Content Recommendation System

This project is a content recommendation system that leverages user interests to suggest relevant documents. It utilizes a pre-trained SentenceTransformer model to create embeddings for both user interests and content, enabling effective matching based on semantic similarity. The application is built using Streamlit for the user interface and ChromaDB for managing the content database.

Table of Contents

Features

Load user and content data from JSON files. Generate content embeddings using a pre-trained model. Match users to content based on their interests. Filter recommendations based on selected interest types. Interactive user interface built with Streamlit.

Installation

To set up the project, ensure you have Python installed (version 3.7 or higher). Then, follow these steps:

Install required packages:

```
pip install -r ./requirements.txt
```

Prepare your JSON files: You will find relevant documentation within the generate_synth_data folder

- Create a users.json file containing user data with interests.
- Create a content.json file containing content data with tags.

Running the Application

To run the application, we need to make sure Chromadb is running. Open a terminal and run

```
chroma run
```

Then execute in a different window the following command in your terminal:

```
streamlit run streamlit_vector_db.py
```

The application will start, and you can access it in your web browser at http://localhost:8501.

Running the Application as a Docker Container

To run the application as a Docker container, follow these steps:

1. Ensure you have Docker installed on your system.
2. Build the Docker image:

   ```
   docker build -t content-recommendation-system .
   ```

3. Run the Docker container:

   ```
   docker run -p 8501:8501 content-recommendation-system
   ```

Access the application in your web browser at http://localhost:8501.

Docker-specific Files

'Dockerfile': Contains instructions for building the Docker image.

Dockerfile Explanation

The Dockerfile includes the following key steps:

1. Uses Python 3.10.14 as the base image.
2. Sets the working directory to /app.
3. Copies and installs the requirements.
4. Installs necessary system dependencies.
5. Installs a specific version of SQLite (3.46.0).
6. Copies the application code into the container.
7. Modifies the main Python file to use pysqlite3 instead of sqlite3.
8. Exposes port 8501 for Streamlit.
9. Sets the command to run the Streamlit application.

Matching Logic

The matching logic involves several key steps:

- Load Data: User and content data are loaded from JSON files.

- Embedding Generation: The SentenceTransformer model generates embeddings for both user interests and content.
- User Embedding Calculation: A user embedding is created by averaging the embeddings of their interests.
- Content Matching: The user embedding is compared against content embeddings in the ChromaDB collection to find the most relevant documents.
- Filtering Recommendations: Recommendations can be filtered based on selected interest types to refine the results.

Key Functions

- load_json(file_path): Loads data from a specified JSON file. prepare_content(content_data): Prepares content for embedding and metadata extraction.
- get_user_embedding(interests): Generates a user embedding based on their interests.
- match_user_to_content(collection, user_id, interests, top_n): Matches a user to content based on their interests.

Additional Matching Techniques

In addition to the vector-based matching using SentenceTransformer and ChromaDB, we also explored other matching techniques to improve the recommendation system. These techniques focus on more specific matching criteria, particularly emphasizing the importance of country-based matching along with other interests.

Country-Based Content Matching

We implemented two additional matching functions that prioritize country-based matching while also considering other user interests:

1. `match_country_content(users, content)`
2. `match_country_and_content(users, content)`

match_country_content

This function matches content to users based on the following criteria:

- Matches content tags with user interests
- Prioritizes matching based on the 'country' interest type
- Also considers other interest types for matching

```
def match_country_content(users, content):
```

Key features:

- Checks for exact matches between content tags and user interests
- Prioritizes country matches
- Includes content if it matches either the country or any other interest type

match_country_and_content

This function provides a more stringent matching criterion: Requires both a country match and a match with at least one other interest type

```
def match_country_and_content(users, content):
```

Key features:

- Uses flag variables to track country matches and other interest matches
- Only includes content in recommendations if both country and at least one other interest match
- Provides a more focused set of recommendations

