### **Database Systems Project Part IV**

### **End-to-End Solution Integration and Data-Driven / Database Programming**

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**Project Title:** Personalized Nutrition Recommendation System - MoodBite

### **Project Overview**

MoodBite is a web-based app designed to provide tailored meal recommendations based on the user's emotional well-being and nutrition goals. By collecting user-specific data such as mood, emotional goals, dietary preferences, allergens, and nutritional needs, the app generates personalized daily menus, nutritional analyses, and snack recommendations.

#### **Value Proposition**

MoodBite stands out as a personalized nutrition and meal-planning system by offering tailored recommendations that align with user-specific needs. It simplifies the process of choosing meals, planning grocery shopping, and adhering to dietary goals. Additionally, its integration of mood-based suggestions enhances emotional well-being, offering a unique value not commonly found in traditional meal-planning tools. The system prioritizes convenience, saving users time and effort while promoting healthier eating habits.

#### **Use Cases**

1. **User Registration and Profile Management**The system allows users to create personalized profiles containing vital details such as age, gender, height, weight, activity levels, and dietary preferences or restrictions. These profiles serve as the foundation for all recommendations provided by the system, ensuring that suggestions align with each user's unique requirements. For instance, a user following a vegan diet with a peanut allergy will only see recipes that adhere to these criteria. By managing their profiles, users can update preferences as their needs evolve, enabling the system to remain relevant over time.
2. **Personalized Recipe Recommendations**MoodBite tailors recipe suggestions to each user's emotional state and dietary requirements. A user feeling low-energy might receive suggestions for nutrient-dense recipes that boost energy levels, while someone seeking comfort might be offered warm, hearty meals. The system integrates these recommendations with user dietary restrictions, ensuring all suggestions are safe and suitable. This feature bridges the gap between emotional well-being and physical health, encouraging users to make food choices that align with both.

## **Mood Tagging Code Documentation**

### **Overview**

There is ongoing research exploring the intricate relationship between food and mood, delving into how specific types of food can influence emotional states. Certain ingredients, nutrients, and cooking methods are believed to evoke particular feelings or mental states—for example, promoting relaxation, boosting energy, or enhancing focus. Drawing from this growing body of research, we have developed a robust methodology for classifying recipes into mood categories. Using scientifically validated insights, we created a system that assigns a **MoodTag** to recipes based on their ingredients, nutrients, cooking techniques, and instructions.

This approach categorizes recipes into the following groups:

1. Reducing Anxiety
2. Boosting Focus and Productivity
3. Boosting Energy Levels
4. Improving Mood and Well-being
5. Promoting Relaxation and Sleep
6. Balanced

By leveraging academic studies and nutritional science, the system aligns the recipe’s components with its emotional and physical benefits, ensuring precise and meaningful classification.

### **Personalized Recipe Recommendations**

MoodBite tailors recipe suggestions to each user's emotional state and dietary requirements. A user feeling low-energy might receive suggestions for nutrient-dense recipes that boost energy levels, while someone seeking comfort might be offered warm, hearty meals. The system integrates these recommendations with user dietary restrictions, ensuring all suggestions are safe and suitable. This feature bridges the gap between emotional well-being and physical health, encouraging users to make food choices that align with both.

This script assigns a MoodTag to recipes based on their ingredients, nutrients, cooking methods, and instructions. It uses research-backed keywords to classify recipes into one of several categories, including Reducing Anxiety, Boosting Focus and Productivity, Boosting Energy Levels, Improving Mood and Well-being, Promoting Relaxation and Sleep, and Balanced. By analyzing the recipe’s components and comparing them to scientific research, the system ensures that each recipe is categorized accurately to align with its intended emotional and physical benefits.

We have conducted extensive research to create a logic-based approach for assigning MoodTags. References from sources such as PubMed, NCBI, and Harvard Health validate the keywords and their associated mood effects. The process ensures that the tagging system is both reliable and backed by scientific insights.

