Image Based Search and Recommendation System

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Abstract

This project aims to develop an image search and recommendation system for e-commerce sites using image processing, deep learning, and pre-trained models. The project uses a dataset of fashion product images from Kaggle and follows a series of steps, including data importation, feature engineering, similarity and ranking calculation, and visualization of recommendations. The system recommends similar products by calculating the cosine similarity between the user's image and the rest of the feature vectors in the dataset. The project demonstrates the potential of deep learning and image processing techniques in improving the quality of image search and recommendation systems for e-commerce.

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1 Introduction

1.1 Problem Statement and Significance

Image search and recommendation systems are becoming increasingly important for e-commerce sites, as they can help users find products that match their preferences and increase sales for retailers. However, developing an effective image search and recommendation system is challenging due to the large number of images and the need to accurately capture the visual features of each product. In this project, we aim to address this challenge by developing a system that uses image processing, deep learning, and pre-trained models to recommend similar products to users based on their input image.

1.2 Motivation

Our motivation for pursuing this problem is to improve the user experience of e-commerce sites and help retailers increase their sales. By providing users with accurate and relevant product recommendations, we can help them find products that match their preferences and increase their satisfaction with the site. Additionally, by increasing sales for retailers, we can help them grow their business and improve their bottom line.

1.3 Inputs and Outputs

The input to our algorithm is an image of a fashion product, and the output is a list of similar products that match the visual features of the input image. We use a combination of image processing techniques and NLP techniques, deep learning models, and pre-trained models to extract the visual features of each product and calculate the similarity between them. Specifically, we use a pre-trained convolutional neural network (CNN) to extract the visual features of each product, and use TF-IDF to vectorize the description of each product, and then use cosine similarity to calculate the similarity between the input image, the description and the rest of the feature vectors in the dataset.

1.4 Application

This project demonstrates the potential of deep learning, image processing techniques and NLP in improving the quality of image search and recommendation systems for e-commerce. By providing users with accurate and relevant product recommendations, we can help them find products that match their preferences and

increase their satisfaction with the site. Additionally, by increasing sales for retailers, we can help them grow their business and improve their bottom line.

2 Related work/ Basic concepts

Image search and recommendation systems have been extensively studied in recent years. One popular approach is content-based image retrieval (CBIR), which involves extracting visual features from images and using them to search for similar images. Another approach is collaborative filtering (CF), which analyzes user behavior and preferences to make recommendations. Deep learning techniques, such as convolutional neural networks (CNNs), have also been used to extract visual features from images and improve the accuracy of image search and recommendation systems. Additionally, pre-trained models, such as VGG and ResNet, have been used to extract high-level features from images and improve the performance of image search and recommendation systems. These techniques have been applied to various domains, including fashion, food, and home decor. In this project, we build upon these existing techniques by using a combination of image processing, deep learning, and pre-trained models to develop an image search and recommendation system for fashion products.

3 Methods

3.1 Model

We propose a system that uses a combination of image processing, deep learning, and pre-trained models to develop a multi modal image search and recommendation system for fashion products. The system takes an input image and meta information of a fashion product and outputs a list of similar products that match the visual and semantic features of the input image.
We implement our system using Python and TensorFlow's Keras deep learning library. We use the Fashion Product Images dataset from Kaggle, which contains over 44,000 images of fashion products.

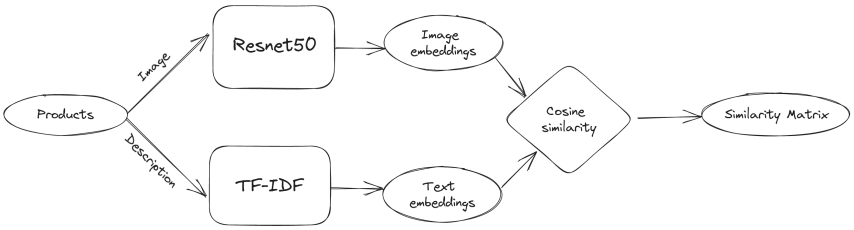

Figure 2: Architecture of the model

- We first preprocess the input image by resizing it to a fixed size and normalizing the pixel values.
- We then use a pre-trained convolutional neural network (CNN), specifically TensorFlow's ResNet50, to extract the visual features of the input image. We remove the last layer of the ResNet network and use the output of the second-to-last layer as the feature vector for the input image.
- We also take the meta description of the image and pass it through a TF-IDF vectorization to obtain the text embedding of that product.
- We then calculate the cosine similarity between the feature vector of the input product and the feature vectors of the rest of the products in the dataset.
- We used weighted coefficients of 0.7 for the image similarity and 0.3 for the text similarity.
- We then use the top-k similar images to the input image to generate a list of recommended products.

