Amazon Electronics Troubleshooting Retrieval System

< Documentation >

CS 410 – Text Information Systems

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Repository: [jasonccfok/amazon-electronics-troubleshooting-retrieval]

Project Keywords: #electronics, #retrieval-system, #troubleshooting, #amazon-reviews, #semantic-search

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1. Project Overview

The Amazon Electronics Troubleshooting Retrieval System is designed to assist users in finding community-sourced solutions hidden within the vast collection of Amazon product reviews for electronic devices. Instead of wading through hundreds of unrelated reviews or generic troubleshooting pages, users can describe their specific issue in natural language — such as:

- *"Bluetooth keeps disconnecting"*
- *"battery drains too quickly"*
- *"screen flickering after update"*

The system intelligently analyzes the input and retrieves reviews where similar problems have been discussed by other customers — often alongside helpful fixes, workarounds, or insights.

2. Motivation

When electronics malfunction, users often seek solutions online, but official documentation rarely addresses real-world issues. Amazon reviews are rich with troubleshooting knowledge, where users share problems and fixes in their own words. This project seeks to harness that valuable resource, making it easily searchable to help users quickly determine if others have faced similar issues and how they resolved them.

3. Technical Approach

The retrieval pipeline integrates and compares two approaches:

A. Keyword-based retrieval (BM25 / TF-IDF)

   Implements traditional term-frequency models to find exact or close keyword matches.

B. Semantic retrieval (Sentence-BERT embeddings)

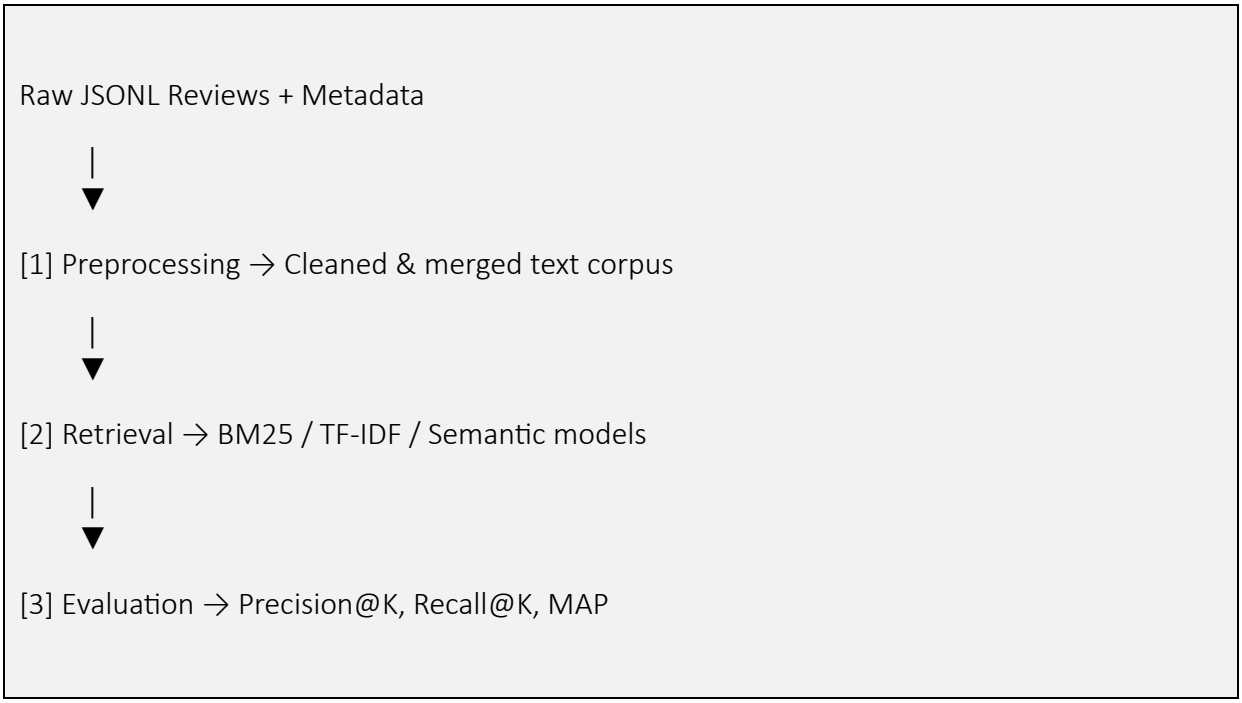
   Uses dense vector embeddings (e.g., all-MiniLM-L6-v2) to capture meaning similarity even when wording differs.