### **Key Features**

#### **1. Research-Backed Keywords:**

* Includes ingredients, cooking methods, and textures supported by scientific research to influence mood and energy levels.

#### **2. Easy Integration:**

* Reads and writes CSV files, making it adaptable for any dataset with columns **Ingredients** and **Instruction Steps**.

#### **3. Scalable:**

* Supports adding more keywords and categories for future enhancements.

### **References for Research**

**Reducing Anxiety:**

* **Magnesium and Stress:** Magnesium plays a crucial role in managing stress and anxiety. Incorporating magnesium-rich foods like leafy greens, nuts, and seeds can help alleviate stress. ([PubMed](https://pubmed.ncbi.nlm.nih.gov/29207171/))
* **Chamomile and Calming Effects:** Chamomile tea is renowned for its calming properties, aiding in stress reduction and improved sleep quality. ([NCBI](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2995283/))
* **Herbal Teas:** Lavender, peppermint, and valerian teas are linked to reduced cortisol levels and stress relief. ([PubMed](https://pubmed.ncbi.nlm.nih.gov/28273551/))

**Boosting Focus and Productivity:**

* **Green Tea and Cognition:** Green tea contains L-theanine and caffeine, which together enhance brain function, improving focus and alertness. ([NCBI](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3545804/))
* **Omega-3 Fatty Acids:** Omega-3s, found in fatty fish like salmon, are essential for brain health and can help reduce anxiety, thereby improving cognitive function. ([PubMed](https://pubmed.ncbi.nlm.nih.gov/22290141/))
* **Turmeric and Curcumin:** Curcumin, found in turmeric, has anti-inflammatory properties and is linked to improved memory and attention. ([NCBI](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5664031/))
* **Dark Leafy Greens:** Spinach and kale, high in antioxidants and folate, can reduce fatigue and enhance mental clarity. ([PubMed](https://pubmed.ncbi.nlm.nih.gov/29998537/))

**Boosting Energy Levels:**

* **Spicy Foods and Endorphins:** Consuming spicy foods can trigger endorphin release, enhancing mood and energy levels. ([PubMed](https://pubmed.ncbi.nlm.nih.gov/24394797/))
* **Carbohydrates for Energy:** Complex carbohydrates, such as those found in whole grains, provide a steady energy supply and can improve mood by increasing serotonin levels. ([Harvard Health](https://www.health.harvard.edu/staying-healthy/foods-and-mood))
* **Granola and Nuts:** A mix of granola, honey, and nuts offers quick-release and sustained energy. ([NCBI](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2885317/))
* **Citrus Fruits:** Oranges and lemons are rich in vitamin C, which can reduce fatigue and boost energy levels. ([PubMed](https://pubmed.ncbi.nlm.nih.gov/16373990/))

**Improving Mood and Well-being:**

* **Dark Chocolate and Serotonin:** Dark chocolate is rich in antioxidants and can boost serotonin levels, contributing to improved mood. ([PubMed](https://pubmed.ncbi.nlm.nih.gov/21446837/))
* **Berries and Mood Improvement:** Berries are high in antioxidants, which help combat oxidative stress, potentially improving mood and cognitive function. ([NCBI](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5409703/))
* **Fermented Foods:** Yogurt, kimchi, and sauerkraut are rich in probiotics that promote gut health and improve mood. ([PubMed](https://pubmed.ncbi.nlm.nih.gov/26082763/))
* **Bananas:** High in vitamin B6, bananas help produce serotonin, aiding in mood regulation. ([NCBI](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5372869/))

**Promoting Relaxation and Sleep:**

* **Tryptophan and Sleep:** Foods rich in tryptophan, like turkey, can promote better sleep by increasing melatonin and serotonin production. ([PubMed](https://pubmed.ncbi.nlm.nih.gov/32082188/))
* **Slow-Cooked Meals and Comfort:** Warm, hearty meals can provide comfort and promote relaxation, aiding in stress reduction. ([NCBI](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7284748/))
* **Warm Milk:** The combination of tryptophan and calcium in milk promotes sleep. ([PubMed](https://pubmed.ncbi.nlm.nih.gov/22995645/))
* **Cherries:** Cherries, especially tart cherries, are natural sources of melatonin, aiding in better sleep cycles. ([PubMed](https://pubmed.ncbi.nlm.nih.gov/19438765/))