Comparison with Vector-Based Matching

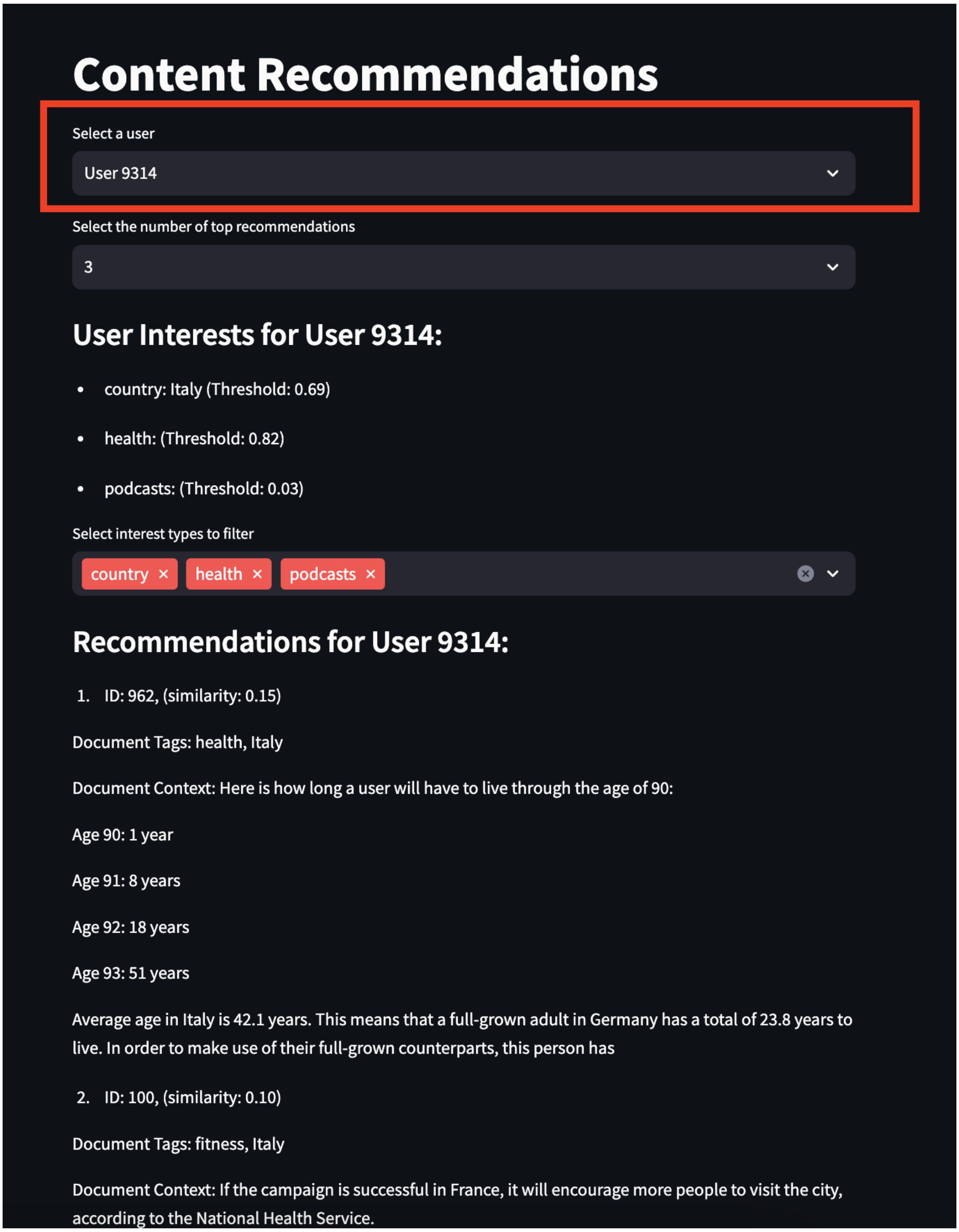
While these methods provide more specific matching based on exact tag comparisons, the vector-based approach using SentenceTransformer and ChromaDB offers the following advantages:

- Semantic understanding of interests and content, allowing for nuanced matching
- Ability to find relevant content even when tags don't exactly match interest keywords
- Scalability to handle large amounts of content efficiently The choice between these methods depends on the specific requirements of the recommendation system, such as the need for exact matches versus semantic similarity, and the scale of the content database.

UI Structure

The user interface is built using Streamlit and consists of the following components:

- User Selection: A dropdown menu allows users to select from a list of available users.



