spending a lot of money, providing useful insights for individuals, nutritionists, and policymakers. Future research will look at including changing food prices and more dietary preferences to improve the model.

1.Problem Statement:

Develop a machine learning-based application that customizes meal plans to maximize health benefits and minimize the cost of ingredients. This tool will cater to individual dietary needs, preferences, and budget constraints, optimizing both nutrition and expense.

2. Market/Customer/Business Need Assessment

Market Needs: The demand for personalized nutrition and affordable meal planning is on the rise as more people aim to stay healthy while managing their budgets. Consumers are looking for easy ways to tailor their diets to their specific health needs without spending too much money. Optimizing meal plans to maximize health benefits and minimize ingredient costs can meet this growing market need, providing a convenient and cost-effective solution for health-conscious individuals.

Customer Needs: Creating personalized meal plans helps individuals and families eat healthier

and save money. These plans take into account dietary needs, nutritional goals, and budget constraints. By optimizing meals to maximize health benefits while minimizing the cost of ingredients, people can enjoy nutritious, tasty, and affordable meals tailored to their specific needs and preferences.

Business Need: Restaurants, meal kit services, and grocery stores could benefit from offering personalized meal planning services to attract and retain health-conscious and budget-sensitive customers.

3. Target Specifications and Characterization

Customer Characteristics:

- **Health-conscious individuals:** People who prioritize eating nutritious foods to maintain or improve their overall health.
- **Budget-conscious families:** Families looking to provide healthy meals without spending too much money on ingredients.
- **People with specific dietary restrictions (e.g., vegan, gluten-free):**Individuals who need to avoid certain foods due to allergies, intolerances, or lifestyle choices.
- **Fitness enthusiasts aiming for specific nutritional goals:**Those who require precise amounts of nutrients like protein, carbs, and fats to support their fitness and exercise routines.
- **Time-constrained professionals seeking convenience:**Busy individuals who need quick and easy meal options that still meet their health and nutritional needs.

4. External Search

The dataset I used in the model making program is a small dataset that I created randomly using the features recipe_name,ingredients,calories,protein,carbs,fat,price($).

Market research: reports on personalized nutrition and meal planning trends leverage machine learning and AI to analyze vast datasets, enabling the development of tailored meal plans based on individual health goals and dietary preferences. These reports highlight advancements such as AI-driven recommendation systems and personalized meal delivery services, aiming to optimize dietary choices and improve overall well-being.

https://www.sciencedirect.com/science/article/abs/pii/B9780128164037000064

https://link.springer.com/article/10.1007/s43393-023-00200-4

Academic journals:on nutrition optimization and cost-effective meal planning

https://www.proquest.com/openview/d510f3fbecb23c0995be1f090a5736d3/1?pq-origsite=gscholar&cbl=18750&diss=

Relevant Papers:

Heitman K.
Nahikian-Nelms M.
Estes H.
et al.

P140 use of the Nutrition Care Process Quality Evaluation and Standardization Tool to inform training in a student cohort.

J Nutr Educ Behav. 2022; **54**: S84-S85

https://doi.org/10.1016/j.jneb.2022.04.181

5. Benchmarking Alternate Products

Comparison with Existing Products/Services:

- **MyFitnessPal**: While MyFitnessPal effectively tracks calories and nutrition intake, it doesn't prioritize cost optimization in meal planning, potentially resulting in higher expenses for users.
- **PlateJoy**: PlateJoy emphasizes personalized meal planning with a focus on health benefits, yet it doesn't prioritize cost-efficiency in ingredient selection, which may lead to higher overall expenses for users.
- **Mealime**: Mealime offers convenient meal plans and shopping lists, but it doesn't actively optimize for cost-effective ingredient choices, potentially resulting in higher grocery bills for users over time.

Optimizing personalized meal plans involves finding the perfect balance between maximizing health benefits and minimizing the cost of ingredients.By benchmarking against these existing products, we aim to highlight our unique value proposition of delivering personalized meal plans that are both healthy and cost-effective.

6. Applicable Patents

- **US20130224694A1 United States** :- Integrated System and Method for Meal Planning and Management

- **US6872077B2 United States :-** System and method for generating personalized meal plans

7. Applicable Regulations

Government Regulations:

- **Nutritional labeling requirements:** These regulations mandate that food products must display accurate information about their nutritional content, helping consumers make informed choices about their diets.
- **Food safety standards:** Regulations ensure that all food items meet specific safety criteria, preventing the risk of contamination and illness.
- **Data privacy regulations (e.g., GDPR, CCPA):** Laws safeguard consumers' personal information collected through meal planning apps, ensuring their data is protected and used ethically.

Environmental Regulations:

- **Sustainable sourcing of ingredients:** Regulations encourage sourcing ingredients in a way that minimizes harm to the environment and supports ethical practices.
- **Waste reduction mandates:** Policies aim to minimize food waste throughout the production and distribution process, promoting sustainability and efficiency.

8. Applicable Constraints

- **Space for storage** and computing infrastructure refers to the physical or virtual space needed to store data and run the algorithms that generate meal plans. This includes servers, databases, and any other technology required to host the application.
- **Budget** considerations encompass the initial costs of developing the meal planning application as well as the ongoing expenses for maintenance, updates, and hosting. It's essential to ensure that the project remains financially sustainable.
- **Expertise in nutrition** involves understanding the principles of healthy eating and how different nutrients interact with the body. Machine learning expertise is necessary to develop algorithms that can analyze data and generate personalized meal plans. Software development skills are required to build and maintain the application, while data analysis knowledge helps in interpreting user data to improve the meal planning process.