4. Evaluation

Model effectiveness is assessed using common IR metrics implemented in the repository:

Metric	*Description*
Precision@K	Fraction of top K retrieved documents that are relevant
Recall@K	Fraction of all relevant documents retrieved
Mean Average Precision (MAP)	Average precision over recall positions for each query

5. System Overview



6. Project Structure

```
project_root/
├── 1. preprocessing/
│   ├── load_raw_data.py                 # Load & merge reviews + metadata
│   ├── text_cleaning.py                 # Clean, normalize, lemmatize text
│   └── exploratory_data_analysis.ipynb  # EDA notebooks (visual insights)
│
├── 2. retrieval/
│   ├── bm25_retrieval.py                # BM25 and TF-IDF retrieval
│   └── semantic_retrieval.py            # Transformer-based semantic model
│
├── 3. evaluation/
│   ├── retrieval_evaluation.py          # Benchmark BM25, TF-IDF, semantic models
│   └── evaluation_plot.ipynb            # Visualization of evaluation metrics
│
├── data/
│   ├── raw/                             # Amazon JSONL input files
│   ├── processed/                       # Cleaned CSVs & cached embeddings
│   └── groundtruth/                     # Gold relevance + evaluation outputs
│
├── requirements.txt                     # Library dependencies
└── README.md                            # Project description
```

7. Setup

a. Clone and Enter Folder

Run:

```
git clone https://github.com/jasonccfok/amazon-electronics-troubleshooting-retrieval.git
cd amazon-electronics-troubleshooting-retrieval
```

b. Create Virtual Environment

Run:

```
python -m venv venv
source venv/bin/activate      # macOS/Linux
venv\Scripts\activate         # Windows
```

c. Install Dependencies

Run:

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

d. Prepare Data

Category	#User	#Item	#Rating	#R_Token	#M_Token	Download
Cell_Phones_and_Accessories	11.6M	1.3M	20.8M	935.4M	1.3B	review, meta
Clothing_Shoes_and_Jewelry	22.6M	7.2M	66.0M	2.6B	5.9B	review, meta
Digital_Music	101.0K	70.5K	130.4K	11.4M	22.3M	review, meta
Electronics	18.3M	1.6M	43.9M	2.7B	1.7B	review, meta
Gift_Cards	132.7K	1.1K	152.4K	3.6M	630.0K	review, meta
Grocery_and_Gourmet_Food	7.0M	603.2K	14.3M	579.5M	462.8M	review, meta

Download from https://huggingface.co/datasets/McAuley-Lab/Amazon-Reviews-2023 and place Amazon Electronics data in:

```
data/raw/Electronics.jsonl.gz
data/raw/meta_Electronics.jsonl.gz
```

8. Usage Guide

a. Step 1 – Load and Merge Raw Data

Run:

```
python "1. preprocessing/load_raw_data.py" ^
  --review "data/raw/Electronics.jsonl.gz" ^
  --meta "data/raw/meta_Electronics.jsonl.gz" ^
  --output "data/processed/electronics_merged.csv" ^
  --limit 50000
```

Output → data/processed/electronics_merged.csv

b. Step 2 – Clean and Normalize Text

Run:

```
python "1. preprocessing/text_cleaning.py" ^
  --input "data/processed/electronics_merged.csv" ^
  --output "data/processed/reviews_clean.csv"
```

Output → data/processed/reviews_clean.csv

c. Step 3 – BM25 / TF-IDF Retrieval

Run:

```
python "2. retrieval/bm25_retrieval.py" ^
  --data "data/processed/reviews_clean.csv" ^
  --query "tripod screw loose problem" ^
  --topk 5
```