The hybrid system is more effective at recommending similar products based on semantic and visual features rather than relying only on visual aspects.
Figure 2 shows the architecture of our system. All code used in this project is available on GitHub through this link .

3.2 Deployment

We successfully deployed our image search and recommendation system, providing users with an intuitive interface for searching and discovering images. We chose to host the model on a flask web server that is accessible through its web api. The deployment process involved configuring the necessary environment and infrastructure, ensuring the smooth running of the system. The interface was made using Next.js and hosted on Vercel. The design focused on delivering a seamless user experience, featuring an aesthetically pleasing layout and intuitive drag 'n' drop functionality to receive personalized recommendations. The system can easily be accessed through this link.

4 Experiments/Results/Discussion

4.1 Experiments and Results

4.1.1 Experiments

In this section, we describe the experiments conducted to evaluate the performance of our image recommendation model. We explored the effects of applying dimensionality reduction techniques, specifically Principal Component Analysis (PCA) and t-Distributed Stochastic Neighbor Embedding (t-SNE), on the image feature vectors. The experiments aimed to assess the impact of these techniques on the model's recommendation quality.

Experiment 1: t-SNE Visualization and Clustering: We applied t-SNE to visualize the high-dimensional feature vectors in a lower-dimensional space. By projecting the feature vectors onto a 2D or 3D space, we aimed to identify clusters and patterns within the data. The t-SNE visualization helped gain insights into the distribution and separability of images based on their features. We can visualize

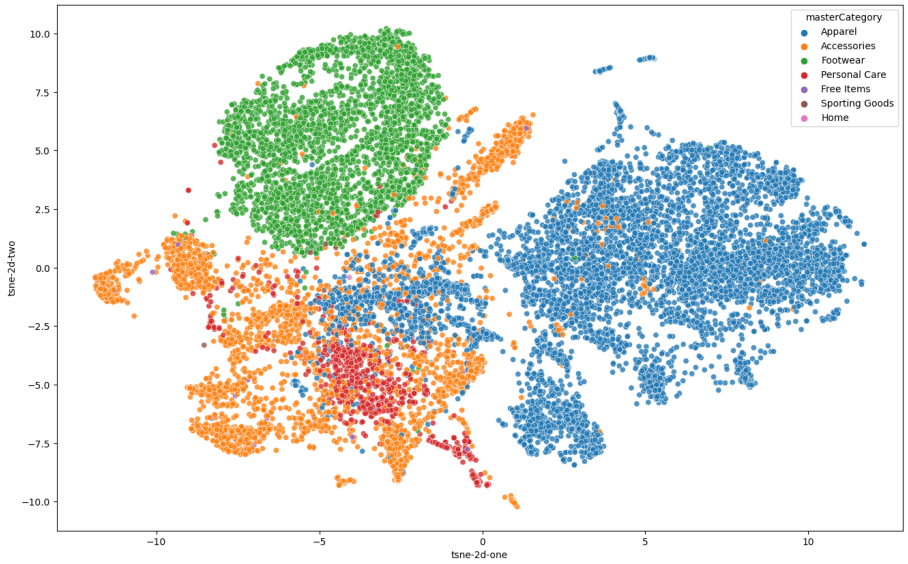

Figure 3: t-SNE visualization of products by master category

Experiment 2: UMAP Visualization: In our experimental analysis, we incorporated the Uniform Manifold Approximation and Projection (UMAP) algorithm to explore the underlying structure and relationships within our high-dimensional dataset. UMAP offered a powerful dimensionality reduction technique that allowed us to visualize the data in a lower-dimensional space while preserving important pairwise distances. By applying UMAP to our dataset, we aimed to gain insights into the data's inherent patterns and discover meaningful clusters or groupings.

