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Content-Based Image Retrieval Using Image Features and Database Signature Indexing

Yosha Jawad[1], Haider Akash[2], Muhammad Imran[3], Muhammad Munawar Iqbal[1], Muhammad Yasir[4*], and Zeeshan Zafar[1]

[1]Department of Computer Science, University of Engineering and Technology Taxila, 47050, Taxila, Pakistan.
[2]Department of Computer Engineering, University of Engineering and Technology Taxila, 47050, Taxila, Pakistan.
[3]Department of Computer Science, Szabist University, Islamabad, Pakistan.
[4]Department of Computer Science, University of Engineering and Technology Lahore, Faisalabad Campus, Pakistan.
[*]Corresponding Author: Muhammad Yasir. Email: muhammadyasir@uet.edu.pk

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Abstract: Billions of images across the internet offer simple access to visual information and rich texture details. Social media users, business tycoons, and researchers sometimes need related pictures. The methods of searching images are very important for users and applications. Content-Based Image Retrieval (CBIR) technique used to find and retrieve images from databases. In this paper, we introduced a CBIR technique that uses texture, color, and morphological features of images as input queries in order to search related images from a particular dataset. The image features are stored separately in a feature database in the form of a matrix. The proposed system is not only fast but efficient enough and takes less storage. The databases are categorized and indexed with stored images' signatures to get more accuracy and efficiency. Histogram intersection and Euclidean distance are used to compare the distance of YCBCR color features. Our proposed method accumulates a recall rate of less than 0.041, which is an exceptional result of the approach.

Keywords: CBIR; Signature Index; Image Retrieval; Online and Offline System; Term Frequency-Inverse Document Frequency

1. Introduction

This is the age of technology, it is used mainly in the form of electronic information and perceived as information in the form of digital electronic media[1]. There is no use in written books or hard copies of data. From three decades to now and onward, all of the information is published in the form of machine-readable format, which can be edited and deleted. In this scenario, the bright side is that all old material that was written in the past has been converted into a digital data format. This data can be in any format, a picture or text. This is an excellent achievement of electronic media that the electronic data can be made accessible for everyone at any time and everywhere, the user can make billions of copies of that data in the same format and size without distorting the original. Although it is a good practice, it can also cause multi multi-challenging environment.

Nowadays, almost all industries are dependent on electronic media for their advertisements and for reaching their customers. Film industries, newspapers, and news channels use the Internet and television channels to access their audience. The Internet makes it easy for people to access this data and information.

Here, electronic media have a huge problem, which is becoming an interesting research topic. The problem is that there are numerous sources of all data that is present online but the searching mechanism of relevant data is becoming more and more difficult because if a user needs to get some pictures of Persian dog then to make the machine understand the characteristics on the basis which it will discriminate among other dogs and a Persian dog from the database, this is the problem. Many users already know what information they want to be retrieved, but they do not know where to find that information. Here, the role of search engines is important because they can provide the facility to users to search for their desired information.

The internet is a collection of hundreds of thousands of image databases that cover all domains of human life, including government, commerce, crime prevention, academics, hospitals, engineering, architecture, journalism, fashion and graphic design, historical research, and surveillance. These professions of life use these images for efficient business and quick services. The collection of internet images of any race is collectively called a Database. An image database is a system where image data is stored after compilation from different sources [2]. If a user queries an image from a web browser to search for its relevant images on the internet, then the user doesn't know the source of those images. For that problem, there is a need for an efficient system that can retrieve closely relevant images from internet databases[3]. The technique of image retrieval is that the system matches the contents of the image to all databases and retrieves the closely related images. Methods that are used for image searching and retrieval include object recognition and computer graphics [4] online image search engine tools. These tools use image features, including color features and texture or shape-based features, to find relevant images from databases.

In this study, we are presenting an image retrieval technique that depends on CBIR (Content-Based Image Retrieval), which uses image texture [5] and color, and some other features to retrieve relevant images. In this technique, the database's images are stored in classes, and their features are extracted and stored in lists. When the system receives a query image then it will extract its features and then compare the distance to the indexed images [6] as shown in Figure 5.

A database contains thousands of images, and a collection of databases contains billions of images of enormous size and features. Thus, it is impossible to search for a relevant image. Even if we succeed in extracting the relevant image then the use of resources and time consumption is very unconventional. There are, furthermore, image-type problems that can also occur. Semantic gap and computational load are also problems that need to be dealt with. We designed a system that can employ CBIR [7] techniques on a query image to show relevant images, called Content-Based Image Retrieval (CBIR). While computationally expensive, the results are far more accurate than conventional image indexing.

This paper is divided into five sections. In section 2, we will discuss the problems faced by the internet user and the needs of the CBIR system. It will also cover the existing work of different authors. Section 3 will discuss the proposed methodology. Section 4 will discuss the results, and Section 5 will conclude.

2. Literature Review

CBIR is an approach that uses visual features such as texture, color, and shape etc. to find similar images from the World Wide Web. The need for CBIR is important due to poor efficiency, an insufficient and extremely time-consuming process of existing traditional methods. Old systems use content lists to find images, but in CBIR, all image features are extracted and matched with the query image. There are different CBIR techniques used by researchers to find relevant images from saved images in databases. Some use texture features, some use color and shape features, and text pattern features. in 1970, text text-based image detection technique was proposed and became popular [6, 8].

The Color Selection exploited the CBIR system [9], is based upon querying the color codes. It uses 11 basic colors to develop YUV color space feature vectors and then compares them to the query image for the retrieval of images. Many systems are finding and comparing the whole image features, but the Region of Interest Image Indexing System [10], is a system developed for user selection based ROI (Region of Interest) retrieval. This universal image retrieval algorithm uses three important image features as color, feature and edge-based histogram descriptors.