9. Business Model

- **Subscription Model:** Users pay a monthly or yearly fee to access the meal planning service. This provides a recurring revenue stream for the company.
- **Freemium Model:** Offer a basic version of the service for free, with limited features or meal plans, and then offer premium features or personalized plans for a subscription fee.
- **Affiliate Marketing:** Partner with food and grocery brands to recommend ingredients or products within the meal plans, earning a commission for each purchase made through the

platform.

- **Data Monetization:** Aggregate and anonymize user data to provide insights to food and health-related companies, such as trends in dietary preferences or ingredient popularity, for a fee.
- **Customization Services:** Offer additional services such as one-on-one nutrition consultations or personalized coaching for an extra fee, catering to users who want more hands-on guidance.

10. Concept Generation

- **Budget-Friendly Meal Plans**: The program allows users to set a budget per meal, ensuring affordability. By optimizing meal plans based on this budget constraint, users can eat healthily without overspending.
- **Nutrition Goals Customization**: Users can select their health goals, such as weight loss, muscle gain, or weight maintenance. The program tailors meal plans to meet these goals while considering budgetary constraints.
- **Streamlined Meal Planning**: With the ability to select dietary preferences, users can quickly generate personalized meal plans that align with their nutritional needs and taste preferences, saving time on meal preparation and planning.

1. Data Exploration: The code starts by looking at the data, checking what it contains, and summarizing its main characteristics like calories, protein, carbs, fat, and price.

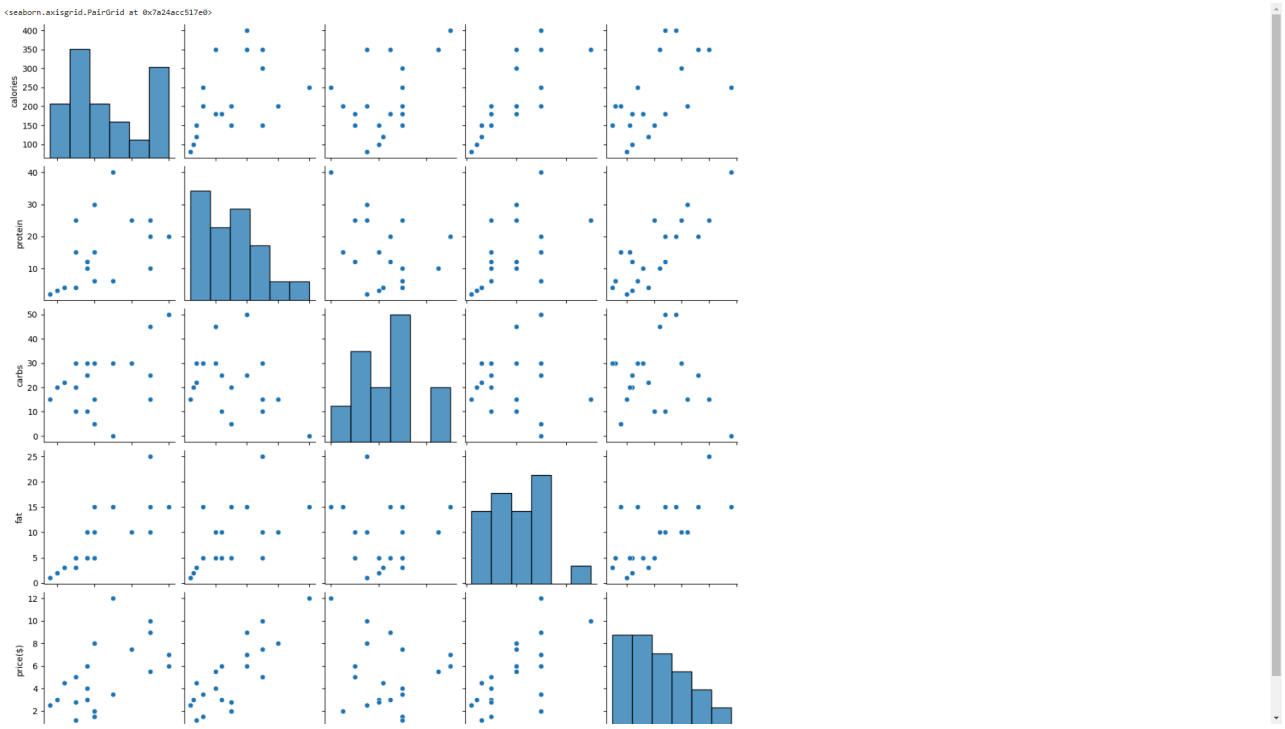
```
import pandas as pd
from sklearn.cluster import KMeans
from sklearn.preprocessing import StandardScaler, OneHotEncoder
import pickle
import seaborn as sns
```

```
# Load the dataset
df = pd.read_excel('/content/recipeeees.xlsx')
df
```