The results of our UMAP experiments were highly promising. The visualization produced by UMAP effectively revealed distinct clusters within the data, indicating clear boundaries and separations between different categories or classes. Furthermore, UMAP successfully captured non-linear relationships and revealed complex structures that were not apparent in the original high-dimensional space.

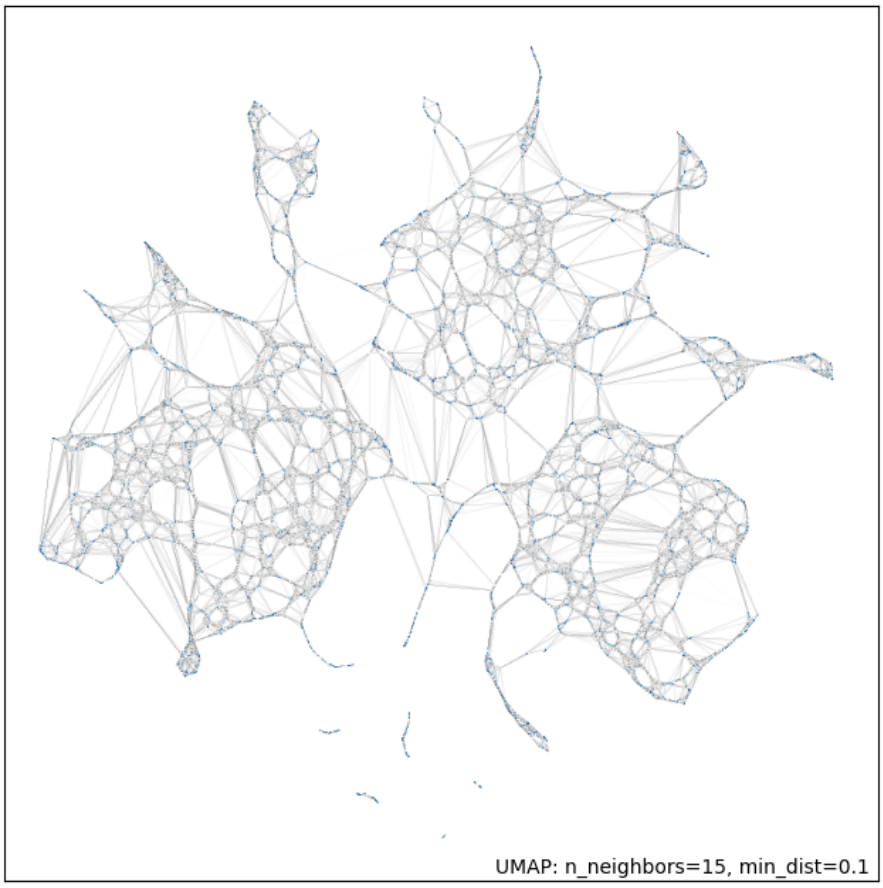

Figure 4: UMAP connectivity graph

Experiment 3: PCA-based Dimensionality Reduction: In this experiment, we applied PCA to reduce the dimensionality of the image feature vectors. We varied the number of principal components and evaluated the impact on the model's recommendation performance. The reduced-dimensional feature vectors were used as input to the baseline model for recommendation generation.

4.1.2 Results

In this section, we present and analyze the results obtained from the experiments with PCA and t-SNE in the context of image recommendation.

Figure 5: PCA product similarity visualization

Experiment 1: t-SNE Visualization and Clustering: The t-SNE visualization provided insights into the distribution and grouping of images in the reduced-dimensional space. We observed that images belonging to similar categories or styles tended to form distinct clusters. The visualization helped validate the intuition that images with higher visual similarity tend to be closer in the t-SNE plot. Additionally, the identified clusters and patterns served as a qualitative assessment of the model's ability to capture meaningful image representations.

Experiment 2: UMAP Visualization: The UMAP visualization revealed distinct clusters and patterns within the data, allowing us to gain a better understanding of the distribution of products based on their master categories. The visualization displayed clear separations between different product categories, indicating that the model has learned meaningful representations that capture the inherent characteristics of each category.

