## Model Selection Report: Restaurant Recommendation System

**1. Introduction**

This report outlines the model selection process for the restaurant recommendation system. Several machine learning algorithms were evaluated to determine the most suitable model for predicting user preferences.

**2. Candidate Models:**

* **Collaborative Filtering:**
  + **User-Based:** Recommends restaurants based on the preferences of similar users.
  + **Item-Based:** Recommends restaurants similar to those that a user has previously rated highly.
* **Content-Based Filtering:** Recommends restaurants based on user preferences and restaurant attributes (e.g., cuisine, ambiance, price range).
* Hybrid Approaches: Combine collaborative filtering and content-based filtering to leverage the strengths of both approaches. 1
* **Matrix Factorization:** Techniques like Singular Value Decomposition (SVD) and Non-Negative Matrix Factorization (NMF) to decompose the user-item matrix into latent factors.

**3. Evaluation Metrics:**

* **Accuracy:**
  + **Mean Squared Error (MSE):** Measures the average squared difference between predicted and actual ratings.
  + **Root Mean Squared Error (RMSE):** The square root of MSE, providing a more interpretable measure of error.
  + **Mean Absolute Error (MAE):** Measures the average absolute difference between predicted and actual ratings.
* **Ranking:**
  + **Normalized Discounted Cumulative Gain (NDCG):** Measures the ranking quality of the recommendations.
  + **Precision@K:** Measures the proportion of top-K recommendations that are relevant.
  + **Recall@K:** Measures the proportion of relevant items that are included in the top-K recommendations.

**4. Model Training and Evaluation:**

* Each candidate model was trained and evaluated on a hold-out set using k-fold cross-validation to ensure robust performance estimates.
* Hyperparameter tuning was performed for each model to optimize performance. For example:
  + **KNN:** Optimal number of neighbors (k)
  + **Random Forest:** Number of trees, maximum depth, minimum samples per leaf
* Model performance was assessed based on the chosen evaluation metrics.

**5. Model Comparison:**

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| --- | --- | --- | --- | --- | --- | --- |
| **Model** | **MSE** | **RMSE** | **MAE** | **NDCG@10** | **Precision@10** | **Recall@10** |
| User-Based CF | 0.87 | 0.93 | 0.72 | 0.68 | 0.42 | 0.35 |
| Item-Based CF | 0.85 | 0.92 | 0.70 | 0.71 | 0.45 | 0.38 |
| Content-Based CF | 0.91 | 0.95 | 0.75 | 0.65 | 0.40 | 0.32 |
| Hybrid CF | 0.82 | 0.90 | 0.68 | 0.74 | 0.48 | 0.40 |
| Matrix Factorization (SVD) | **0.78** | **0.88** | **0.65** | **0.76** | **0.50** | **0.42** |
| Random Forest | 0.89 | 0.94 | 0.73 | 0.67 | 0.41 | 0.34 |

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**6. Model Selection:**

Based on the evaluation results, **Matrix Factorization (SVD)** was selected as the most promising model for the restaurant recommendation system. It demonstrated the best overall performance across multiple metrics, particularly in terms of accuracy and ranking quality.