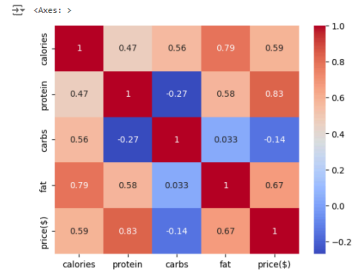
	recipe_name	ingredients	calories	protein	carbs	fat	price($)
0	Chicken Salad	Chicken, Lettuce, Tomato	150	25	10	5	5.0
1	Veggie Stir Fry	Carrot, Broccoli, Soy Sauce	100	3	20	2	3.0
2	Beef Stew	Beef, Potato, Carrot	200	30	15	10	8.0
3	Grilled Salmon	Salmon, Lemon, Dill	250	40	0	15	12.0
4	Quinoa Salad	Quinoa, Tomato, Cucumber	120	4	22	3	4.5
5	Tofu Stir Fry	Tofu, Bell Pepper, Soy Sauce	180	12	10	10	6.0
6	Spaghetti Bolognese	Spaghetti, Ground Beef, Tomato Sauce	400	20	50	15	7.0
7	Chicken Curry	Chicken, Coconut Milk, Curry Powder	350	25	15	25	10.0
8	Vegetable Soup	Carrot, Potato, Celery	80	2	15	1	2.5
9	Pancakes	Egg, Milk, Flour	200	6	30	5	1.5
10	Greek Yogurt Parfait	Greek Yogurt, Honey, Berries	180	12	25	5	3.0
11	Avocado Toast	Avocado, Bread, Lemon	250	6	30	15	3.5
12	Turkey Sandwich	Turkey, Bread, Lettuce	150	15	20	5	2.8
13	Lentil Soup	Lentils, Carrot, Celery	180	10	30	5	4.0
14	Egg Omelette	Egg, Cheese, Bell Pepper	200	15	5	15	2.0
15	Mushroom Risotto,	Rice, Mushroom, Parmesan	350	10	45	10	5.5
16	Baked Ziti	Pasta, Tomato Sauce, Cheese	400	20	50	15	6.0
17	Chicken Fajitas	Chicken, Bell Pepper, Onion	300	25	30	10	7.5
18	Shrimp Tacos	Shrimp, Tortilla, Avocado	350	20	25	15	9.0
19	Spinach Smoothie	Spinach, Banana, Almond Milk	150	4	30	3	1.2

2. Visualizing Relationships: It then creates visual plots to see how these different characteristics relate to each other, helping us understand if there are any patterns or correlations in the data.

```
[17] df.shape

(20, 7)

sns.pairplot(df[['calories', 'protein', 'carbs', 'fat', 'price($)']])
```




```
import numpy as np

#Correlation Matrix
sns.heatmap(df[['calories', 'protein', 'carbs', 'fat', 'price($)']].corr(), annot=True, cmap='coolwarm')
```



3. Preparing Data: After understanding the data, it prepares it for analysis by selecting the important features and scaling them so they're all on the same scale.

```
# Features for clustering
X = df[['calories', 'protein', 'carbs', 'fat', 'price($)']]

X.shape

(20, 5)

[19] X.head()
```

	calories	protein	carbs	fat	price($)
0	150	25	10	5	5.0
1	100	3	20	2	3.0
2	200	30	15	10	8.0
3	250	40	0	15	12.0
4	120	4	22	3	4.5

4. Training a Model: It uses a method called SVM to group similar recipes together based on their nutritional content and price, making it easier to analyze and understand the data.

SVM

```
[19] # SVM Classification
     svm_model = SVC(kernel='linear', random_state=42)
     svm_model.fit(X_train, y_train)
     svm_predictions = svm_model.predict(X_test)
     svm_score = svm_model.score(X_test, y_test)
     print(f"SVM Classification Accuracy: {svm_score}")
```

```
SVM Classification Accuracy: 0.9

Classification Report(SVM):
              precision    recall  f1-score   support

           0       1.00      0.62      0.77         8
           1       0.87      1.00      0.93        20
           2       1.00      1.00      1.00         2

    accuracy                           0.90        30
   macro avg       0.96      0.88      0.90        30
weighted avg       0.91      0.90      0.89        30
```

5. Saving the Model: Once the model is trained, it's saved so that we can use it later without having to train it again, which saves time and resources.

```
# Save the model and scaler to .sav files
with open('kmeans_model11.sav', 'wb') as model_file:
    pickle.dump(kmeans, model_file)
with open('scaler_model11.sav', 'wb') as scaler_file:
    pickle.dump(scaler, scaler_file)

print("Model and scaler saved successfully.")
```

```
Model and scaler saved successfully.
```

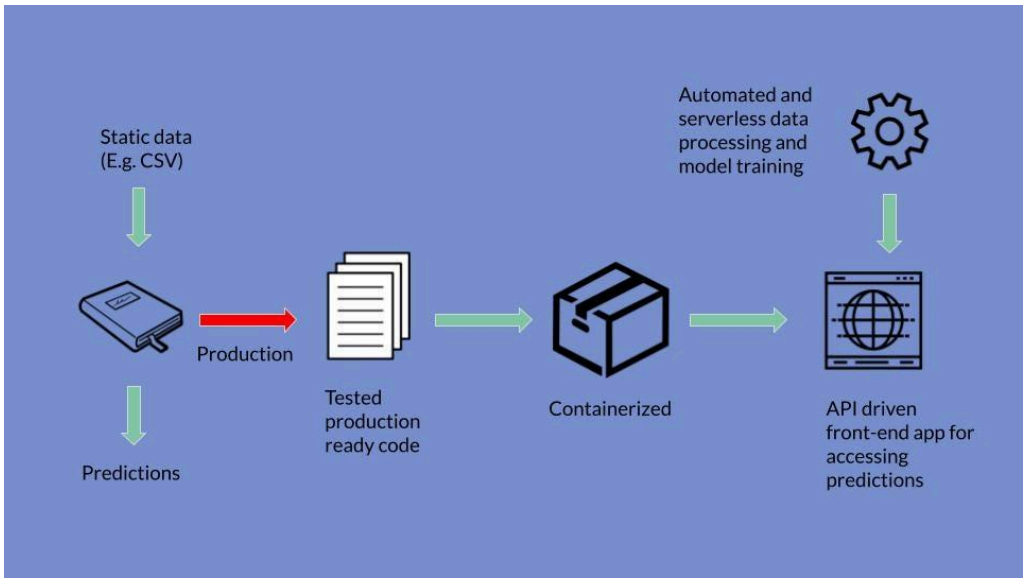
11. Concept Development

Brief Summary of Product/Service:

- **Mobile App Functionality:** The app works on your phone or tablet. It helps you plan your meals for the week ahead.
- **Customization:** You can personalize your meal plans. This means you can choose the kinds of foods you like to eat, consider any health goals you have, and also set a budget for your groceries.
- **User Input:** You tell the app what you like to eat, any dietary restrictions you have (like being vegetarian or avoiding gluten), what you want to achieve with your health (like losing weight or gaining muscle), and how much you want to spend on groceries each

week.