Sample terminal output:

```
================= QUERY RESULTS =================
Query: tripod screw loose problem

------ BM25 Top Results ------
1. parent_asin: B0BZB56D2J | Score: 16.0709
   Review (raw): Loose screw inside, Bulky but very useful! The design is very bulky but it's very useful feature t
o clamp into place. quality feels nice. Mine has 1 problem which does worries me a little: when I shake it a little
 you can tell there is a screw loose inside. this is a potential cause of a short circuit. But because once is set
in place I don't move it anymore it doesn't worry me as much. Tripp Lite 3 Outlet Surge Protector Power Strip with
Desk Clamp, 10ft. Cord, 510 Joules, 2 USB Charging Ports, Black, $20K Insurance & (TLP310USBC)

2. parent_asin: B01F5SIVBQ | Score: 15.5608
   Review (raw): Good but could be improved It doesn't come with any sort of quick release for the attachment of th
e camera, so very time you want to use it you have to screw the camera into the entire tripod. I believe they sell
an attachment that you can use for quick release, but I wish it was integrated. The tripod itself is really easy to
 use and holds my dslr sturdily with no problem. The height is not really adjustable so it's not as flexible that w
ay. Tamrac TR404 ZipShot® Mini Tripod - Black

3. parent_asin: B0043OAI9M | Score: 15.3906
   Review (raw): Heavy duty! This tripod is heavy duty and very sturdy. The only thing that wasn't mentioned in any
 reviews, is the fact that the tripod sits at an angle and there isn't anything you can do about it. If you want yo
ur antenna to point straight ahead, like I did, then you got a problem. I will just get some longer screws to adjus
t the 5' mast that I ordered, because the one that came with it, same shipment I might add, was too short. Like I s
aid, it's heavy duty, easily mounts to the roof, doesn't come with pitch pads or screws, but all in all it serves i
ts purpose. Four stars, only for the fact it doesn't sit straight up and down, rather at an angle. 3 feet Satellite
 Tripod Mount with 2-Inch OD Mast
```

```
------ TF-IDF Top Results ------
1. parent_asin: B0BZB56D2J | Score: 0.1722
   Review (raw): Loose screw inside, Bulky but very useful! The design is very bulky but it's very useful feature t
o clamp into place. quality feels nice. Mine has 1 problem which does worries me a little: when I shake it a little
 you can tell there is a screw loose inside. this is a potential cause of a short circuit. But because once is set
in place I don't move it anymore it doesn't worry me as much. Tripp Lite 3 Outlet Surge Protector Power Strip with
Desk Clamp, 10ft. Cord, 510 Joules, 2 USB Charging Ports, Black, $20K Insurance & (TLP310USBC)

2. parent_asin: B013FUZJ2U | Score: 0.1578
   Review (raw): Very Handy! Very handy to have these adapters! EXMAX® 17 in 1 Kit 1/4" 3/8" Threaded Male Female S
crew Adapter D Shaft D-Ring Tripod Screw Hot Shoe Mount Compatible with Canon Nikon Camera Flash Light Stand Bracke
t Holder Monopod

3. parent_asin: B07L3TN59S | Score: 0.1465
   Review (raw): Lensball suction cup for tripod heads Exactly as pictured in description..<br /> Would be nice to
have a step up adapter for tripod  legs included.. as is you will have to use tripod head. Suction seems adequate w
ith original 80mm lensball.  Would prefer suction cup to be just a bit bigger for increased grip insurance Original
 Lensball Stand | Suction Mount + Flat Base + Tripod Screw Thread
```

d. Step 4 – Semantic Retrieval (Transformer Embeddings)

Run:

```
python "2. retrieval/semantic_retrieval.py" ^
  --data "data/processed/reviews_clean.csv" ^
  --query "phone adapter screw problem" ^
  --topk 5 ^
  --model "all-MiniLM-L6-v2"
```

Sample terminal output:

```
================ QUERY RESULTS ================
Query: phone adapter screw problem
------ Semantic (SentenceTransformer) Top Results ------
1. parent_asin: B006C13X4Q | Score: 0.6141
   Review (raw): wont work with adapter I bought this as a cute gag gift for my dad for Christmas. He doesn't have
an iPhone so I bought an adapter to use with it and it didn't work for him AT ALL! It was so upsetting on Christmas
 day. It did however work on the iPhone, just not on his with an adapter. SANOXY Retro Cell Phone Handset

2. parent_asin: B07P94PB7Z | Score: 0.5454
   Review (raw): Adaptor VERY poorly constructed This adaptor simply does not fit an iPhone.  Period.  It is not us
eable.  The plug that fits into the iphone is too small so it is loose when inserted into the iphone and falls righ
t out.  I am baffled that such a poor device would be sold by Amazon.  All I can do now is throw it away.  It is an
 absolute waste of money. USB 3 Camera Adapter,3 in 1 USB Female OTG Adapter with Charging and 3.5mm Headphone Audi
o Jack Splitter for iPhone/iPad,Support USB Flash Drive,MIDI Keyboard

3. parent_asin: B078SQWBDY | Score: 0.5348
   Review (raw): Adapter fell apart The Adapter broke and fell right off in my computer I was so luck I could pull
it out. I was able to return for a full credit IPEAK USB C to USB Adapter with Keychain 4Pack, Type C Male to USB A
 Female OTG Connector for MacBook Pro 2017/2016 15&13inch MacBook 12inch Samsung Galaxy S9 S8 A8 Plus Note 8 Chrome
Book Pixelbook
```

e. Step 5 – Quantitative Evaluation of Models

Prepare a gold_set.csv file such as:

query	*parent_asin*	*relevance*
bluetooth disconnecting	B001234ABC	1
bluetooth disconnecting	B00XYZ567	0