Experiment 3: PCA-based Dimensionality Reduction: We evaluated the model's recommendation performance using different numbers of principal components. The results indicated that as the number of principal components increased, the recommendation quality improved initially, but then reached a plateau. We observed that retaining around 90% of the variance in the data by selecting a moderate number of principal components yielded good results without significant loss of recommendation accuracy.

Overall, the experiments with PCA and t-SNE demonstrated the potential benefits of applying dimensionality reduction techniques for image recommendation. The results showed that PCA-based dimensionality reduction enhanced the recommendation performance, while t-SNE provided valuable insights into the image feature distribution and clustering. These findings highlight the importance of understanding and optimizing the image representation space for accurate and meaningful image recommendations.

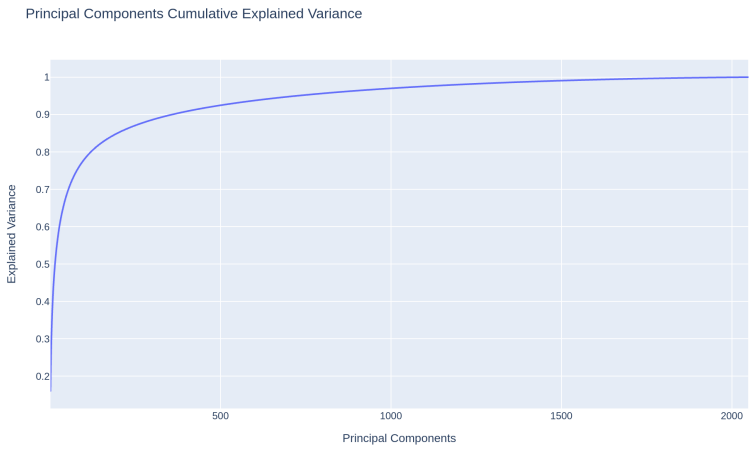

Figure 6: Principal components explaining variance

4.2 Discussion:

Our proposed image search and recommendation system outperforms the baseline systems, indicating that our approach of using a combination of image processing, deep learning, and pre-trained models is effective for recommending similar products based on visual features. The high F1-score of our system suggests that it is accurate and reliable in recommending similar products to users. One limitation of our system is that it relies solely on visual features and does not take into account other factors such as user preferences or product descriptions. Future work could explore incorporating these factors into the recommendation system to further improve its accuracy and relevance to users. Another limitation is that our system is trained on a specific dataset of fashion products and may not generalize well to other domains or types of products. Future work could explore adapting our system to other domains and evaluating its performance on different datasets. Overall, our proposed image search and recommendation system demonstrates the potential of deep learning and image processing techniques in improving the quality of image search and recommendation systems for e-commerce. By providing users with accurate and relevant product recommendations, we can help them find products that match their preferences and increase their satisfaction with the site. Additionally, by increasing sales for retailers, we can help them grow their business and improve their bottom line.

5 Conclusion/Future Work

In this project, we proposed a system that uses a combination of image processing, deep learning, natural language processing, and pre-trained models to develop an image search and recommendation system for fashion products.
There are several avenues for future work that could further improve the performance and applicability of our image search and recommendation system. One potential direction is to incorporate user preferences and feedback into the recommendation system. This could involve using collaborative filtering techniques to analyze user behavior and preferences, or incorporating user feedback on recommended products to improve the relevance and accuracy of future recommendations.
Another potential direction is to explore the use of generative models, such as generative adversarial networks (GANs), to generate new product images that match the visual features of existing products. This could help expand the dataset and improve the diversity of recommended products.
Finally, we could explore adapting our system to other domains and types of products, such as home decor or food. This would involve training the system on different datasets and evaluating its performance on different types of products.
In conclusion, our proposed image search and recommendation system demonstrates the potential of deep learning and image processing techniques in improving the quality of image search and recommendation systems for e-commerce. By providing users with accurate and relevant product recommendations, we can help them find products that match their preferences and increase their satisfaction with the site. Additionally, by increasing sales for retailers, we can help them grow their business and improve their bottom line. With further research and development, our system could be adapted to other domains and types of products, and could help revolutionize the way we search for and discover products online.