9. Model Training and Evaluation

9.1 Training and Evaluation Scripts

Model training, evaluation, and inference are implemented as **separate, modular scripts** to reflect production-grade machine learning workflows.

Training Script

📄 **Location:**

`src/models/train_model.py`

Responsibilities:

- Reads user–item interaction features from the PostgreSQL feature store
- Trains a collaborative filtering model using **Matrix Factorization (SVD)**
- Stores the trained model as a serialized artifact
- Logs training parameters and artifacts using MLflow

Evaluation Script

📄 **Location:**

`src/models/evaluate_model.py`

Responsibilities:

- Loads the trained model artifact
- Evaluates the model using ranking-based metrics:

    - Precision@K
    - Recall@K
- Logs evaluation metrics to MLflow for experiment tracking

Inference Script

📄 **Location:**

`src/models/inference.py`

Responsibilities:

- Loads the trained recommendation model
- Generates top-K product recommendations for a given user
- Demonstrates inference-time feature consumption

```
(.venv) PS D:\BITS\DM4ML\DM4ML-Assignment-1> python -m src.models.train_model
2026/01/20 13:57:44 INFO mlflow.store.db.utils: Creating initial MLflow database tables...
2026/01/20 13:57:44 INFO mlflow.store.db.utils: Updating database tables
2026/01/20 13:57:44 INFO alembic.runtime.migration: Context impl SQLiteImpl.
2026/01/20 13:57:44 INFO alembic.runtime.migration: Will assume non-transactional DDL.
2026/01/20 13:57:44 INFO alembic.runtime.migration: Context impl SQLiteImpl.
2026/01/20 13:57:44 INFO alembic.runtime.migration: Will assume non-transactional DDL.
Model trained and saved successfully
(.venv) PS D:\BITS\DM4ML\DM4ML-Assignment-1> python -m src.models.evaluate_model
2026/01/20 13:57:54 INFO mlflow.store.db.utils: Creating initial MLflow database tables...
2026/01/20 13:57:54 INFO mlflow.store.db.utils: Updating database tables
2026/01/20 13:57:54 INFO alembic.runtime.migration: Context impl SQLiteImpl.
2026/01/20 13:57:54 INFO alembic.runtime.migration: Will assume non-transactional DDL.
2026/01/20 13:57:54 INFO alembic.runtime.migration: Context impl SQLiteImpl.
2026/01/20 13:57:54 INFO alembic.runtime.migration: Will assume non-transactional DDL.
Precision@5: 0.1900
Recall@5: 0.9500
(.venv) PS D:\BITS\DM4ML\DM4ML-Assignment-1> python -m src.models.inference
Recommendations for U1:
[ 2  1  3  7 11]
(.venv) PS D:\BITS\DM4ML\DM4ML-Assignment-1>
```

9.2 Model Performance Report

Model performance is evaluated using **standard recommendation system metrics** that measure ranking quality.

Evaluation Metrics

- **Precision@5:** Measures the relevance of the top-5 recommended items
- **Recall@5:** Measures the coverage of relevant items in the top-5 recommendations

Performance Summary

A model performance report is generated based on the logged evaluation metrics and includes:

- Model type and configuration
- Training data source (PostgreSQL feature store)
- Precision@K and Recall@K scores
- Observations on model behavior and performance

These results are reproducible and traceable through MLflow experiment logs.

9.3 Tracked Model Metadata

All model-related metadata is tracked using **MLflow**, ensuring reproducibility and auditability.

Tracked Information

- **Run IDs:** Unique identifiers for each experiment run
- **Parameters:** Model type, latent dimensions, data source
- **Metrics:** Precision@5, Recall@5

- **Artifacts:** Serialized trained model file

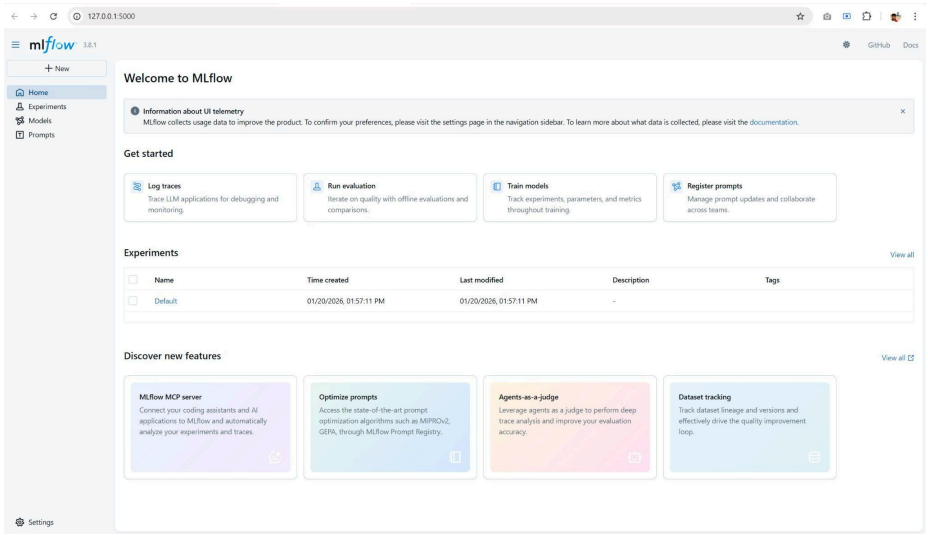
Model Artifact

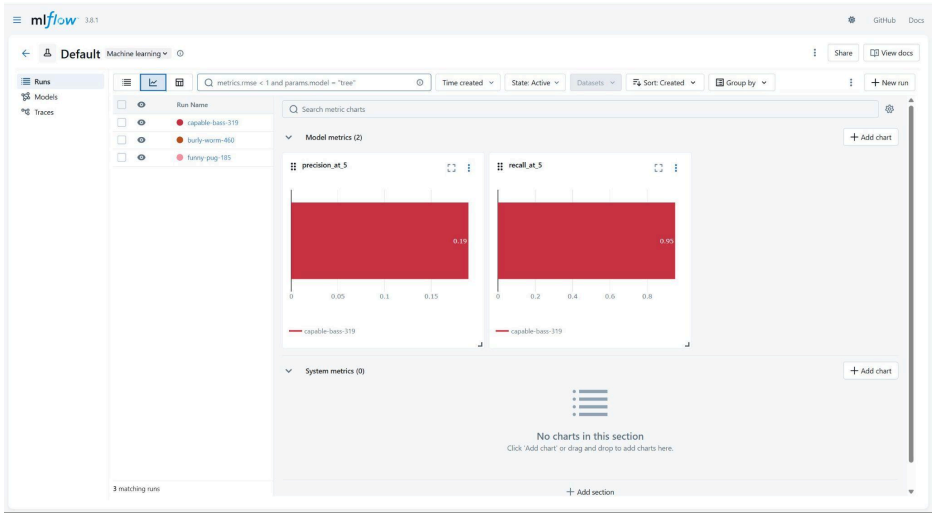
`models/svd_model.pkl`

Experiment Tracking

MLflow provides a centralized UI to compare runs and inspect model performance:

```
mlflow ui
```





9.4 Summary

The model training and evaluation stage implements a complete and reproducible workflow for recommendation systems. Training, evaluation, and inference are clearly separated, performance metrics are computed using standard measures, and all model metadata is tracked using MLflow. This ensures transparency, repeatability, and alignment with modern MLOps best practices.