- **Machine Learning Algorithms:** The app uses smart computer programs to figure out what recipes would be best for you. It looks at all the information you gave it and then suggests meals that match your tastes, health goals, and budget.
- **Recipe Suggestions:** Based on your input, the app gives you ideas for what to cook each day of the week. It tries to pick recipes that are healthy, fit your dietary needs, and won't break the bank.
- Shopping Lists: Once you've chosen your recipes for the week, the app creates a shopping list for you. This list includes all the ingredients you'll need to buy at the store.
- **Cost Analysis:** The app also helps you understand how much your meals will cost. It adds up the prices of all the ingredients on your shopping list so you can see if it fits within your budget.

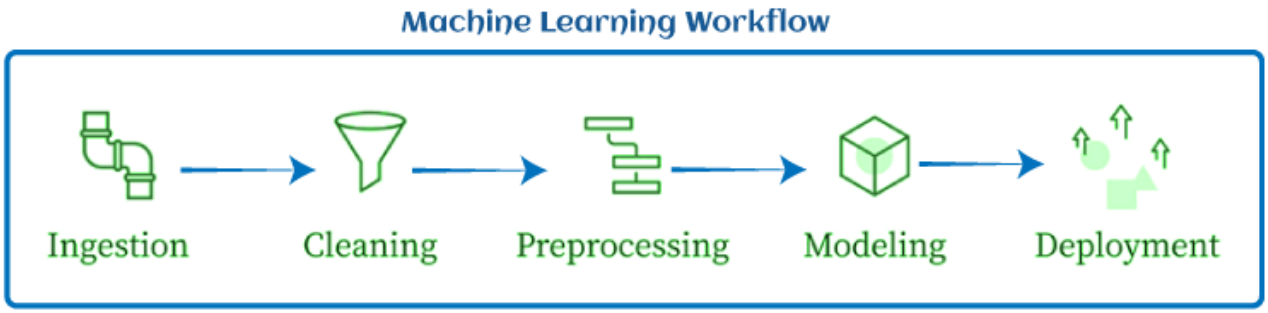


By combining all these features, the app aims to make it easier for you to eat healthily, stick to your dietary preferences, and save money on groceries.

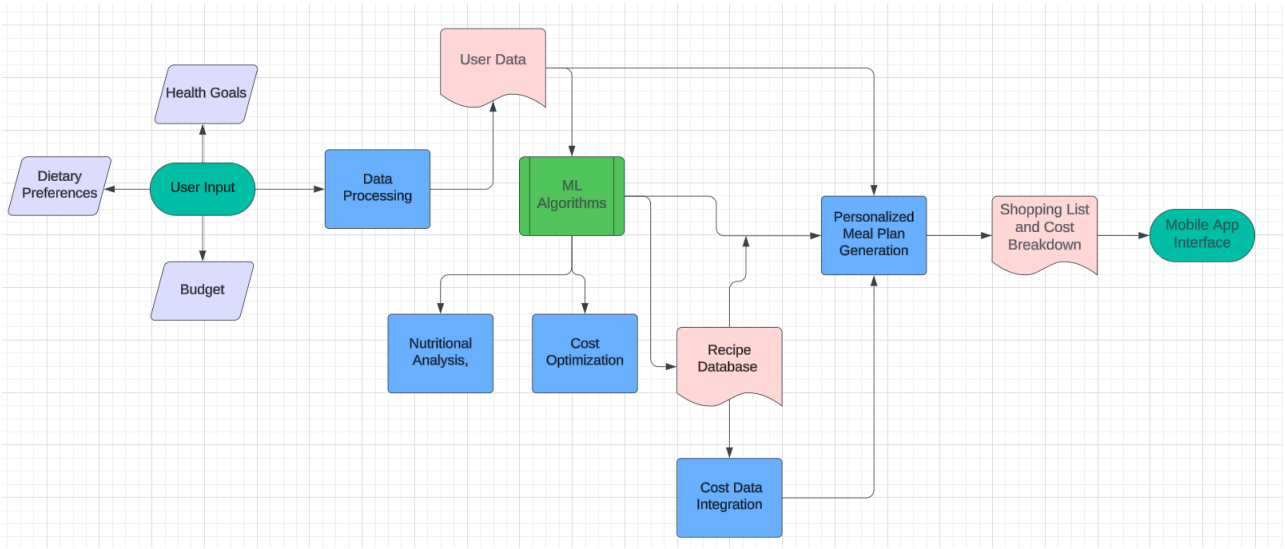
12. Final Product Prototype (Abstract) with Schematic Diagram

Final Product Prototype:

Abstract: In this project, we aim to develop a personalized meal planning system to optimize health outcomes while minimizing ingredient costs. Utilizing a dataset containing recipes along with their nutritional information, we apply SVM to group similar recipes based on their nutritional profiles. By incorporating user preferences and health goals, our system generates customized meal plans tailored to individual needs. Through exploratory data analysis and machine learning techniques, we seek to provide an efficient and cost-effective solution for planning nutritious meals.



