Content-Based Image Retrieval Using Customized Convolutional Neural Network

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ABSTRACT

In today's world due to multimedia development, there is a huge image database. Content-Based Image retrieval (CBIR) is a widely used method for image retrieval from a large image database. Existing retrieval methods are based on the basic content of an image like color, Shape, and Texture. The system based on basic features requires more time for processing and provides less accuracy. To reduce time and improve accuracy we are proposing CBIR Using CNN in this paper. CNN is used for feature extraction and similarity measurement Hamming distance is used. In this technique, the user has to provide an image as an input query image. The similar images related to the query image are displayed as a result. The performances of a system are evaluated by precision and mean average precision (MAP). After comparing with existing methods, we found encouraging results that lead to improving accuracy.

KEY WORDS: CONTENT-BASED IMAGE RETRIEVAL, CNN, DNN, LSH.

INTRODUCTION

In this day and age, there is an expansion in the component of interactive media databases. It comprises information like image, sound, video, and so forth. The utilization of images in the area of medicinal, individual, news coverage makes a lot of image databases. In this manner, the Content-Based Image Retrieval system was created to manage huge image databases. Content-Based Image retrieval system restores a lot of images from a progression of images in the database to fulfill the user's need with closeness assessment. The CBIR framework has two fundamental stages in the primary stage: the pre-processing with feature extraction dependent on

attributes such as color, shape, and texture. In the second stage assessment of similarity between a query image and indexed images from the database is performed.

Figure 1: Basic CBIR System

The above figure explains the basic operation of the CBIR System. In the retrieval system, there are essentially three most important fields: text-based image retrieval, retrieval based on visual features, and semantic features. In a text-based image retrieval system images are provided through labels and for retrieval cause similarity of these labels are used. A predominant disadvantage of these types of structures is that a lot of human work evolved for image

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labeling and if the database of images in a massive quantity then it is pretty difficult. And labeling of images is no longer user friendly; it relies upon database creators labeling strategies. Then the visual-based image retrieval systems used for image retrieval purposes and low-level features are considered for feature extraction. The systems are based on visual features along with semantic features in use. The three most important features that exist in an image specifically are color, texture, and shape (Latif, A et. al. and Ganar, A.N et. al.). All the methods utilizing color, text, and shape features are time-consuming because for each feature we require to train the image database then compute the results. Hence CNN is used for feature extraction. Once the pre-training is done it will provide faster results.

2. Literature Survey

2.1 Neural Network: Neural Network is an interconnected network of neurons in which inputs are independent variables and output is dependent on the weighted inputs connected to neurons. The neural network consists of input values, weights, activation function, and output values (LeCun, Y). Generally, four activation functions are commonly used: Threshold function, Sigmoid function, Rectifier function, and Hyperbolic Tangent function. Depending on the application appropriate activation functions can be selected. The weights are estimated by using Gradient Descent and Back Propagation algorithm. The weighted inputs are applied to a neuron to get the output. And inside the neuron activation function is applied to the weighted sum of the inputs present. The output is determined by using initial weights that can be random or fixed. Finally, an error is calculated and a Backpropagation algorithm is applied to fine-tune the weights and reduce the error.

2.2 Convolutional Neural Network: The Convolutional Neural Network is a neural network having four steps. The first step is applying 2D convolution to the input image. 2D Convolution is a mathematical operation in which two matrices are used. For the application of CNN one matrix is an image and the other matrix is a feature detector. Generally, the Feature detector is a matrix of size 3x3 but size may change. In a convolution operation, when a feature detector is applied to an image, a matrix with different values from the original is obtained (Wu, J). In this step, the feature detector is applied to the input image which results in the generation of the feature map. For removing unwanted information in the feature map, the ReLU (Rectified Linear Unit) activation function is used (Kuo, C.C.J). In the second stage, the pooling operation is performed. Three types of pooling are used: max pooling, mean pooling, and sum pooling. Stage three consists of flattening, which generates a feature map. And in the last stage full connection is done. The softmax and cross-entropy are the two functions used for improving accuracy in CNN.

Figure 2: Basic Convolutional Neural Network

The above figure 2 shows Basic Convolutional Neural Network which is used for feature extraction. In this CNN, max-pooling, and ReLU are used. The input for this network is an image. The output is provided by a fully connected CNN network (Simonyan, K. and Zisserman, A).

3. Proposed Method

Figure 3: Proposed Method

Figure 3 provides the proposed method of data flow. The algorithm for the proposed method is explained below. Step 1: In an image database several images with different categories are present. Step 2: These images are fed to CNN for feature extraction. Step 3: For each image feature vector generated. Each vector consists of 1280 elements.

Step 4: Features are indexed in the database. Step 6: The user has to provide an input image considered as a query image. Step 7: Features of a query image extracted using CNN. Step 8: Using Hamming distance similarity between features of the query image matched with the index.

Step 9: Finally similar images are displayed.
Step 10: Repeat from step 6 for another input.

Performance Evaluation: The performance of the system was evaluated using two parameters Precision and Mean Average Precision (MAP). Precision is the ratio of the number of relevant images retrieved to the total number of images retrieved.

$$MAP = \sum_k^K \frac{Avg P(k)}{K} \quad (1)$$

Where k = value of precision for query and K is the number of query images.

EXPERIMENTAL RESULTS AND DISCUSSION

The image database consists of 60000 images with 10 categories (CIFAR Image Database). The performance of CNN is given in figure 4.

Figure 4: Performance of CNN

After training the model we evaluate the performance of the system by providing a query image. The results show the matched images from the image database. Figure 5 shows sample results that are tested on a few query images.

The database consists of 10 categories and in each category 6000 images. Figure 5 shows sample results of some categories like airplanes, cats, and birds. The top 10 matching images are considered for performance evaluation.

Table 1 represents the performance of the proposed system with precision and MAP. We can conclude that

Figure 5: Sample Results of the proposed system

Table 1. Precision and MAP

Category	Precision
Airplane	90.18
Automobile	90.28
Bird	90.28
Cat	90.70
Dear	90.70
Dog	90.24
Frog	90.20
Horse	90.25
Ship	90.90
Truck	90.85
MAP	90.45

Table 2. Comparisons with existing methods

Methods	Images in Database	Precision %
Color in YCBCR, Color Moment (Dandotiya, Y. and Atre, A)	1000 Images	82.70
HSV Color Histogram and Hu moment invariant (Rajkumar, R. and Sudhamani, D.M)	1000 Images	84.20
CBIR Using Customised CNN (Proposed)	60000 Images	90.45

in all categories results provides promising results. Table 2 provides a comparison analysis with existing methods.

CONCLUSION AND FUTURE WORK

We can conclude that the performance of CBIR improves significantly using CNN. Since the existing methods based on image content like color, shape, and texture provides less accuracy as compared to the proposed system. We can use CNN for improving accuracy and retrieval time. In all categories presented in the database, the proposed

system provides significant results. In the future, we can evaluate CNN using different image databases.

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