Content Recommendations

Select a user

User 9314

Select the number of top recommendations

3

User Interests for User 9314:

- country: Italy (Threshold: 0.69)
- health: (Threshold: 0.82)
- podcasts: (Threshold: 0.03)

Select interest types to filter

country × health × podcasts ×

Recommendations for User 9314:

1. ID: 962, (similarity: 0.15)

Document Tags: health, Italy

Document Context: Here is how long a user will have to live through the age of 90:

Age 90: 1 year

Age 91: 8 years

Age 92: 18 years

Age 93: 51 years

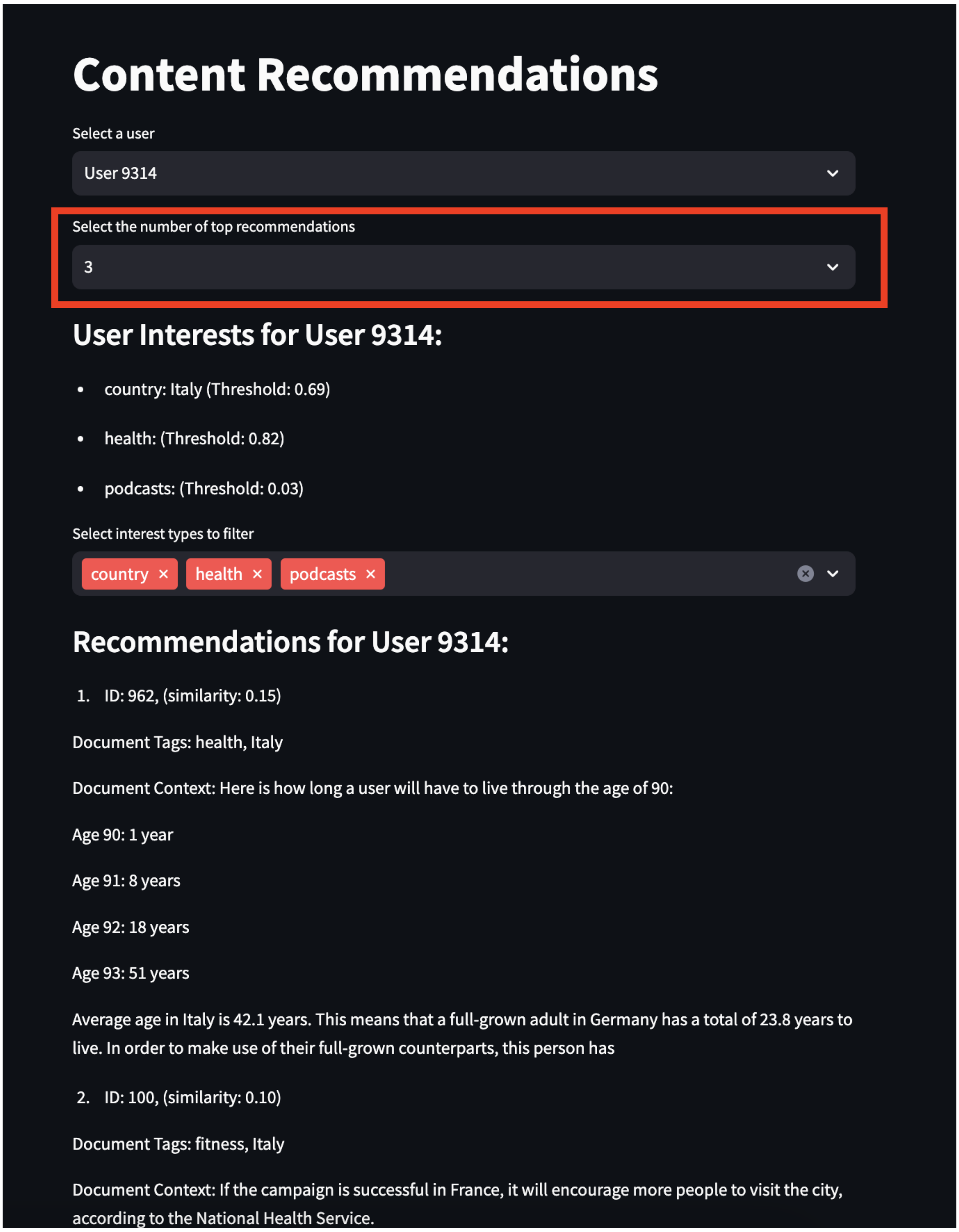
Average age in Italy is 42.1 years. This means that a full-grown adult in Germany has a total of 23.8 years to live. In order to make use of their full-grown counterparts, this person has

2. ID: 100, (similarity: 0.10)

Document Tags: fitness, Italy

Document Context: If the campaign is successful in France, it will encourage more people to visit the city, according to the National Health Service.

- Recommendation Count: A dropdown menu to select the number of top recommendations to display.