Schematic Diagram:



- **Data Acquisition:** Recipe data is collected from external sources or uploaded by users. This dataset includes nutritional information such as calories, protein, carbs, fat, and price for each recipe.
- **Data Preprocessing and Model Training:** The dataset undergoes preprocessing steps, including feature selection, standardization, and model training. Machine learning models, such as K-Means clustering, are trained on the preprocessed data to cluster recipes based on their nutritional profiles.
- **Model Serialization:** Trained models, along with preprocessing components like StandardScaler, are serialized and stored for future use. This allows for efficient loading and utilization within the web application.
- **Web Application Development:** A user-friendly web application is developed using Streamlit, a Python library for building interactive web apps. The application interface allows users to input their dietary preferences, health goals, budget constraints, and meal

frequency.

- **User Interaction and Input:** Users interact with the web application by selecting their dietary preferences, health goals, and budget constraints through intuitive widgets and dropdown menus. Their inputs guide the generation of personalized meal plans.
- **Recommendation Generation:** Based on the user's inputs, the application utilizes the pre-trained machine learning models to generate personalized meal recommendations. Recipes are clustered into groups that align with the user's nutritional goals and budget.
- **Output Presentation:** The application presents the user with a weekly meal plan, including recommended recipes, ingredient lists, nutritional information, and estimated costs. Users can review and modify the meal plan according to their preferences.
- **Nutritional Analysis and Shopping List Generation:** The application calculates the total nutritional values of the recommended meal plan and generates a shopping list based on the required ingredients. This assists users in making informed decisions about their meal planning and grocery shopping.

13. Product Details

How Does It Work?

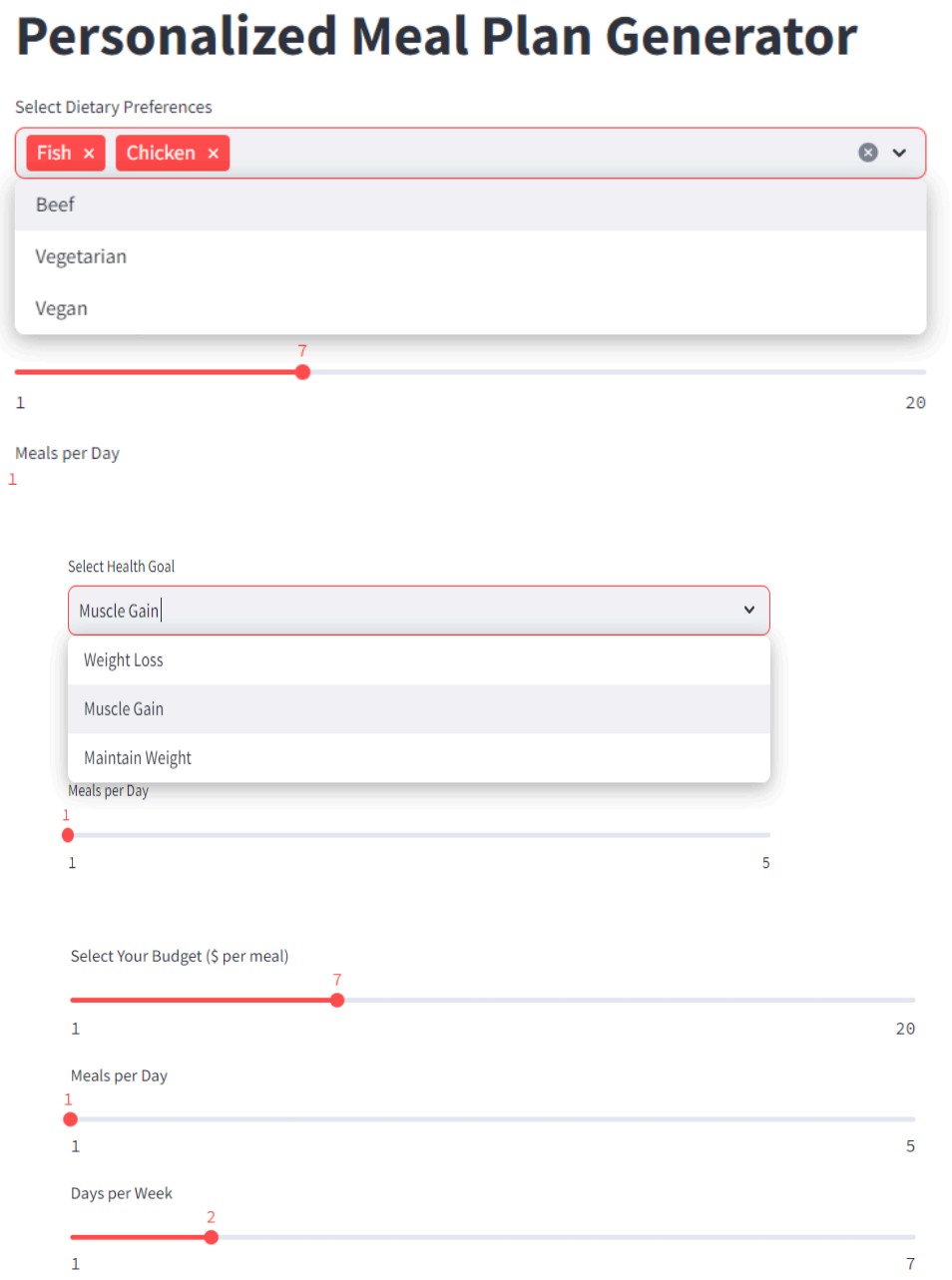
I have created a Web App on this project using a small dataset of recipes and giving the result to the user with a weekly meal plan, including recommended recipes, their ingredients, nutritional information, and estimated prices.The app calculates the user's nutritional goals and uses the K-Means model to generate personalized meal plans by clustering recipes.

