

# **INFORMATION RETRIEVAL**

## **Assignment -2 Report**

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**Multimodal Retrieval System**

### **Problem Statement:**

To build a Multimodal Retrieval System that suggests images and reviews text for Text and Images as Input Data.

### **1) Abstract:**

This report presents a comprehensive analysis of image and text similarity within a product review dataset. The study employs techniques such as image feature extraction using a pre-trained ResNet50 model, manual TF-IDF calculation for text preprocessing, and cosine similarity for similarity comparison. The analysis aims to identify relationships between images and textual reviews, offering insights into potential retrieval strategies for related content.

### **2) Introduction:**

In the modern digital landscape, understanding the relationship between images and text is crucial for various applications such as content recommendation, search optimization, and user engagement. Product reviews often contain both textual descriptions and accompanying images, providing rich sources of information for analysis. This report investigates the similarity between images and text within product reviews, aiming to uncover patterns and connections that can enhance content retrieval and recommendation systems. By leveraging techniques in image feature extraction and text processing, the analysis seeks to provide actionable insights into effective retrieval strategies for related content.

### **3) Data Preprocessing:**

Data preprocessing plays a pivotal role in preparing the dataset for subsequent analysis.

## **1) Image Preprocessing:**

Data Loading and Expansion: The code loads the dataset from the CSV file (A2\_Data.csv) and expands rows to handle multiple image links associated with each review.

Image Feature Extraction: Utilizes a pre-trained ResNet-50 model to extract features from images. Preprocessing steps such as resizing and normalization are applied to images before feature extraction.

## **2) Text Preprocessing:**

Text Cleaning: The code preprocesses textual content by removing noise such as URLs, hashtags, and mentions.

Tokenization: Text is tokenized into individual words.

Normalization: Words are converted to lowercase to ensure consistency.

Stopwords Removal: Common stopwords are removed to focus on meaningful content.

Stemming and Lemmatization: Words are reduced to their base forms to simplify analysis and improve accuracy.

## **2) Feature Extraction:**

### **1) Image Features:**

Extract Image Features: Utilizes a pre-trained ResNet-50 model to extract high-level features from images.

Normalization: Normalizes extracted image features to ensure consistency and facilitate comparison.

### **2) Text Features:**

Manual TF-IDF Calculation: Computes TF-IDF scores manually for the preprocessed text data.

TF-IDF Calculation: Term frequency-inverse document frequency (TF-IDF) scores are calculated to represent the importance of terms in reviews relative to the entire corpus.

## 4) Retrieval Strategies:

### 1) Image Retrieval:

Cosine Similarity Calculation: Calculates cosine similarity between extracted image features to identify similar images.

### 2) Text Retrieval:

Cosine Similarity Calculation: Computes cosine similarity between TF-IDF scores of textual content to identify similar reviews.

### 3) Combined Retrieval:

Composite Similarity Calculation: Combines cosine similarity scores from both image and text features to generate composite similarity scores.

Ranking: Sorts the results based on composite similarity scores to identify top similar images, reviews, and composite scores representing combined image-text similarity.

## 6) Results and Analysis:

The results of the analysis showcase the effectiveness of the proposed approach in identifying similarities between images and text within product reviews. Top similar images, reviews, and composite scores are presented, along with associated cosine similarity scores. The analysis provides actionable insights into potential retrieval strategies, highlighting the importance of considering both image and text content for content recommendation and user engagement.

## Why ResNet-50 for Image Feature Extraction?

ResNet-50 Architecture: ResNet-50 is a deep convolutional neural network (CNN) architecture renowned for its effectiveness in image recognition tasks. It consists of 50 layers, including residual blocks, which alleviate the vanishing gradient problem, enabling deeper networks to be trained effectively.

Pre-trained Model: ResNet-50 is pre-trained on the large-scale ImageNet dataset, which contains millions of images across thousands of categories. Pre-training allows the model to learn generic features from diverse images, making it suitable for transfer learning.

High-Level Features: ResNet-50 captures high-level features such as shapes, textures, and patterns, which are essential for understanding the content of images. These features enable the model to represent images in a semantically meaningful manner, facilitating tasks like similarity comparison and content retrieval.