Run:

```
python "3. evaluation/retrieval_evaluation.py" ^
  --data "data/processed/reviews_clean.csv" ^
  --gold "data/groundtruth/gold_set.csv" ^
  --topk 5 ^
  --embeddings "data/processed/review_embeddings.pkl"
```

Output → data/processed/reviews_clean.csv

Sample terminal output:

```
=== SUMMARY RESULTS (avg across queries) ===
bm25_p@k     0.400000
bm25_r@k     0.139125
bm25_map     0.149821
tfidf_p@k    0.100000
tfidf_r@k    0.029380
tfidf_map    0.050740
sem_p@k      0.600000
sem_r@k      0.313692
sem_map      0.295665
dtype: float64

Detailed results saved → data/groundtruth/retrieval_evaluation_results.csv
```

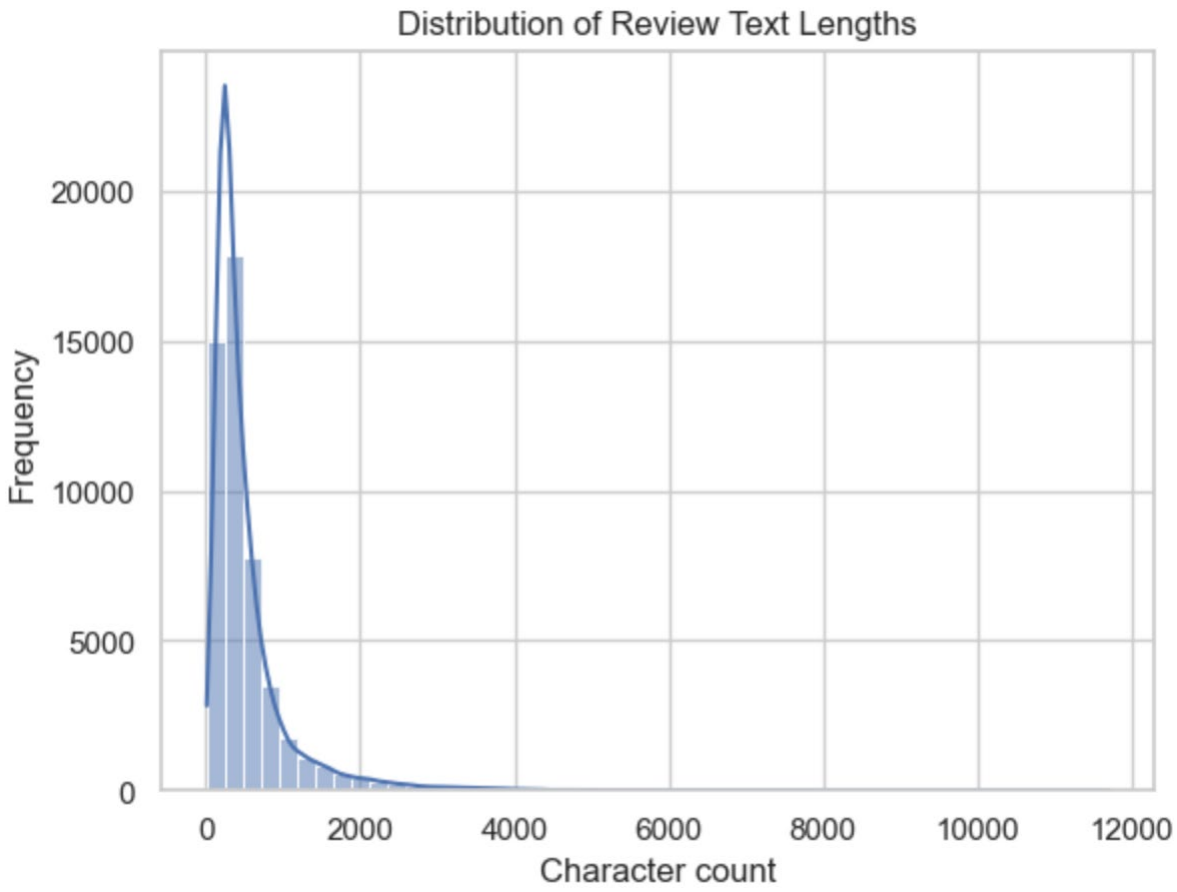
9. Data Exploration

a. Sample Data

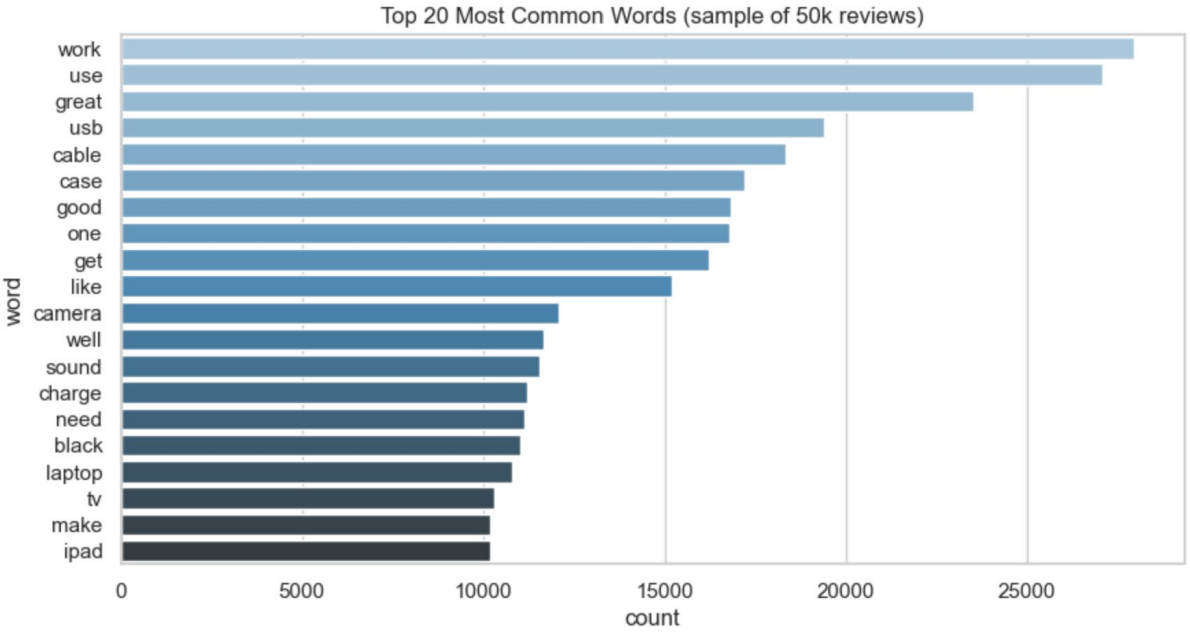
Raw texts before cleansing and after cleansing (stop-words removal and lemmatization).

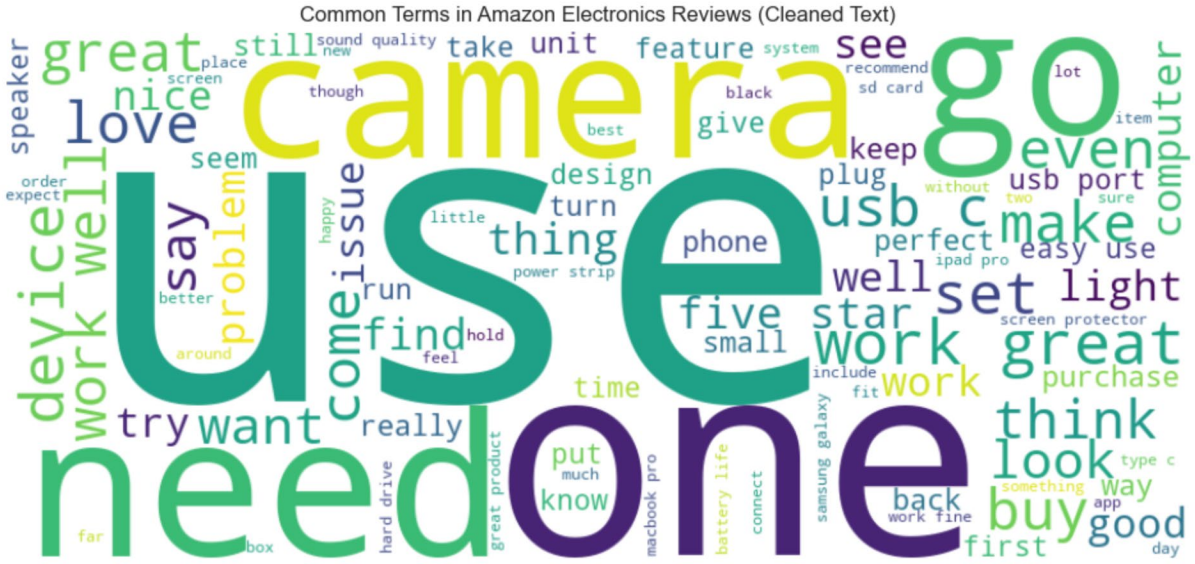
	parent_asin	review_text	clean_text
0	B083NRGZMM	Smells like gasoline! Going back! First & most offensive: they reek of gasoline so if you are sensitive/allergic to petroleum products like I am you will want to pass on these. Second: the phone ...	smell like gasoline go back first offensive reek gasoline sensitive allergic petroleum products like want pass second phone adapter useless mine drill far enough able tighten place iphone 12 max s...
1	B07N69T6TM	Didn't work at all lenses loose/broken. These didn't work. Idk if they were damaged in shipping or what, but the lenses were loose or something. I could see half a lens with its edge in the frame ...	work lenses loose break work idk damage ship lenses loose something could see half lens edge frame rest miss look like come loose break toy 4 5 year old boys mom myaboys 8 x 21 kid binoculars chil...
2	B01G8JO5F2	Excellent! I love these. They even come with a carry case and several sizes of ear bud inserts. Thank heaven! I get ear pain from most, but the smallest buds fit great. They also have a charger ...	excellent love even come carry case several size ear bud insert thank heaven get ear pain smallest bud fit great also charger fit carry case wish come color preferably something bright leave night...