Model Program (Data Preprocessing and Model Training):

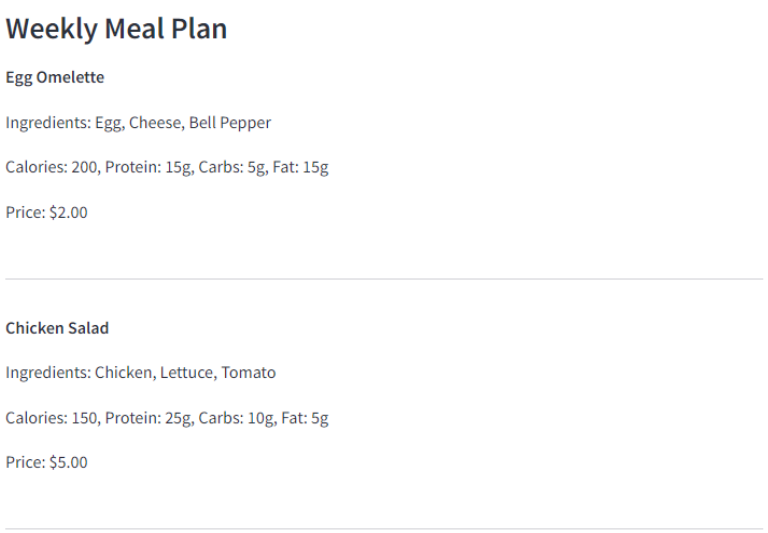
1. **Data Loading**: The program loads recipe data from an Excel file using pandas.
2. **Exploratory Data Analysis (EDA)**: It performs EDA by describing the dataset, visualizing feature distributions, and creating correlation matrices to understand the relationships between features.
3. **Data Preprocessing**: Features for clustering are selected, and the data is standardized using StandardScaler.
4. **Model Training**: A SVM model is trained on the standardized data to cluster recipes based on their nutritional content and price.
5. **Model Serialization**: The trained SVM model and the StandardScaler are saved to disk using pickle for future use.

Web App Program (Streamlit App):

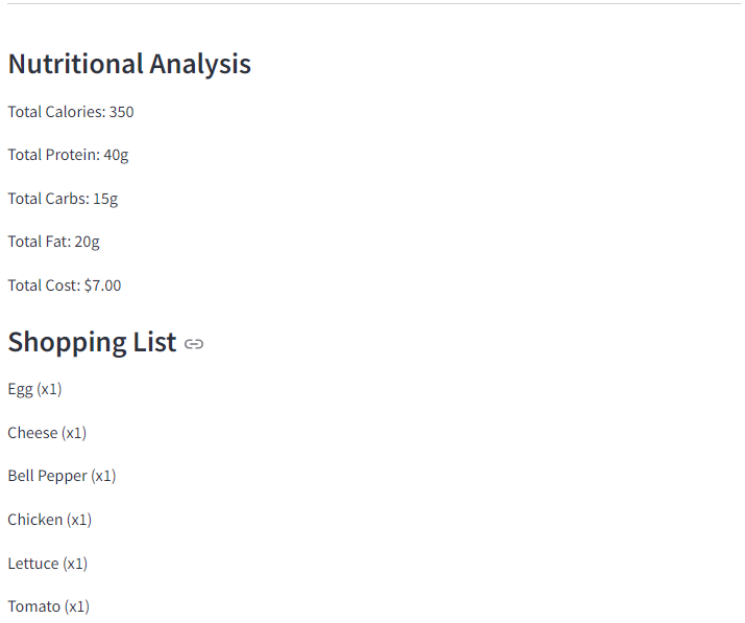
1. **Data and Model Loading**: The web app loads the pre-trained K-Means clustering model and StandardScaler from the saved files.
2. **User Interaction**: Users are prompted to provide their dietary preferences, health goals, budget, and meal frequency through interactive widgets.



3. **Filtering Recipes**: Based on the user's input, the app filters recipes from the dataset that match their dietary preferences.
4. **Generating Meal Plans**: The app calculates the user's nutritional goals and uses the K-Means model to generate personalized meal plans by clustering recipes.
5. **Displaying Results**: The app presents the user with a weekly meal plan, including recommended recipes, their ingredients, nutritional information, and estimated prices.



6. **Nutritional Analysis**: It calculates the total nutritional values of the recommended meal plan, including calories, protein, carbs, fat, and cost.
7. **Shopping List Generation**: The app generates a shopping list based on the ingredients required for the recommended recipes.



Team Required to Develop:

- Nutritionist
- Data Scientist/ML Engineer
- Software Developer (Mobile and Backend)

- UX/UI Designer
- Project Manager

14. Code Implementation/Validation on Small Scale (Optional - Bonus Grades)

This is a github link for the project implementation using the Streamlit Cloud platform :-

https://github.com/Ru1chi/Nutrition_in_budget

15. Conclusion

This machine learning-based app addresses the dual needs of optimizing health and minimizing food costs. By leveraging advanced algorithms and comprehensive data sources, the app offers a personalized and cost-effective solution for meal planning. This innovation holds significant potential for individuals seeking to balance their dietary goals with budget constraints, offering a viable market opportunity with multiple monetization strategies.