1. **Shopping List Management**The system generates shopping lists based on selected recipes, detailing the necessary ingredients and their quantities and searching for these ingredients in the Trader Joe’s groceries dataset. Users can view these lists directly within the system, streamlining the grocery shopping process. This feature not only saves time but also helps users stay organized by ensuring they purchase everything needed for their planned meals. For instance, if a user selects a recipe for a vegetable stir-fry, the system will list all the required vegetables, oils, and spices.
2. **User Feedback on Recipes**MoodBite allows users to rate and provide feedback on recipes, creating a continuous feedback loop that enhances data quality and system performance. For example, if multiple users rate a recipe poorly due to complexity, the system can adjust its priority in recommendations. This feedback data is also integrated into the training process of machine learning models, refining the recommendation algorithm to better align with evolving user preferences and ensuring more personalized and accurate future suggestions.

#### **Models/Algorithms Used**

The system employs a combination of algorithms to enhance its functionality. Partial match scoring is used to rank recipes by suitability, while filtering algorithms exclude recipes containing restricted ingredients. Sorting mechanisms organize results based on match percentages and external ratings. These algorithms work in tandem to provide personalized, ranked recommendations for users.

**Recipe Fetching Algorithm**

The algorithm filters recipes based on user preferences and mood goals, ensuring personalized recommendations. Here's how it works:

1. **Retrieve User Preferences**:
   * The system fetches the user’s dietary preferences, including diet type and restrictions, from the database.
2. **Fetch Recipes by Mood**:
   * It retrieves recipes tagged with the specified mood goal, focusing on breakfast and lunch/dinner dishes.
3. **Filter Recipes**:
   * Recipes are evaluated for compatibility with user dietary preferences, checking for matches with diet labels and excluding recipes containing restricted ingredients.
   * Recipes are scored based on match percentage and sorted by relevance and Spoonacular score.
4. **Recommend Recipes**:
   * The top recipes are displayed, tailored to user preferences and mood.
   * If no recipes match, the algorithm provides the highest-scoring alternative.

**Machine Learning: Recipe Quality Assessment Model**

A Random Forest Classifier was implemented to filter high-quality recipes based on historical data. Recipes were labeled as "popular" or "not popular" using features such as views, ratings, and user engagement.

**Key Steps:**

* **Data Preprocessing:** Missing values were handled, and data consistency ensured.
* **Class Balancing:** SMOTE was used to address imbalanced data.
* **Model Training:** The classifier was tuned for accuracy to predict recipe quality.

**Prediction and Filtering:** The model assigns a predicted\_quality label to each recipe, enabling the system to prioritize high-quality recipes for user recommendations.

**Impact:**

* Ensures consistent, scalable quality control as the dataset grows.
* Improves user satisfaction by reducing low-quality recommendations.
* Strengthens platform credibility with reliable, personalized suggestions.

#### **Technical Functions**

1. **Relational Database in MySQL** The MySQL relational database underpins the system, organizing data into normalized tables for users, recipes, ingredients, preferences, and feedback. A relational database is used for its ability to handle complex queries, enforce data consistency, and maintain scalability. Key relationships include:
   * User profiles linked to dietary preferences and feedback via foreign keys.
   * Recipes linked to ingredient tables for dynamic list generation.
   * Feedback linked to users and recipes for personalized insights.
2. **Backend Development in Python**

The Python backend serves as the core logic layer, interacting with the MySQL database and processing user requests. Flask is employed to create a RESTful API using SQLAlchemy as connector (/backend/app.py), however due to complications of connecting MySQL databases on a remote host, backend endpoints could only be tested on a local host to create the database. Therefore, there were complications with developing the front-end which would require communication with the database relying on backend endpoints.

