CSE508 Information Retrieval

Winter 2024

Assignment-2

Konam Akhil Vamshi

2020513

Approach and methodology:

Image Feature Extraction:

- Utilized the provided dataset to download images using the URLs provided. The following preprocessing steps were applied:
    - Random horizontal flipping.
    - Random rotation with a probability of 0.1.
    - Random contrast adjustment by a factor of 0.1.
- The images were then resized and underwent feature extraction, followed by normalization using ResNet50. A batch dimension was added, and the extracted image features were saved to text files.

Text Feature Extraction:

- The review column of the dataset underwent the following preprocessing steps:
    - Lowercase the text.
    - Tokenization.
    - Removal of stopwords.
    - Removal of punctuations.
    - Stemming and Lemmatization.
- SpaCy was favoured over NLTK for preprocessing due to its robustness and broader set of stopwords. TF-IDF features were calculated from scratch and saved as pickle files.

Image Retrieval, Text Retrieval and Combined Retrieval

Data Loading and Processing:

- Load input data from CSV files containing image URLs, reviews, and associated features.
- Preprocess the data to extract necessary information.

Similarity Calculation:

- Compute cosine similarity between input features (text or image) and features of other entries in the dataset.
- Utilize TF-IDF scores for text similarity and extracted image features for image similarity.

Saving Results:

- Save the calculated similarity metrics using Python's pickle module for later retrieval and analysis.

Composite Score Calculation:

- Calculate composite similarity scores by averaging similarity scores from both text and image retrieval.

Results Display:

- Display top similar images and reviews based on cosine similarity scores.
- Output composite similarity scores for images, text, and final composite scores.

Combined Retrieval:

- Combine results from text and image retrieval methods.
- Rank the pairs based on the composite similarity score.

Assumptions and Consideration:

I have observed Images from 6 IDs as not found, so the total size of the dataset became 994 from 1000

When retrieving similar items, I have not considered retrieving from the same ID. For ID 1, if there are two image URLs, a and b, and we are finding similar to a, I am excluding b in the search as they belong to the same ID.

I have retrieved the top 3 pairs for a given retrieval system, whether they are text or images. Considering that for each pair, we calculate cosine similarities for both text and images,

Defined the composite score for images in the retrieval system as follows:

- **Composite score**
  Composite score = (Cosine similarity score of Image+ Cosine similarity score of Text0/2
- **Top 3 pairs**
  Ranked top 3 pairs among 6 pairs by taking their composite scores.

Results and Analysis:

Input:

—----------

input_image_url = "https://images-na.ssl-images-amazon.com/images/I/71bztfqdg+L._SY88.jpg"
input_review_text = "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."

Output:

—----------

USING IMAGE RETRIEVAL
1) Image URL:
['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 additions 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 similarity of images: 0.7491
Cosine similarity of text: 0.1401
Composite similarity score: 0.4446

2) Image URL:
['https://images-na.ssl-images-amazon.com/images/I/711kGbkdzEL._SY88.jpg']
Review: Had to drill into my headstock. Needs 2 holes per tree because of the mounting peg. Use a ruler and a 1/16 drillbit and you'll be fine. I recommend installing with the strings on so you can set them properly.
Cosine similarity of images: 0.7042
Cosine similarity of text: 0.0000
Composite similarity score: 0.3521

3) Image URL:
['https://images-na.ssl-images-amazon.com/images/I/61WsGzCckEL._SY88.jpg']
Review: Can't say they look exactly like what's in the picture, especially since they don't have that gold ring around the center. However they're still perfectly usable, cheap, and still look neat on the guitar
Cosine similarity of images: 0.6482
Cosine similarity of text: 0.0000

Composite similarity score: 0.3241

—----------

USING TEXT RETRIEVAL

1) Image URL:

['https://images-na.ssl-images-amazon.com/images/I/61DvLcapd8L._SY88.jpg']

Review: I went from fender chrome non-locking to fender gold locking. It made my guitar look beautiful and play beautiful. I think locking tuners are the way to go. If you are new to locking tuners look on YouTube for instructions.