Business/Financial Modelling

Step 1: Prototype Selection

Prototype Idea:
Nutrition on a Budget: Tailored Meal Planning for Health and Savings

Criteria:

a. Feasibility:
The development of a personalized meal planning app that optimizes health benefits while minimizing costs is feasible within 2-3 years. This can be achieved using existing machine learning techniques and available datasets. The availability of nutritional data, recipe datasets, and machine learning models for clustering and recommendations supports this feasibility.

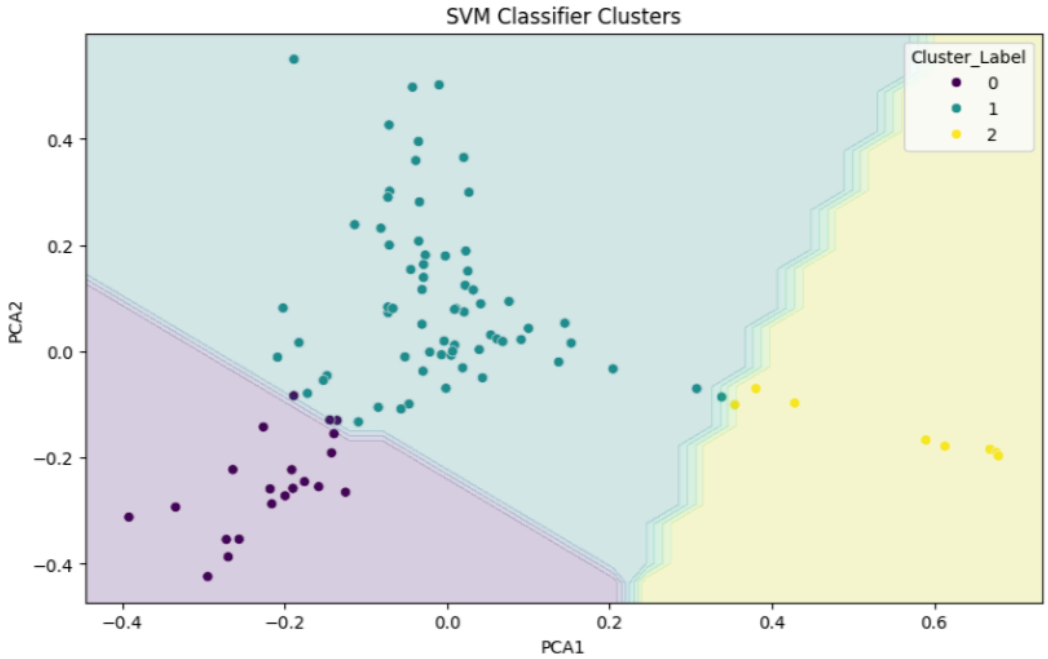
b. Viability:
The need for personalized nutrition and cost-effective meal planning is expected to grow over the next 20-30 years as people become more health-conscious and budget-aware. The increasing trends in health and wellness, coupled with the economic need to manage food budgets, ensure the long-term relevance of this product.

Step 2: Prototype Development

For prototype development, a small-scale model of the personalized meal planning service can be created. This could involve:

- Implementing a basic machine learning model (e.g., K-Means clustering) to group recipes based on nutritional profiles.

```
# Plotting the SVM decision boundaries
plt.figure(figsize=(10, 6))
sns.scatterplot(x='PCA1', y='PCA2', hue='Cluster_Label', data=df, palette='viridis')
plt.title('SVM Classifier Clusters')
# Plot decision boundaries
ax = plt.gca()
xlim = ax.get_xlim()
ylim = ax.get_ylim()

xx, yy = np.meshgrid(np.linspace(xlim[0], xlim[1], 30), np.linspace(ylim[0], ylim[1], 30))
Z = svm_model.predict(np.c_[xx.ravel(), yy.ravel()])
Z = Z.reshape(xx.shape)

ax.contourf(xx, yy, Z, alpha=0.2, cmap='viridis')
plt.show()
```



- Developing a simple web app or mobile app to allow users to input dietary preferences and budget constraints, which then generates a customized meal plan.

Step 3: Business Modelling

Business Model:

1. Subscription Model: Users pay a monthly or yearly fee to access the service, which provides continuous updates and personalized recommendations.
2. Freemium Model: Basic features are available for free, encouraging user acquisition, with advanced features accessible through a premium subscription.
3. Affiliate Marketing: Partner with grocery stores, food brands, and other related businesses to recommend products and earn commissions on resulting sales.
4. Data Monetization: Aggregate and anonymize user data to sell insights to food and health-related companies for market analysis and targeted advertising.
5. Customization Services: Offer personalized nutrition coaching or consultations for an additional fee, providing a more tailored experience.

Step 4: Financial Modelling

Market Identification:
Target Market:
- Health-conscious individuals
- Budget-conscious families
- People with specific dietary restrictions (e.g., vegetarians, vegans, non-vegetarian)
- Fitness enthusiasts
- Time-constrained professionals

Data Collection:
Collect data on:
- Nutritional needs and preferences
- Food prices and availability
- Individual health profiles and dietary goals

Market: The product would be launched in the health and wellness market, targeting health-conscious individuals, budget-conscious families, and those with dietary restrictions.

Data Collection: Gather data on market growth, customer segments, and trends in health and wellness, especially personalized nutrition services.