1. **Recipe Filtering and Recommendation Engine** The recommendation engine combines user data, mood inputs, and recipe attributes using filtering algorithms implemented in Python. A matching scoring algorithm is employed to rank recipes by suitability, taking into account mood-specific attributes and dietary restrictions. The engine uses optimized SQL queries to retrieve and rank recipes from the database efficiently.
2. **Frontend Development**The system’s frontend has been planned to be designed as a React-based web application that interacts with the backend API. React is chosen for its component-based structure, enabling the creation of a responsive and intuitive user interface that would allow features such as recipe browsing, shopping list viewing, and rating submissions. However, due to complications in connecting to database from remote host, the user interaction is completed in command line
3. **Recipe Rating System**Users rate recipes through the frontend, and ratings are logged in the database via API calls. The feedback table includes fields for user IDs, recipe IDs, rating scores, and textual feedback, enabling granular analysis of user preferences. These ratings are processed to update the recommendation engine dynamically.

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### **How Recipe Filtering Works in the MoodBite Application**

#### The MoodBite application provides a comprehensive filtering system to recommend recipes tailored to user preferences and mood goals. This process integrates user-specific dietary restrictions, activity levels, and mood objectives to deliver accurate and personalized recommendations.

#### Key Steps in Recipe Filtering:

#### User Registration and Preferences Storage:

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FIgure - User registration

#### During registration, users provide their personal details such as age, height, weight, and activity levels.

#### Users also specify their dietary preferences, including whether they are vegetarian, vegan, gluten-free, or have other specific restrictions.

#### Mood Goal Selection:

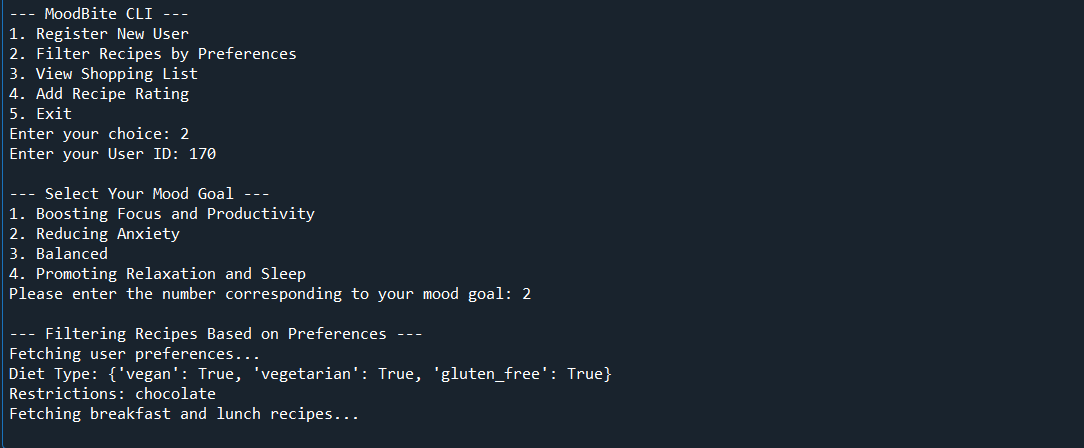


Figure -Mood selection

#### Users are prompted to select a mood goal from predefined categories such as:

#### Boosting Focus and Productivity

#### Reducing Anxiety

#### Promoting Relaxation and Sleep

#### Balanced

#### This mood goal determines the type of recipes to be recommended

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#### Recipe Retrieval:

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*Figure - recommended recipe*

#### Recipes from the database are filtered based on the selected mood goal. Each recipe in the database is tagged with a mood category (e.g., Boosting Focus, Relaxation).

#### Recipes matching the mood goal are retrieved for further filtering.

#### Dietary Preference Matching:

#### For each recipe, the system evaluates its DietLabels to check compatibility with the user's dietary preferences.

#### Compatibility is calculated by comparing the user's preferences (e.g., vegetarian, vegan, gluten-free) against the recipe's dietary attributes.

