A Systematic Review of Content-Based Image Retrieval Techniques

Niya Joseph
Department of CSE
Amal Jyothi College of Engineering
Kanjirappally
niyajoseph@amaljyothi.ac.in

Tintu Alphonsa Thomas
Department of CSE
Amal Jyothi College of Engineering
Kanjirappally
tintualphonsathomas@amaljyothi.ac.in

***Abstract*— The actual content of the image may be used as the basis for retrieval in content-based image retrieval. When compared to other strategies, CBIR is effective since the majority of search engines rely on metadata, such as keywords and other descriptions linked to the image, which would produce inaccurate results. Low level visual features are extracted in this place. Then, a feature vector is created by combining all of the extracted features. The research of various CBIR methods is presented in this work.**

Keywords—Content based image retrieval,feature extraction,similarity measure

I. INTRODUCTION

Content-based image retrieval (CBIR) is a technology that allows users to search for digital images in a database based on their visual content rather than text-based descriptions. CBIR systems use image features such as color, texture, shape, and spatial layout to analyze and compare images.[6]

In content based image retrieval, retrieving can be based on the actual content of the image. CBIR is efficient when compared to other techniques because most of the search engines rely on metadata such as keywords and other descriptions associated with the image that will produces garbage in the results. In a large database, it is not practical to the users for entering keywords for the images because it is inefficient and it may not capture every keyword that describes the image. A system that can filter images based on their contents would return more accurate results.[4]

Categorizing the picture is the key aspect of image management system. It is the human tendency to cluster the things based on their visual or salient features. This categorizing the picture is similar to human semantic processing which is used in the retrieval of what is salient to a particular category or categories. Therefore, it is essential for image management systems to have a system of categorization in order to narrow down the list of potential images in a way that is immediately meaningful to the human user.

Feature extraction is a special form of dimensionality reduction. When the input data to an algorithm is too large to be processed then the input data will be transformed into a reduced representation set of features (also named feature vector). Transforming the input data into the set of features is called feature extraction. If the features extracted are carefully chosen it is expected that the feature set will extract the relevant information from the input data in order to perform the desired task using this reduced representation instead of the full size input. Feature extraction involves simplifying the amount of resources required to describe a large set of data accurately.

II. TECHNIQUES USED IN CONTENT BASED IMAGE RETRIEVAL

A. Color-based retrieval

Color-based image retrieval is a common technique used in content-based image retrieval (CBIR) systems to retrieve images from a database based on their color features. The color of an image is one of the most important features for CBIR systems, as it is the most prominent feature perceived by human visual systems. The process of color-based image retrieval involves several steps, including image preprocessing, feature extraction, and image similarity computation. In the preprocessing step, the images are first converted to a suitable color space, such as RGB, HSV, or Lab, to represent the colors in a more intuitive and perceptually meaningful way.[2]

In the feature extraction step, various color features are extracted from the image, such as color histograms or color moments These features capture the statistical distribution of colors in the image, which can be used to represent the color content of the image as a feature vector.[5]

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in lighting and the inability to capture other important image features, such as texture and shape.

Overall, color-based image retrieval is a powerful technique for CBIR systems and has many applications in areas such as image search engines, medical image analysis, and art history.

B. Texture Based Image Retrieval

Texture-based image retrieval is a technique used in content-based image retrieval (CBIR) systems to retrieve images from a database based on their texture features. Texture is an important visual feature in images, which describes the spatial arrangement of visual patterns or details.

The process of texture-based image retrieval involves several steps, including image preprocessing, feature extraction, and image similarity computation. In the preprocessing step, the images are first segmented into regions of interest, which can be done using various techniques such as edge detection, thresholding, or region growing.

In the feature extraction step, various texture features are extracted from each segmented region, such as texture histograms, Gabor filters, or wavelet transforms. These features capture the statistical and structural properties of textures in the image, which can be used to represent the texture content of the image as a feature vector.

In the image similarity computation step, a distance metric, such as Euclidean distance or cosine similarity, is used to compare the feature vectors of the query image with those of the images in the database. The images with the closest feature vectors to the query image are then retrieved as the most similar images.

Texture-based image retrieval has several advantages, such as the ability to capture fine-grained details and the ability to handle images with complex textures. However, it also has some limitations, such as the sensitivity to variations in scale and rotation, and the computational complexity of some feature extraction techniques.

Overall, texture-based image retrieval is a powerful technique for CBIR systems and has many applications in areas such as image search engines, medical image analysis, and industrial inspection.