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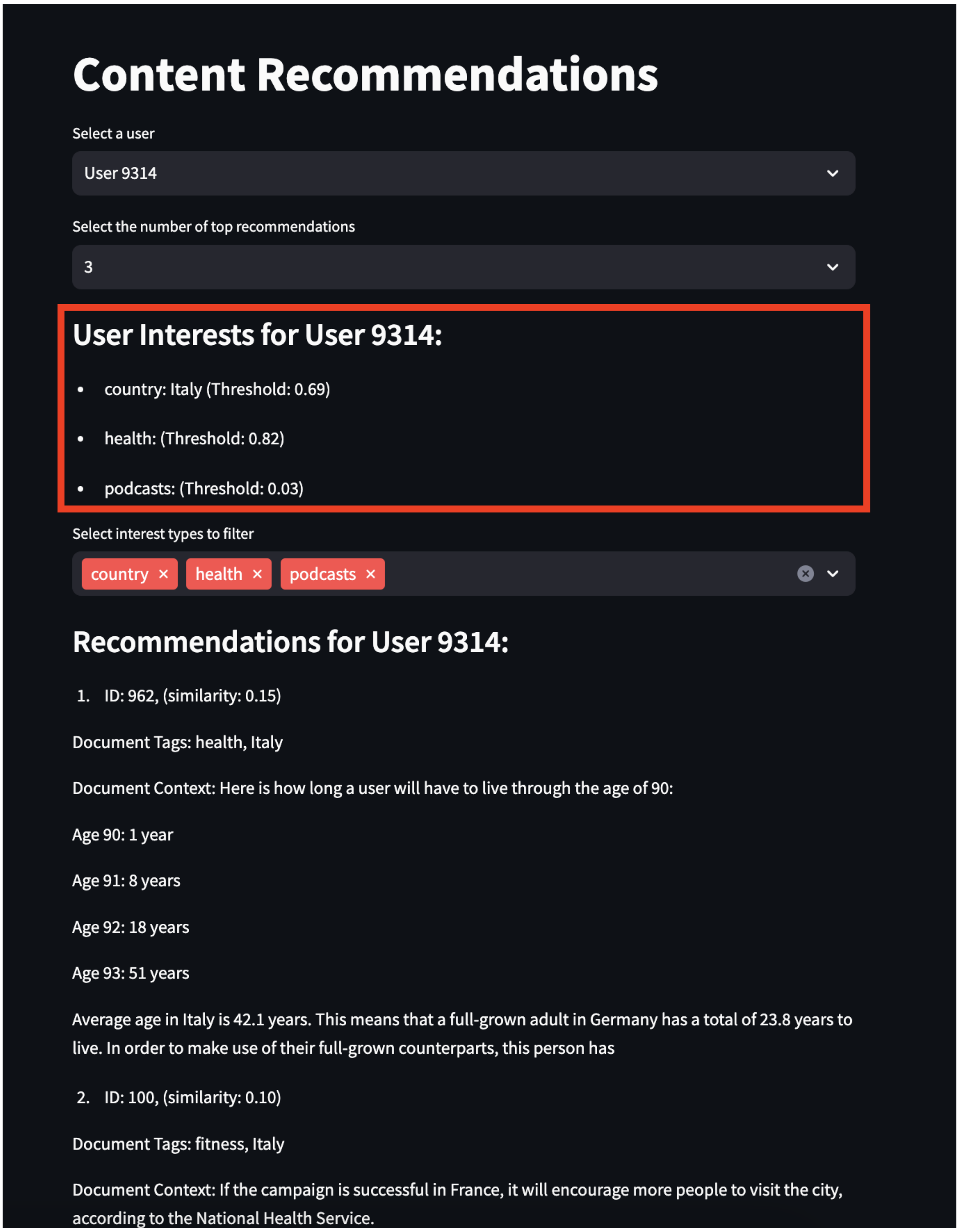
- User Interests Display: Displays the selected user's interests with thresholds.