#### Ingredient Restriction Check:

#### The system examines the recipe's ingredient list to ensure it does not contain items flagged by the user as restricted.

#### Recipes containing restricted ingredients are excluded from the final list.

#### Scoring and Ranking:

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*Figure- Rating Recipe*

#### Recipes are scored based on:

#### Match percentage with user preferences.

#### Spoonacular score (a third-party API rating for recipes considering healthiness, popularity, and quality).

#### Recipes with higher scores are ranked higher in the recommendations.

#### Final Recommendation:

#### The top three recipes, based on their scores, are displayed to the user.

#### Each recommended recipe includes details such as:

#### Recipe name

#### Preparation time

#### Cuisine type

#### Summary

#### Instruction steps

#### Caloric breakdown

#### If no recipes meet the exact criteria, the best recipe available is presented as a fallback.

#### Shopping List Integration:

#### Users can view or manage their shopping list directly from the app. Ingredients for selected recipes are automatically added to the shopping list, ensuring convenience for meal preparation.

#### By storing all this data in structured tables, the application can efficiently retrieve, filter, and display the most relevant information for the user. This robust database architecture underpins all the functionality of the application, ensuring that it operates smoothly and reliably.

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*Figure- Database.*

Select \* from Users

**Future Technical Enhancements**

1. **Integration with External APIs** Expanding the recipe database through APIs such as Spoonacular or Edamam will enhance the system’s content. Real-time nutrition data sourced from these APIs will provide more accurate and diverse recommendations.
2. **Machine Learning for Recommendations** A machine learning recommendation model will be trained on user feedback and historical data to improve suggestion accuracy. Python libraries like TensorFlow or Scikit-learn will be used to develop and deploy these models.
3. **Nutritional Analysis** Integrating nutritional analysis capabilities will allow the system to break down recipes into macronutrient components and suggest dietary adjustments. The backend will compute these metrics dynamically, storing the results in dedicated database fields for easy access.
4. **Web and Mobile Applications** A fully responsive web application and mobile app are planned, using React and React Native respectively. These interfaces will provide users with intuitive access to all system features, including recipe browsing, shopping lists, and feedback submission.
5. **Scalability** As user adoption grows, transitioning the database to a cloud-based solution like Amazon RDS or Google Cloud SQL will ensure scalability and reliability. Load balancing and API optimization will also be implemented to handle increased traffic.

#### **Risks and Mitigation**

1. **Lack of User-Friendly UX/UI**

The current system lacks an intuitive and visually appealing user interface, which may hinder user engagement and satisfaction. Without a well-designed UX/UI, users might find it inconvenient to interact with the platform, navigate through recipes, or follow cooking instructions effectively. This can lead to decreased user retention and reduced platform credibility.

Mitigation: to address this pitfall, the next phase involves developing a web application with engaging and responsive design.

1. **Competitive Market**

As identified, there are many meal planning, nutrition tracking platforms available online, however our uniqueness is in offering meal plans that are tailored to match emotional goals of users. Therefore more focus should be put in refining matching algorithms and presenting scientific justification behind to achieve positive outcomes. Apart from emotional goal matching, the database of recipes should be increased and cleaned to contain high-quality recipes only.

1. **Data Security**

Sensitive user data, such as dietary preferences and health metrics, must be protected. The system will implement SSL encryption for data transmission and hash algorithms for securely storing passwords.

1. **Database Reliability**

Potential downtime or corruption of the database could disrupt the system. To mitigate this, regular backups and replication strategies will be employed, ensuring data is recoverable and the system remains operational.

1. **Algorithm Bias**

Recommendation algorithms may favor certain recipes over others, limiting personalization. Regular audits of algorithm performance and retraining with updated data will ensure fairness and accuracy.

#### **Conclusion**

The "MoodBite" system is a promising innovation in personalized nutrition and emotional well-being. By integrating mood-based recommendations with dietary guidance, it offers a unique and comprehensive solution for health-conscious individuals. With future enhancements and effective risk management, MoodBite has the potential to redefine meal planning and promote holistic wellness.