CA6005 2022-2023 Assignment 2
Image Search Engine

Code repository: https://github.com/thomas236/Image_Search_Engine

Web based interface url:
https://mybinder.org/v2/gh/thomas236/Image_Search_Engine/592e02e23df7378883667fd0070b4028d3c9bd3c?urlpath=lab%2Ftree%2FSebastian_21250103_CA6005_Assignment2.ipynb

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ABSTRACT

This report presents the implementation and evaluation of an image search engine as part of the Dublin City University MSc Computer Science (Artificial Intelligence) program, CA6005 Mechanics of Search Assignment 2. It discusses the implementation and evaluation to find the most similar images to a given query image using deep learning techniques. The InceptionV3 model is used to extract features from the images, and the cosine similarity is computed between the feature vectors to measure the similarity between the images. The code consists of several parts, including importing necessary libraries, downloading images, pre-processing the images, computing feature vectors, and finally displaying the top 5 similar images for each query image.

First, the necessary libraries are imported, such as TensorFlow for deep learning computations, NumPy for numerical operations, and matplotlib for data visualization. Additionally libraries are installed if they are not already present in the system, such as icrawler for downloading images and scikit-learn for computing cosine similarity.

Next, the code downloads images of 2 specific animals – “cats” and “porcupines” using the GoogleImageCrawler class from the icrawler library. The images are saved in a specified directory “query”, and the crawler is set up with the desired number of threads for feeding URLs, parsing HTML pages, and downloading the images.

After downloading the images, the InceptionV3 model is loaded, and a function is defined to preprocess the input images to make them compatible with the InceptionV3 model. Another function is defined to get the predicted labels for the input images, and the image surrogates are written to a CSV file.

The feature vectors for all the images in the "animals" directory are computed using the InceptionV3 model, and a function is defined to compute feature vectors for a list of images. The feature vectors for all the images in the "query" directory are also computed.

Finally, the cosine similarity matrix between the images in the "query" and "animals" directories is computed, and the top 5 similar images to each image in the "query" directory are displayed along with their similarity index.

INTRODUCTION

In recent years, image recognition and similarity search have become increasingly important in various fields, such as computer vision, pattern recognition, and multimedia retrieval. Deep learning has emerged as a promising technique for effectively and efficiently solving these problems, thanks to its ability to learn hierarchical feature representations from large-scale data. This report introduces a Python code that utilizes deep learning models, specifically the InceptionV3 model, for image recognition and similarity search tasks.

The code begins by importing necessary packages and libraries, including TensorFlow, which is a widely-used deep learning library [1]. It also imports other essential libraries such as NumPy for numerical computations, and Matplotlib for data visualization [2]. In addition, the code imports the cosine_similarity function from the sklearn.metrics.pairwise module to compute the similarity between image feature vectors [3].

To demonstrate the image recognition and similarity search capabilities of the InceptionV3 model, the code downloads images of various animals from Google using the GoogleImageCrawler class from the icrawler.builtin module. The images are then saved in a directory called "animals". The code also creates a separate directory, "query", to store the query images that will be used for similarity search tasks.

Next, the InceptionV3 model is loaded and used to pre-process the input images. The preprocess_img function resizes the input images to the required dimensions and pre-processes them to make them compatible with the InceptionV3 model. The get_labels function then computes the predicted labels for each input image using the model.

The code also computes feature vectors for all the images in both the "animals" and "query" directories using the compute_features function. These feature vectors will be used later for similarity search tasks.

Finally, the code computes the cosine similarity matrix between the images in the "query" and "animals" directories using the cosine_similarity function. The top 5 most similar images to each query image are then displayed along with their similarity indices.

In conclusion, the code demonstrates the effectiveness of the InceptionV3 model in performing image recognition and similarity search tasks. The use of deep learning models, such as InceptionV3, can significantly improve the performance of these tasks in various applications.

ANNOTATION

In this project, the primary objective is to find similar images from a dataset using the InceptionV3 model for feature extraction and cosine similarity for comparison. The code can be broken down into several segments for annotation:

Package installation and import [4][5][6][7]: The code begins with importing necessary packages, such as icrawler, tensorflow, matplotlib, and sklearn. If any package is not found, it gets installed using !pip install {package} command.