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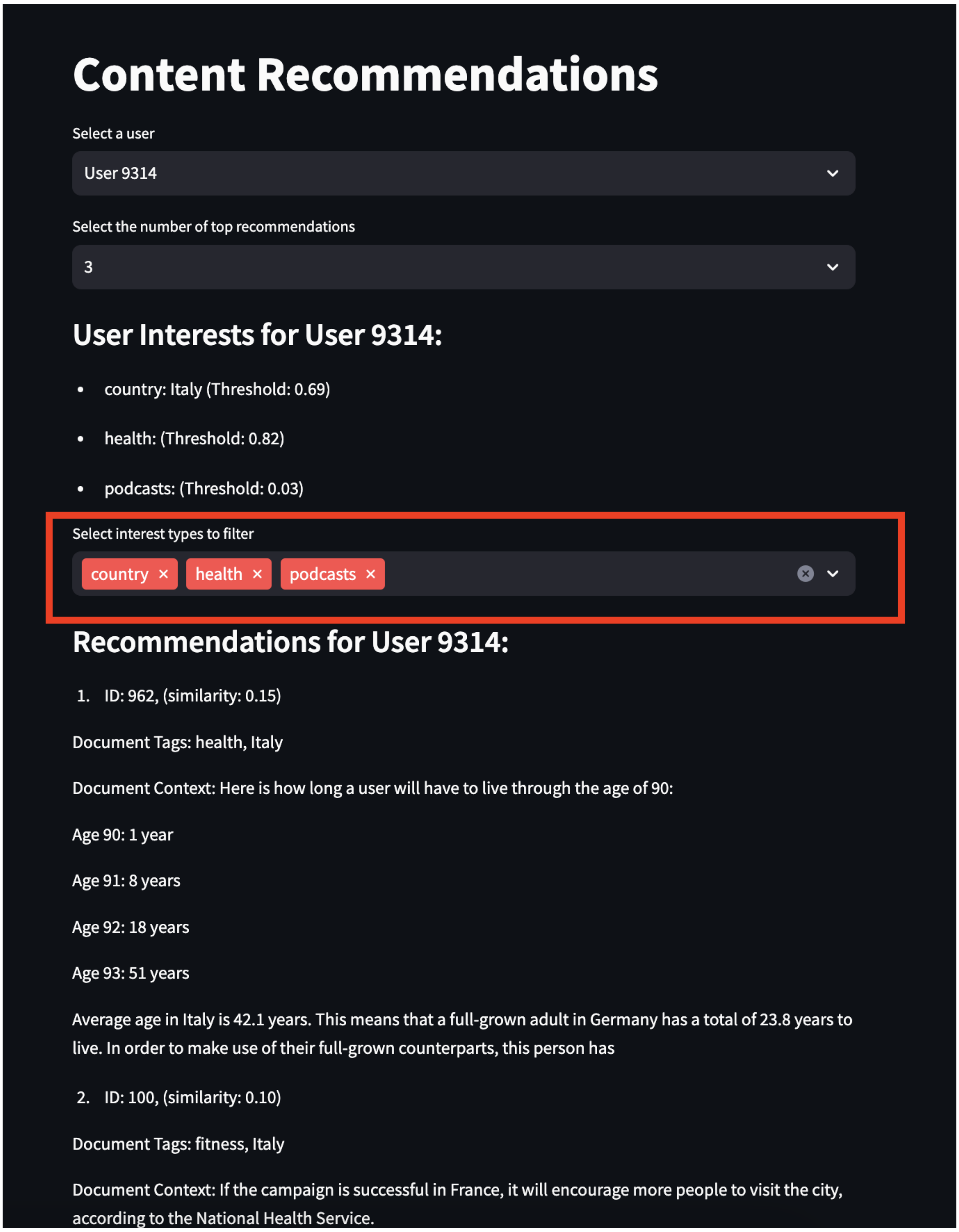
- Interest Type Filtering: A multiselect option to filter recommendations based on specific interest types.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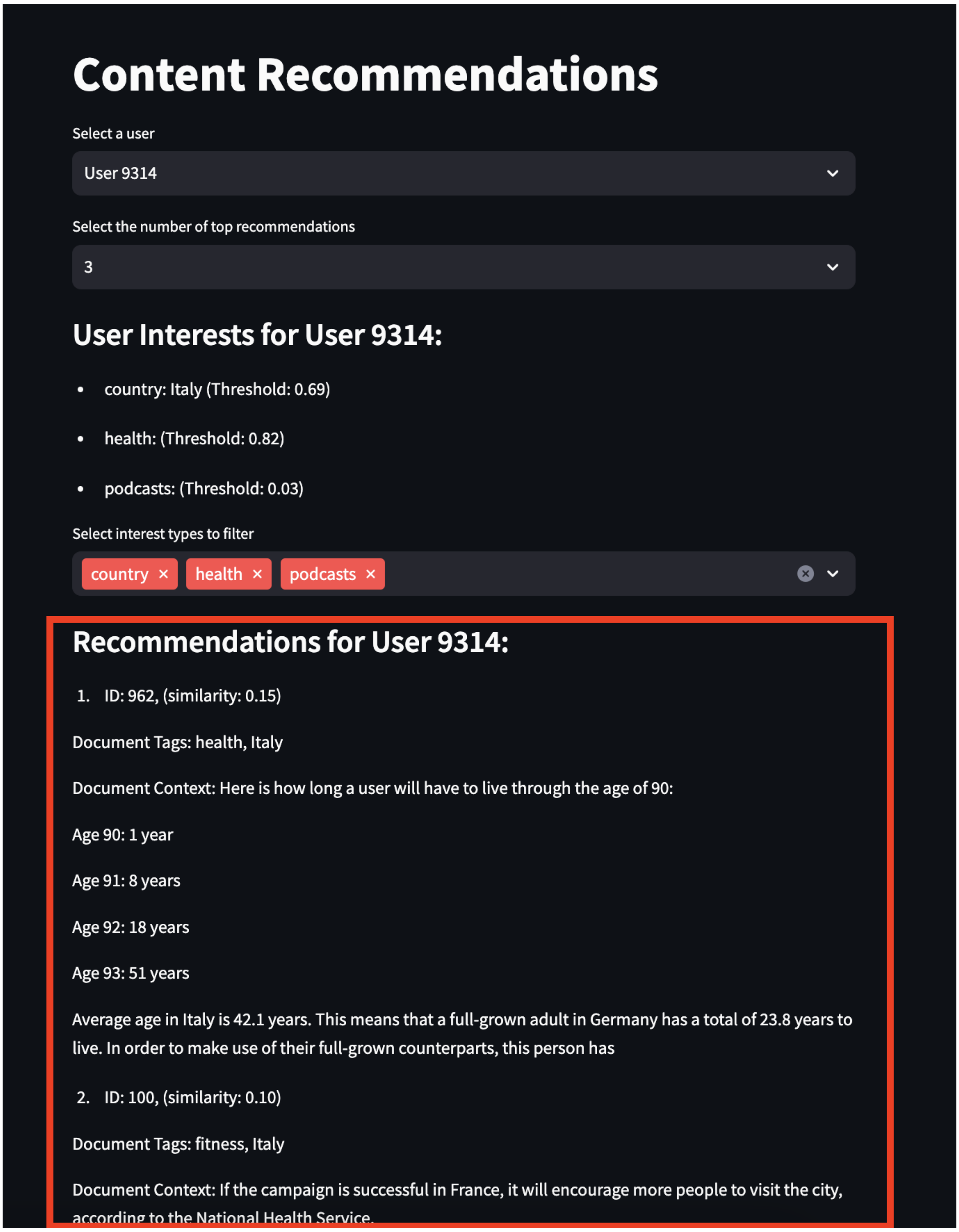
- Recommendations Display: Shows the filtered recommendations, including document IDs, similarity scores, and document context.