Cosine similarity of images: 0.5432

Cosine similarity of text: 0.2231

Composite similarity score: 0.3831

2) Image URL:

['https://images-na.ssl-images-amazon.com/images/I/51Mqwv4MnAL._SY88.jpg']

Review: I've had this tuner for about 4 years and it's been great. It tunes fine. For a long time the tuner just sat in my room, but recently I started taking the tuner around to practice and transporting it in my bag. Unfortunately one of the 3 plastic pieces where the gooseneck attaches to the tuner broke off. It still works but the head sometimes falls off of the tuner. Now I'm looking for a clip on tuner that is a little more durable. If anyone has any suggestions, please let me know.

I've added a photo that shows where one of the plastic pieces is missing (so you can see the joint)

Cosine similarity of images: 0.4433

Cosine similarity of text: 0.2143

Composite similarity score: 0.3288

3) Image URL:

['https://images-na.ssl-images-amazon.com/images/I/71mhnYAH5VL._SY88.jpg']

Review: My Tele is perfect, thank you very much.

Cosine similarity of images: 0.3923

Cosine similarity of text: 0.2050

Composite similarity score: 0.2987

—----------

TOP 3 COMBINED PAIRS BASED ON COMPOSITE SIMILARITY SCORE

1) Image URL:
['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 additions 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 similarity of images: 0.7491
Cosine similarity of text: 0.1401
Composite similarity score: 0.4446

2) Image URL:
['https://images-na.ssl-images-amazon.com/images/I/61DvLcapd8L._SY88.jpg']
Review: I went from fender chrome non-locking to fender gold locking. It made my guitar look beautiful and play beautiful. I think locking tuners are the way to go. If you are new to locking tuners look on YouTube for instructions.
Cosine similarity of images: 0.5432
Cosine similarity of text: 0.2231
Composite similarity score: 0.3831

3) Image URL:
['https://images-na.ssl-images-amazon.com/images/I/711kGbkdzEL._SY88.jpg']
Review: Had to drill into my headstock. Needs 2 holes per tree because of the mounting peg. Use a ruler and a 1/16 drillbit and you'll be fine. I recommend installing with the strings on so you can set them properly.
Cosine similarity of images: 0.7042
Cosine similarity of text: 0.0000
Composite similarity score: 0.3521

Observation on Retrieval Techniques and Reasoning

From the output provided, it's clear that the Image Retrieval system has a higher final composite similarity score compared to the Text Retrieval system. This suggests that, for this specific input, the image-based features were more effective in retrieving similar items than text-based features.

Reasoning:

- **Image Features**: The higher composite score for image retrieval could be attributed to the rich and multi-dimensional nature of image data captured by the feature extraction process. Images contain a vast array of information (colour, texture, shape, etc.) that can be effectively encoded into features using CNNs like ResNet50. This might lead to more distinctive and recognizable patterns for similarity comparison.
- **Text Features:** While still effective, text-based retrieval might face challenges due to the inherent sparsity of text data and the limitations of TF-IDF in capturing semantic meaning. TF-IDF weighs terms without understanding the context or the semantic relationships between words, which can sometimes lead to less accurate similarity measures, especially in nuanced or context-heavy textual content.

Challenges Faced and Potential Improvements
Challenges:

- **Variability in Data:** Both images and text can vary widely in quality and relevance. For images, differences in angles, lighting, and occlusions can affect feature extraction. For text, variability comes from the writing style, spelling errors, and jargon or slang.
- **Semantic Understanding:** While TF-IDF is useful for capturing the importance of words in documents, it lacks in capturing the deeper semantic meaning. Similarly, pre-trained CNNs might not always capture the nuances specific to the dataset's domain.
- **Scalability:** As the dataset grows, the computation of cosine similarities becomes more resource-intensive. Efficient indexing and retrieval become crucial.

Potential Improvements:

- **Advanced Feature Extraction:** Leveraging more advanced NLP techniques like word embeddings (Word2Vec, BERT) could improve the semantic understanding of texts. For images, fine-tuning the CNN with a small dataset specific to the task could improve relevance.

- **Dimensionality Reduction:** Techniques like PCA for images and SVD for text can reduce the feature space, making the computation more efficient without significantly compromising accuracy.
- **Hybrid Models**: Combining text and image features from the beginning and using machine learning models to learn the best features could provide a more integrated and accurate retrieval system.
- **Indexing Strategies:** Implementing efficient indexing strategies like KD-trees for images and inverted indices for text can significantly speed up retrieval.