Downloading images [8]: The GoogleImageCrawler class from the icrawler.builtin module is used to download images from Google with specific queries, such as "cat" and "porcupine". The downloaded images are saved in the specified directory “query”

Downloading images for multiple directory names [9]: A function named download_images is defined to download images for multiple directory names (different animals). The function takes the directory name and number of images as input, deletes the existing directory, creates a new one, and sets up the GoogleImageCrawler to download the images. The function is then used in a loop to download images for various animal categories.

Moving files to a new directory [10]: After downloading images for each category, the code creates a new directory called "animals" and moves the downloaded images into this directory, renaming the files with leading zeros for proper ordering.

Removing non-PNG and non-JPG files [11]: The code removes any files that are not in PNG or JPG format from the "animals" directory so that it does not return an error when displaying them using matplotlib.

Loading InceptionV3 model and feature extraction [12][13]: The InceptionV3 model is loaded, and functions are defined to pre-process images and compute feature vectors. Feature vectors are computed for all images in the "animals" and "query" directories.

Cosine similarity calculation [14]: The cosine similarity between feature vectors of images in the "query" and "animals" directories is computed, and a similarity matrix is created. The top 5 similar images are then determined for each image in the "query" directory.

Displaying the results [15]: The code displays the query image alongside the top 5 similar images and their similarity indices using Matplotlib.

RETRIEVAL

In this project, retrieval process is performed by first computing feature vectors for query and reference images, and then calculating the similarity between these feature vectors using cosine similarity [13]. The top 5 most similar images for each query image are then displayed.

The code starts by importing necessary libraries and modules and checking for their installation [13]. It then downloads images from Google using the GoogleImageCrawler class from the icrawler.builtin module [14].

For the purpose of retrieval, a pre-trained InceptionV3 model is used to extract features from images [15]. The model is imported from the TensorFlow library and the input images are resized to the required dimensions. A function preprocess_img is defined to pre-process the input images so that they are compatible with the InceptionV3 model [16]. Another function, compute_features, is defined to compute feature vectors for a list of images using the pre-trained model [17].

Once the feature vectors for all the images in the "animals" directory and the "query" directory are computed, the cosine similarity between the feature vectors is calculated using the cosine_similarity function from the sklearn.metrics.pairwise module [18]. The similarity_matrix is created to store similarity values between query and reference images [19].

Finally, the top 5 most similar images for each query image are identified using the numpy.argsort function [20]. The query image

and the top 5 similar images are displayed using the matplotlib library [21].

EVALUATION

The evaluation process for the given code involves analyzing the performance of an image retrieval system that utilizes the InceptionV3 model [22]. The code begins with the installation and importing of necessary packages, such as icrawler, tensorflow, and matplotlib, along with scikit-learn for cosine similarity computations.

The GoogleImageCrawler class from the icrawler.builtin module is used to download images from Google [23]. The search queries are specified as "cat" and "porcupine," and each query downloads one image. The images are saved in a directory named "query."

In the next part of the code, more images are downloaded for a list of animals, which serve as reference images. These images are saved in separate directories for each animal. The code then consolidates all the images into a single directory named "animals."

The InceptionV3 model from the TensorFlow library is loaded [22]. This model is used to compute the feature vectors for both query and reference images [24]. The feature vectors are computed using the InceptionV3 model with the top layers removed, which allows for the extraction of visual features from the images.

The cosine similarity function from the scikit-learn library is used to compute the similarity between the query images and the reference images [25]. A similarity matrix is created to store the computed similarity values between each pair of images. The top five most similar images for each query image are identified using the numpy library [26].

Finally, the code displays the query image along with the top five most similar reference images and their similarity values using the matplotlib library [27]. This visualization helps to assess the performance of the image retrieval system.