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Example UI Flow

- The user selects their name from the dropdown.
- The user can choose how many recommendations they want to see.
- The application displays their interests.
- The user can filter recommendations based on interest types.
- The filtered recommendations are displayed, showing relevant content based on the user's interests.

Run Testing

Using pytest:

To run the tests using pytest, follow these steps: Ensure you have pytest and pytest-cov installed.

** Also make sure the path of the python project is already exported in the bashrc file ** and then run

```
python3 -m pytest ./tests/*.py
```

Using run_cov_tests.sh

Alternatively, you can use the provided run_cov_tests.sh script to run the tests with coverage:

```
./run_cov_tests.sh
```

After running the above script it will export an index.html file within htmlcov folder that shows the percentage of each file that the test covered.

Additional Development Steps

To further improve the robustness, reliability, and efficiency of our content recommendation system, we've implemented the following additional steps:

1. Enhanced Synthetic Data Generation

We've improved our synthetic data generation process to create more realistic and diverse datasets for testing and development:

- Expanded the range of interest types and values
- Introduced more varied content structures and tags
- Implemented realistic user behavior patterns
- Created edge cases to test system boundaries

2. Comprehensive Testing and Code Coverage

We've significantly expanded our testing suite to ensure better code coverage and system reliability:

- Unit tests for all core functions
- Integration tests for the entire recommendation pipeline
- Edge case testing for unusual user profiles and content
- Performance testing for large datasets

3. CI/CD Pipeline Implementation

We've set up a comprehensive CI/CD pipeline to automate testing, security checks, and deployment:

Pipeline Stages

- Code Linting and Formatting
- Unit and Integration Testing
- Security Vulnerability Scan
- Performance Benchmarking
- Docker Image Building
- Deployment to Staging
- Production Deployment