b. Review Text Lengths



c. Word Frequency





d. Vocabulary Size and Average Token Length

Estimated vocabulary size: 37,756

Average tokens per review: 57.13

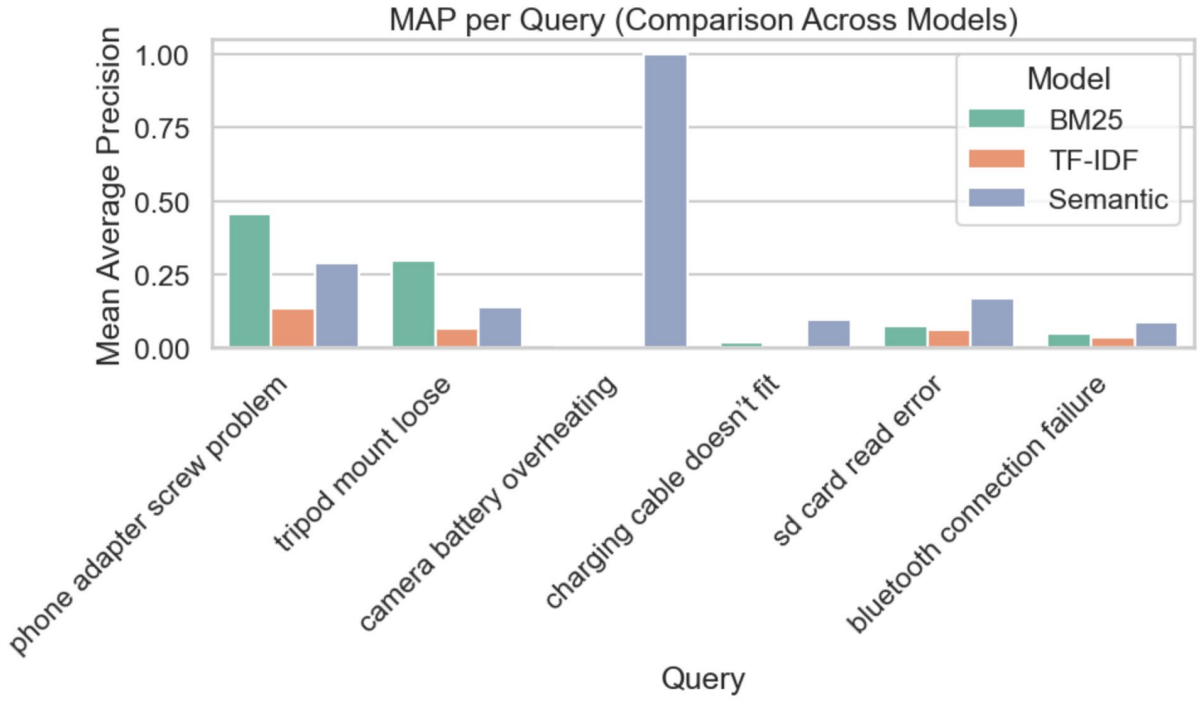
10. Evaluation

a. Model Comparison, Per Query

Precision@k, Recall@k, and Mean Average Precision (MAP)