Efficiency and Performance: ResNet-50 strikes a balance between model complexity and performance, making it suitable for a wide range of computer vision tasks. Its architecture allows for efficient feature extraction while achieving state-of-the-art performance on various benchmarks.

## How TF-IDF is Calculated in Code?

Term Frequency-Inverse Document Frequency (TF-IDF): TF-IDF is a statistical measure used to evaluate the importance of a term within a document relative to a collection of documents. It consists of two components:

Term Frequency (TF): Measures the frequency of a term within a document. It is calculated by dividing the number of occurrences of a term by the total number of terms in the document.

Inverse Document Frequency (IDF): Measures the rarity of a term across the entire collection of documents. It is calculated as the logarithm of the total number of documents divided by the number of documents containing the term.

Manual Calculation: The code manually computes TF-IDF scores for the preprocessed text data. It first calculates term frequencies (TF) for each term in each document. Then, it determines the document frequency (DF) for each term across the entire corpus. Finally, it computes IDF scores using the formula  $\text{idf} = \text{math.log}(\text{len}(\text{tokenized\_texts}) / \text{freq})$ , where `freq` represents the document frequency of the term.

TF-IDF Scores: The TF-IDF scores represent the importance of terms within individual documents relative to the entire corpus. These scores are utilized for text retrieval and similarity comparison, enabling the identification of related textual content based on term frequencies and document frequencies.

# Screenshot

	ID	Image \
0	3452	<a href="https://images-na.ssl-images-amazon.com/images...">https://images-na.ssl-images-amazon.com/images...</a>
1	1205	<a href="https://images-na.ssl-images-amazon.com/images...">https://images-na.ssl-images-amazon.com/images...</a>
2	1205	<a href="https://images-na.ssl-images-amazon.com/images...">https://images-na.ssl-images-amazon.com/images...</a>
3	1205	<a href="https://images-na.ssl-images-amazon.com/images...">https://images-na.ssl-images-amazon.com/images...</a>
4	1708	<a href="https://images-na.ssl-images-amazon.com/images...">https://images-na.ssl-images-amazon.com/images...</a>
...	...	...
1635	1882	<a href="https://images-na.ssl-images-amazon.com/images...">https://images-na.ssl-images-amazon.com/images...</a>
1636	1547	<a href="https://images-na.ssl-images-amazon.com/images...">https://images-na.ssl-images-amazon.com/images...</a>
1637	1547	<a href="https://images-na.ssl-images-amazon.com/images...">https://images-na.ssl-images-amazon.com/images...</a>
1638	1004	<a href="https://images-na.ssl-images-amazon.com/images...">https://images-na.ssl-images-amazon.com/images...</a>
1639	1306	<a href="https://images-na.ssl-images-amazon.com/images...">https://images-na.ssl-images-amazon.com/images...</a>

  

	Review Text \
0	Loving these vintage springs on my vintage str...
1	Works great as a guitar bench mat. Not rugged ...
2	Works great as a guitar bench mat. Not rugged ...
3	Works great as a guitar bench mat. Not rugged ...
4	We use these for everything from our acoustic ...
...	...
1635	This is a great stereo reverb with plenty of c...
1636	I really like the simplicity of this bridge. I...
1637	I really like the simplicity of this bridge. I...
1638	Great Product, but there is no warranty in the...
1639	This product is good and is used in profession...

  

	Image features
0	[1.371263, -1.0438677, -0.7493192, -1.3473889,...
1	[-3.1160443, -1.976818, -0.43816474, -1.253221...

