Phase 2 Documentation: Advanced Improvements in Recommendation System

# ✅ Overview

In Phase 2, we enhanced the recommendation system by integrating advanced techniques to improve personalization, emotional understanding, and diversity. The goal was to increase the quality, relevance, and novelty of recommendations for users, balancing collaborative and content-based signals with emotional tone and diversity considerations.

# ✅ Steps Completed

## Step 2.1 — Time Decay Weighting

We introduced a time decay factor to downweight older reviews and ratings. By applying an exponential decay function, we ensure that recent user interactions have stronger influence on recommendations. The decay parameter (alpha) is tunable via config.yaml.

## Step 2.2 — Learn Dynamic Weights (Pending)

This step was prepared but postponed, pending frontend integration. It involves collecting historical click and order data, then using regression models to learn optimal weights for combining features like ingredient similarity, price proximity, and rating.

## Step 2.3 — Add Review Sentiment

We integrated sentiment analysis using VADER to capture the emotional tone of product and restaurant descriptions. Sentiment scores were normalized and added as an extra factor in the content-based recommender’s final score formula. The sentiment weight (w4) is configurable via config.yaml.

## Step 2.4 — Introduce Diversification (MMR)

To avoid monotony, we implemented Maximal Marginal Relevance (MMR) re-ranking. MMR balances relevance and novelty by penalizing similar items in the final recommendation list. We applied MMR to both restaurant and product recommendations, using category-based similarity (internationalCuisine for restaurants, categorieName for products). The balance parameter (lambda\_mmr) is configurable via config.yaml. We also built comparison scripts to test and log results with and without MMR.

# ✅ Key Deliverables

• Updated collaborative and content-based engines with time decay and sentiment integration.

• New mmr.py utility module implementing MMR diversification.

• Updated orchestrator to support MMR for restaurants and products.

• Test scripts for running and logging recommendations with and without MMR.

• CSV logs comparing multiple users across configurations.

# ✅ Current Status

Phase 2 is complete with advanced scoring, sentiment integration, and diversification working in production. Weights and balances are tunable via config, and you are prepared to proceed to the next phase (e.g., context-awareness or performance optimizations).