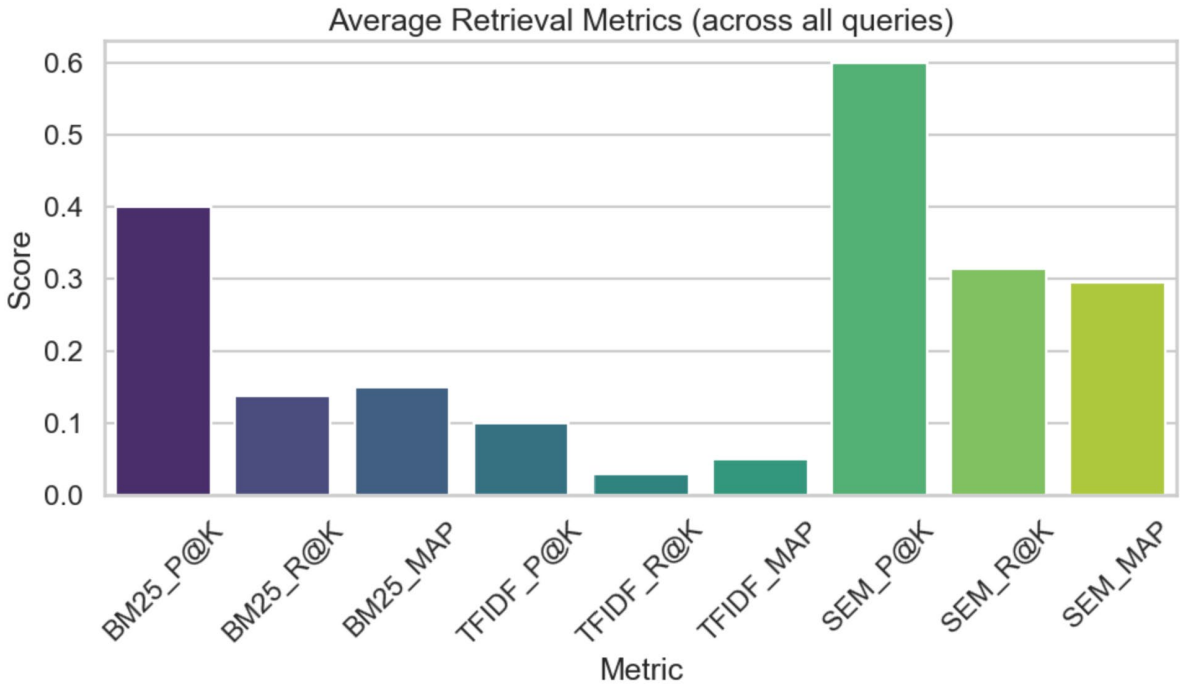
k=5

	query	bm25_p@k	bm25_r@k	bm25_map	tfidf_p@k	tfidf_r@k	tfidf_map	sem_p@k	sem_r@k	sem_map
0	phone adapter screw problem	0.6	0.375000	0.455508	0.2	0.125000	0.134777	0.6	0.375000	0.286438
1	tripod mount loose	0.6	0.300000	0.298225	0.0	0.000000	0.066863	0.4	0.200000	0.137864
2	camera battery overheating	0.0	0.000000	0.005475	0.0	0.000000	0.001235	0.4	1.000000	1.000000
3	charging cable doesn't fit	0.2	0.071429	0.018627	0.0	0.000000	0.004722	0.4	0.142857	0.093789
4	sd card read error	0.4	0.051282	0.073810	0.4	0.051282	0.062155	0.8	0.102564	0.169439
5	bluetooth connection failure	0.6	0.037037	0.047279	0.0	0.000000	0.034688	1.0	0.061728	0.086461