## Tf-idf

```
In [7]: tf_idf_pd
```

Out[7]:	love	vintag	spring	strat	good	tension	great	stabil	float	bridg	...	yngwie	neoclass	john	mayer	importanti	tonej
0	0.129524	0.520793	0.727539	0.200533	0.100905	0.327836	0.076447	0.333637	0.339991	0.223960	...	0.0	0.0	0.0	0.0	0.0	0.000
1	0.000000	0.000000	0.000000	0.000000	0.065808	0.000000	0.049857	0.000000	0.000000	0.000000	...	0.0	0.0	0.0	0.0	0.0	0.000
2	0.000000	0.000000	0.000000	0.000000	0.065808	0.000000	0.049857	0.000000	0.000000	0.000000	...	0.0	0.0	0.0	0.0	0.0	0.000
3	0.000000	0.000000	0.000000	0.000000	0.065808	0.000000	0.049857	0.000000	0.000000	0.000000	...	0.0	0.0	0.0	0.0	0.0	0.000
4	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	...	0.0	0.0	0.0	0.0	0.0	0.000
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1635	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.156368	0.000000	0.000000	0.000000	...	0.0	0.0	0.0	0.0	0.0	0.334
1636	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.131741	...	0.0	0.0	0.0	0.0	0.0	0.000
1637	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.131741	...	0.0	0.0	0.0	0.0	0.0	0.000
1638	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.099713	0.000000	0.000000	0.000000	...	0.0	0.0	0.0	0.0	0.0	0.000
1639	0.000000	0.000000	0.000000	0.000000	0.151357	0.000000	0.000000	0.000000	0.000000	0.000000	...	0.0	0.0	0.0	0.0	0.0	0.000

```
Enter image URL (or press Enter to finish): https://images-na.ssl-images-amazon.com/images/I/71bztfdqdg+L.\_SY88.jpg
REVIEW: I have been using Fender locking tuners for about five years on various strats and teles. Definitely helps with tuning stability and way faster to restring if there is a break.
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Top 3 similar images:
1. Image URL: https://images-na.ssl-images-amazon.com/images/I/71bztfdqdg+L.\_SY88.jpg
Review: I have been using Fender locking tuners for about five years on various strats and teles. Definitely helps with tuning stability and way faster to restring if there is a break.
Cosine score image: 1.0000001192092896
Cosine score text: 0.07903665389491232
Cosine score composite: 0.5395183865521009

2. Image URL: https://images-na.ssl-images-amazon.com/images/I/719-SDMi0oL.\_SY88.jpg
Review: These locking tuners look great and keep tune. Good quality materials and construction. Excellent upgrade to any guitar. I had to drill additional holes for installation. If your neck already comes with pre-drilled holes, then they should drop right in, otherwise you will need to buy a guitar tuner pin drill jig, also available from Amazon.
Cosine score image: 0.9115102291107178
Cosine score text: 0.12994053496072275
```

Top 3 similar reviews:

1. Image URL: [https://images-na.ssl-images-amazon.com/images/I/71Md5ihUFLl.\\_SY88.jpg](https://images-na.ssl-images-amazon.com/images/I/71Md5ihUFLl._SY88.jpg)

Review: We use these for everything from our acoustic bass down to our ukuleles. I know there is a smaller model available for ukules, violins, etc.; we haven't yet ordered those, but these will work on smaller instruments if one doesn't extend the feet to their maximum width. They're gentle on the instruments, and the grippy material keeps them secure.

The greatest benefit has been when writing music at the computer and needing to set a guitar down to use the keyboard/mouse - just easier for me than a hanging stand.

We have several and gave one to a friend for Christmas as well. I've used mine on stage, and it folds up small enough to fit right in my gig bag.

Cosine score image: 0.6928731799125671

Cosine score text: 0.23185982835968613

Cosine score composite: 0.4623665041361266

Top 3 similar composites:

1. Image URL: [https://images-na.ssl-images-amazon.com/images/I/71bztfdg+L.\\_SY88.jpg](https://images-na.ssl-images-amazon.com/images/I/71bztfdg+L._SY88.jpg)

Review: I have been using Fender locking tuners for about five years on various strats and teles. Definitely helps with tuning stability and way faster to restring if there is a break.

Cosine score image: 1.0000001192092896

Cosine score text: 0.07903665389491232

Cosine score composite: 0.5395183865521009

2. Image URL: [https://images-na.ssl-images-amazon.com/images/I/719-SDMiOoL.\\_SY88.jpg](https://images-na.ssl-images-amazon.com/images/I/719-SDMiOoL._SY88.jpg)

Review: These locking tuners look great and keep tune. Good quality materials and construction. Excellent upgrade to any guitar. I had to drill additional holes for installation. If your neck already comes with pre-drilled holes, then they should drop right in, otherwise you will need to buy a guitar tuner pin drill jig, also available from Amazon.

Cosine score image: 0.9115102291107178

Cosine score text: 0.12994053496072275

Cosine score composite: 0.5207253820357203