Forecasting and Financial Equation:
- Linear Market Growth: If the market is expected to grow linearly, the financial model can be (y = mx(t) + c), where:
  - (y) = total profit
  - (m) = price of the service

- (x(t)) = total sales as a function of time
- (c) = fixed costs like development, maintenance, and operational costs

- Exponential Market Growth: If the market grows exponentially, the financial model can be represented as (y = a . e^{bt}), where:
  - (a) = initial profit
  - (b) = growth rate of sales
  - (t) = time

Key Components for Financial Modeling

1. Revenue: Depends on the number of users (sales) and the price of the service.
2. Costs: Includes fixed costs (e.g., development, maintenance) and variable costs (e.g., customer acquisition costs, operational costs).
3. Profit: The difference between revenue and costs.

Basic Financial Equation
Let's consider a linear growth model for simplicity. The financial equation can be:
$Profit(t)=Revenue(t)-Costs(t)$

Where:

- Revenue is calculated as:
  $Revenue(t)=P\times N(t)$
  P = Price of the service per user
  N(t) = Number of users at time t
- Costs is a combination of fixed and variable costs:
  $Costs(t)=F+V(t)$
  F = Fixed costs (e.g., development, hosting)
  V(t)= Variable costs, which may increase with the number of users.

(a) Linear Financial Model
If we assume a linear growth in the number of users:
$N(t)=N0+r\times t$

Where:

- No = Initial number of users
- r = Growth rate of users per unit time
- t = Time

Then the financial equation becomes:
$Profit(t)=P\times(N0+r\times t)-(F+V(t))$
For simplicity, let's assume variable costs are proportional to the number of users:
$V(t)=C\times N(t)$
Where:

- C = Variable cost per user

Finally, the financial equation is:
$Profit(t)=P\times(N0+r\times t)-(F+C\times(N0+r\times t))$

Simplifying:
Profit(t)=(P−C)×(N0+r×t)−F

(b) Non-Linear Financial Model

In a non-linear growth model, the number of users or the market growth does not increase linearly over time. Instead, it follows an exponential or logarithmic pattern, where the growth rate might be higher initially and then taper off, or it could start slow and then accelerate.

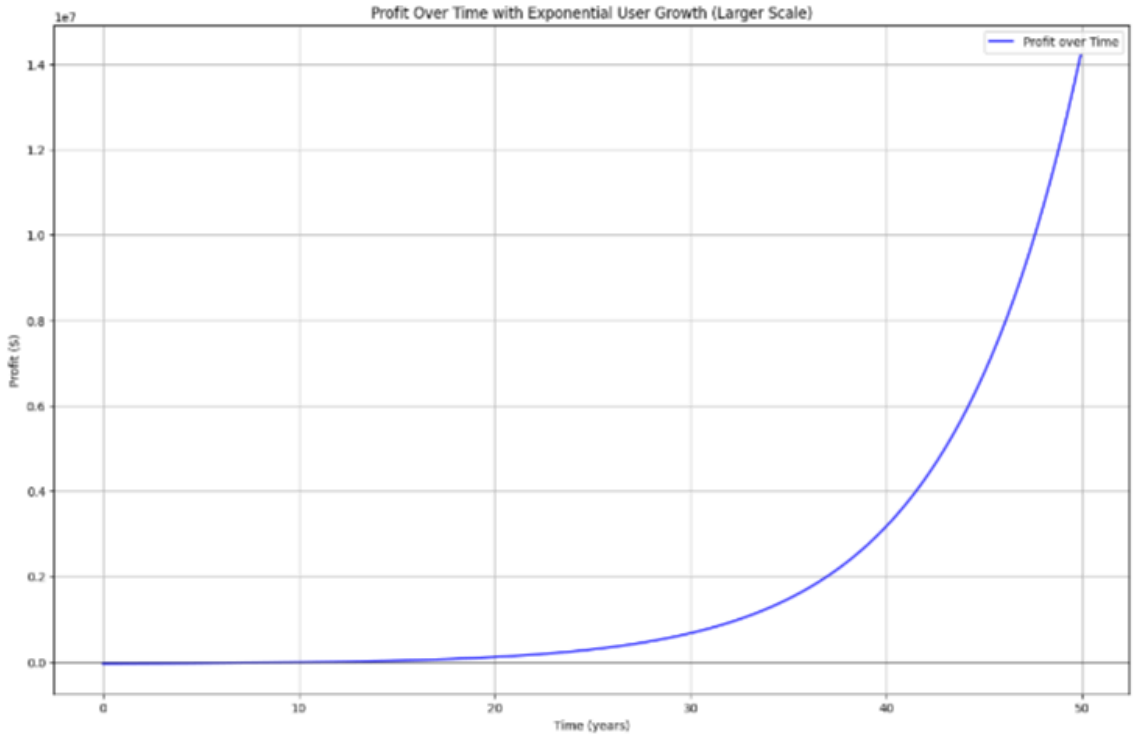
Exponential Growth Model

If we assume that the number of users grows exponentially over time, the equation for user growth would be:
N(t)=No * e^(rt)
Where:

- N(t)= Number of users at time t
- No = Initial number of users
- r = Growth rate
- t = Time

This implies that the number of users is multiplied by a factor erte^{rt}ert (where eee is Euler's number, approximately equal to 2.718) over time. As a result, the profit equation also becomes exponential:

Profit Equation for Exponential Growth



Profit(t)=(P−C)×N0×e^(rt)−F

Where:

- P = Price per user
- C = Variable cost per user
- F = Fixed costs
- r = Growth rate
- t = Time

Refrences

- https://be10x.in/blog/ai-driven-nutritious-meal-planning/#chef-gpt
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10436119/
- https://medium.com/ai-in-the-family/ai-meal-planners-simplifying-family-nutrition-and-grocery-shopping-3f854de19628
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