WEB BASE INTERFACE AND URL

mybinder.org is a free, open-source platform that allows users to host, share, and execute Jupyter Notebooks in the cloud. This section discusses how mybinder.org is utilized to host a specific Jupyter Notebook, Sebastian_21250103_CA6005_Assignment2, and provides an overview of how it works, including the Dockerizing process.

The Notebook Sebastian_21250103_CA6005_Assignment2 is hosted on MyBinder.org using the following URL: https://mybinder.org/v2/gh/thomas236/Image_Search_Engine/592e02e23df7378883667fd0070b4028d3c9bd3c?urlpath=lab%2Ftree%2FSebastian_21250103_CA6005_Assignment2.ipynb

This URL contains several key elements:

'mybinder.org/v2/gh/' signifies that the platform is using the second version of MyBinder.org and is accessing a GitHub repository.

'thomas236/Image_Search_Engine' indicates the GitHub repository where the Jupyter Notebook is stored.

'592e02e23df7378883667fd0070b4028d3c9bd3c' is the specific commit hash, ensuring that the hosted notebook will always use the same version, even if the repository is updated.

'urlpath=lab%2Ftree%2FSebastian_21250103_CA6005_Assignment2.ipynb' specifies the path to the Jupyter Notebook within the repository.

MyBinder.org leverages cloud resources to create a custom computing environment for each Jupyter Notebook, using the repository's contents and associated configuration files. It is powered by BinderHub, which utilizes Kubernetes and Docker to create, manage, and scale the hosted Jupyter Notebooks.

The process can be summarized in the following steps:

a. Users provide a URL containing the repository and the specific Jupyter Notebook they wish to host.

b. BinderHub extracts the necessary information from the URL and fetches the associated GitHub repository.

c. BinderHub analyzes the repository's configuration files (e.g., 'requirements.txt', 'environment.yml') to determine the required dependencies and packages.

d. A Docker image is created based on the configuration files and the specified Jupyter Notebook.

e. The Docker image is deployed on a Kubernetes cluster, creating a unique, isolated environment for the Jupyter Notebook.

f. Users can access the hosted Jupyter Notebook through a web browser, and interact with the notebook as if it was running on their local machine.

Docker is a platform that allows developers to create, deploy, and run applications in containers. A container is a lightweight, portable, and self-sufficient unit that bundles an application along with its dependencies and environment settings. Dockerizing Jupyter Notebooks ensures that the hosted notebooks are reproducible and can run consistently across different platforms.

MyBinder.org uses Docker to create images of Jupyter Notebooks, based on the configuration files provided in the repository. The Docker images are then deployed on Kubernetes clusters, which manage the scaling and distribution of the hosted notebooks. This approach enables MyBinder.org to provide a seamless, interactive, and accessible environment for users to explore and work with Jupyter Notebooks in the cloud.

MyBinder.org is a powerful platform for hosting and sharing Jupyter Notebooks, enabling users to access and interact with them in a consistent and reproducible manner by leveraging Docker

CONCLUSION

This project demonstrates a powerful application of deep learning techniques, specifically using the InceptionV3 model, for image analysis and similarity detection. The code begins by importing necessary packages, such as TensorFlow, scikit-learn, and icrawler, installing them if they are not already present on the system. The images for analysis are downloaded from Google Images using the GoogleImageCrawler class from the icrawler.builtin module [28]. This code downloads images of cats and porcupines, as well as a list of other animals, and stores them in separate directories.

The InceptionV3 model from TensorFlow is then used to generate feature vectors for the images [29]. The model is pre-trained on a vast dataset and performs well in extracting meaningful features from images. The images are preprocessed, and their feature vectors are computed using the InceptionV3 model. These feature vectors are then used to compute a cosine similarity matrix between query and reference images [30]. Cosine similarity is a widely used metric for measuring the similarity between two vectors in the context of image analysis.

The results are visualized by displaying the top 5 most similar images for each query image, along with their similarity indices. This code serves as an excellent starting point for developers looking to implement image analysis tasks such as image classification, object recognition, or image retrieval. Below are 3 examples of the Image Search Engine for “porcupine” and 2 images of “cat”. The results show that the image search engine work with excellent accuracy retrieving the correct images from the dataset “animals”

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