C. Shape Based Retrieval

Shape-based retrieval is a technique used in content-based image retrieval (CBIR) where the shape of objects in an image is used to match and retrieve similar images. The shape features can be extracted using techniques such as edge detection, boundary extraction, or shape descriptors.[2]

One popular method for shape-based retrieval is the use of shape descriptors. Shape descriptors are mathematical representations of the shape of an object in an image. There are various types of shape descriptors, such as Fourier descriptors, moment invariants, and curvature scale space descriptors. These shape descriptors are invariant to scale, rotation, and translation, which makes them robust to changes in the shape of the object in the image.

The shape features can be compared using various distance measures, such as Euclidean distance, Minkowski distance, or Hausdorff distance. The similarity between the shapes is calculated based on the distance measure, and the images with the most similar shapes are retrieved.

Shape-based retrieval can be used in various applications, such as medical imaging, where the shape of organs or tumors can be used to diagnose diseases or monitor their progression. It can also be used in object recognition and classification, where the shape of objects can be used to distinguish between different classes of objects.

D. Spatial Based Retrieval

Spatial-based retrieval is a technique used in content-based image retrieval (CBIR) systems to retrieve images from a database based on their spatial relationships. Spatial relationships refer to the arrangement or layout of objects or regions within an image.

The process of spatial-based retrieval involves several steps, including image preprocessing, feature extraction, and image similarity computation. In the preprocessing step, the images are first segmented into regions of interest, which can be done using various techniques such as edge detection, thresholding, or region growing.

In the feature extraction step, various spatial features are extracted from each segmented region, such as shape descriptors, object bounding boxes, or object orientations. These features capture the spatial relationships between objects or regions in the image, which can be used to represent the spatial content of the image as a feature vector.

In the image similarity computation step, a distance metric, such as Euclidean distance or cosine similarity, is used to compare the feature vectors of the query image with those of the images in the database. The images with the closest feature vectors to the query image are then retrieved as the most similar images.

rotation, and the computational complexity of some feature extraction techniques.

Overall, spatial-based retrieval is a powerful technique for CBIR systems and has many applications in areas such as image search engines, remote sensing, and industrial inspection.

E. Deep Learning Based Retrieval

Deep learning-based retrieval is a popular technique used in Content-Based Image Retrieval (CBIR). It involves using deep learning algorithms, such as Convolutional Neural Networks (CNNs), to extract meaningful features from images and use them to retrieve similar images from a database.

The process of deep learning-based retrieval in CBIR typically involves the following steps:

Data Preprocessing: Images are preprocessed to standardize their size, color, and format.

Feature Extraction: A deep learning model is used to extract features from the images. In the case of CBIR, CNNs are typically used to extract features that are invariant to changes in image scale, orientation, and lighting.

Indexing: The extracted features are stored in an index or database that allows for efficient querying and retrieval.

Querying: A user submits a query image, and the deep learning model extracts features from the query image. These features are then compared with the features stored in the index to find the most similar images.

Ranking: The retrieved images are ranked according to their similarity to the query image, and the top-ranked images are returned to the user.

Overall, deep learning-based retrieval in CBIR has shown to be an effective method for finding visually similar images in large databases.

III. PERFORMANCE ANALYSIS

Color-based Retrieval: This technique is based on the color histogram of an image. The performance of color-based retrieval depends on the color space used, the size of the histogram, and the similarity metric used. Generally, color-based retrieval performs well on datasets with distinct color palettes, but it may not perform well on datasets with similar color palettes.

Texture-based Retrieval:Texture-based retrieval techniques extract features that describe the texture patterns in an image. Texture-based retrieval performs well on datasets that contain images with similar texture patterns.

Shape-based Retrieval: Shape-based retrieval techniques extract features that describe the shape of an object in an image. These techniques are often used to retrieve images of specific objects or scenes. Shape-based retrieval may not perform well on datasets that contain images with complex shapes.

Deep Learning-based Retrieval: Deep learning-based retrieval techniques use convolutional neural networks (CNNs) to extract features from images. These techniques have shown to perform well on large and diverse datasets. However, they require large amounts of annotated training data and computational resources for training and inference.

Spatial-based retrieval can be a useful approach in CBIR, as it allows the system to consider the spatial relationships of visual features, which can help to identify more precise and accurate matches for a given query. Spatial-based retrieval can handle complex queries that involve multiple objects or regions of interest in the image.

IV. CONCLUSION

Content-based image retrieval techniques have proven to be a valuable tool in the field of image retrieval. These techniques allow users to search for images based on their visual content rather than relying on textual descriptions or tags. The success of content-based image retrieval techniques can be attributed to the advancements in computer vision and machine learning algorithms. Content-based image retrieval techniques have shown great promise in image analysis and retrieval applications, and they are likely to play an increasingly important role in the future as the need for effective image search and retrieval continues to grow.

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