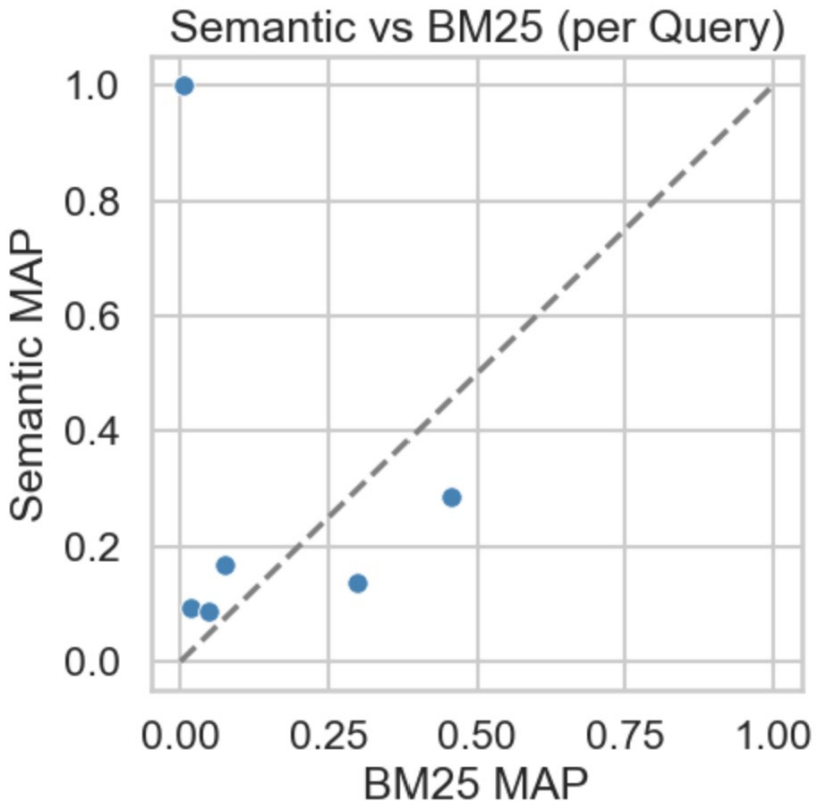


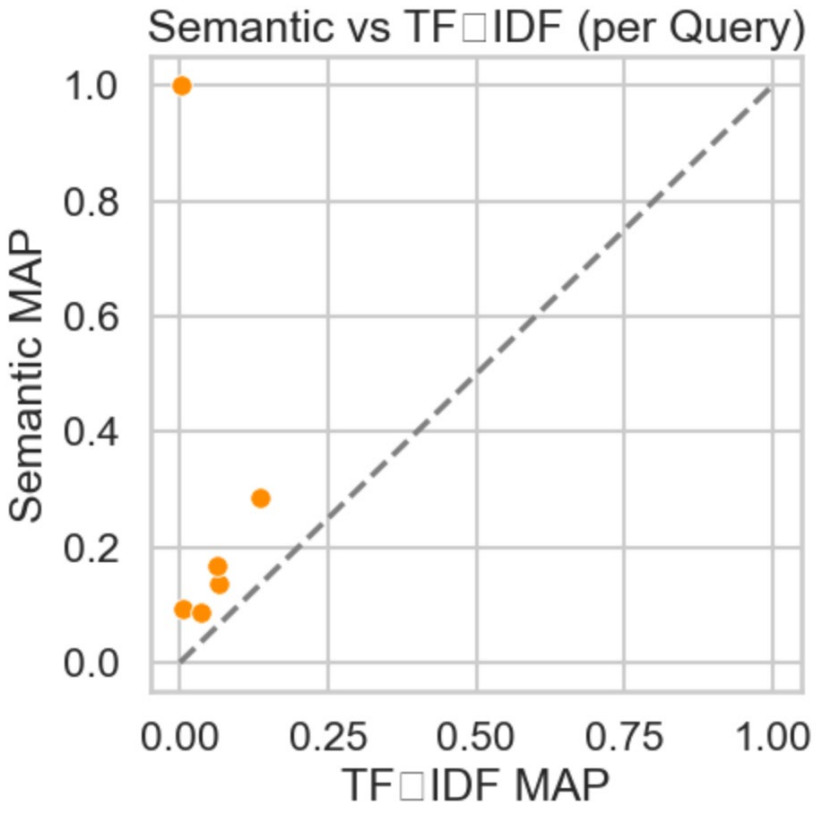
b. Model Comparison, Across All Queries

	Metric	Score
0	BM25_P@K	0.400000
1	BM25_R@K	0.139125
2	BM25_MAP	0.149821
3	TFIDF_P@K	0.100000
4	TFIDF_R@K	0.029380
5	TFIDF_MAP	0.050740
6	SEM_P@K	0.600000
7	SEM_R@K	0.313692
8	SEM_MAP	0.295665



c. Pairwise Scatter (Semantic vs BM25, TF-IDF)





11. Technologies

Python Version: 3.13 (or later). Refer to requirements.txt for version of each package.

Library	*Role*
pandas, numpy	Data manipulation, math operations
nltk	Tokenization, stopword lists, lemmatization
rank-bm25	BM25 ranking algorithm
scikit-learn	TF-IDF vectorization, cosine similarity, metrics
sentence-transformers	Transformer-based sentence embeddings
torch	GPU support for embedding computation
tqdm	Iteration progress monitoring
matplotlib, seaborn, wordcloud	Visualization support
faiss-cpu (optional)	Fast nearest-neighbor search for large embedding sets