A visual and semantic feature-based image retrieval technique is used in CBIR. Usually, these systems use the following scenario: random browsing, search from examples, sketch searching, and text searching (including keyword). QBIC stands for "query by image content", is the first commercial CBIR system. QBIC supports queries based on example images, user-constructed sketches and drawings, and selected color and texture patterns [11]. Virago, a content-based picture search engine that is comparable to QBIC, is the alternative system. It allows visual queries based on color, composition, texture, and structure. Assessing the potential for closing the Semantic Gap using a novel technique might allow a framework to be developed that an image retrieval system might utilize to help retrieve photos with different structural content but comparable semantic information [12, 13].

Image retrieval depends on visually significant points and features are discussed in detail in the papers [7]. In paper [14]Some major image features, like local features, color features, and texture features, are calculated from the surrounding points of the image. A General-purpose corner detection system [9] is also developed for this purpose. In [15-17] A most important logic-based fuzzy [18] features are calculated to use in a system that captures the shape information of an image and compares it with databases later. Shape feature set signatures [19] are calculated from blurred images, and global invariant moments are captured as shape. The overall performance of image retrieval of images is calculated better than the accuracies that are calculated in the systems developed by [2]

For efficient and effective image retrieval, a block-oriented decomposition method and image segmentation are used[5, 20] . A wavelet-transform and quadtree segmentation approach is introduced [21]. Genetic algorithms for CBIR with Support Vector Machine (SVM) are used in the Web 3.0 architecture [22] to retrieve images by taking users' considerations into account.

Table 1. Literature Review Table

Sr. No	Author	Year	Problem Statement	Solution	Future Work
1.	Pragati et al. [23]	2014	Image classification using KNN (K-Nearest Neighbors Algorithm)	CBIR technique is used to retrieve images from a large database on the basis of shape, color, and texture.	Apply and check the results of the KNN classifier on similar data
2.	Deepu et al. [24]	2014	Developing an application-specific system for similar kinds of images, like X-Ray, fingerprints, etc	Image retrieval relevant to the query image using a modified SVM technique	Time of retrieving the images will be reduced, and this system will work in real-time using Computer vision
3.	Anbarasa et al. [25]	2015	To improve the accuracy of image retrieval	Reduction of the semantic gap between visual features and the richness of human semantics	Retrieval using the extraction of high-level features
4.	Abrishami et al. [8]	2013	Indexing the images for their fast retrieval from the database	The Enhanced Gabor Wavelet Correlogram (EGWC) scheme is introduced for the indexing of images	To test this introduced scheme on real-time image data
5.	Subrahmanyam et al.[26]	2012	Introduce a new method for image retrieval and compare	Directional Local Extrema Pattern (DLEP) is proposed, and results show an	Combining Gabor Transform (GT) with Directional

			its results with the existing one	improvement in evaluation measures in comparison to the existing patterns	local extrema patterns (DLEP)
6.	Megha et al. [27]	2012	To improve the retrieval performance of images from large datasets	A feature descriptor named torus wavelet correlogram is introduced for image representation	Improvement in the performance of the proposed method
7.	Rasli et al. [28]	2017	To reduce computational time and to achieve maximum accuracy	K-Means method has the highest accuracy and takes less computation time, according to the experimental results	More features will be added for CBIR other than text, color, and shape
8.	Sanjay et al. [29]	2012	Comparison of performance between six different distance metrics	Bray Curtis, Canberra, Square Chi-Square, and Square chord have better performance compared to Manhattan and Euclidean distance, according to the results	Implementing better performance distance metrics on real image data
9.	Kaur et al.[30]	2012	Image segmentation into some meaningful regions to make them readable for machines	Improvement in image retrieval results based on regions in the Hindi language dialect	Reducing computation time using a similar approach
10.	Chao et al.[31]	2017	Embedding the data in the image while maintaining the quality of the image	Differential expansion of reversible data is proposed for image-based hidden encryption	The cellular automata concept will be used for embedding data in images
12.	Zihuan et al. [32]	2017	Volume of internet news expands rapidly, and it's hard to get topic-based recommended news	A keyword extraction approach is used using text-mining techniques like Term Frequency-Inverse Document Frequency (TF-IDF)	The data will be acquired from a large number of different categories, other than politics, only

3. Proposed Methodology

Our proposed system is based on strong image processing techniques used in the database [33]. We divided our work into stages; dataset is classified into different categories of images, such as logos, etc.

Our dataset contains a variety of images of organized events of our university, like seminars and sports weeks etc. All images are standard size of 648 x 424 pixels. Before resizing the images, we make sure that the given pixel values do not destroy the pixel information of the images. All Images are classified in different folders according to their category shown in table 2.

Table 2. Image Dataset

Image Names	Category	Total Images in the Category
1 – 11	Bonfire	11
12 - 82	Face Painting	95
83 – 140	Farewell Football Team	71
141 – 181	Repelling	58
182 – 200	Shooting and Archery	53
201 – 253	Paintball	41
254 – 314	Sketching and Painting	19
315 – 384	Sky Lanterns	61
385 – 578	Wall Graffiti	70
579 – 673	Convocation	194
Total Images in the Database		**673**

In our work, MATLAB [34] is used for image acquisition and processing. MATLAB is a powerful tool that provides a variety of algorithms and an image processing toolkit. The training and testing stages are referred to as offline and online processing.

In offline stage all databases' images are automatically loaded to system and then their features such as color texture and morphological signatures are extracted and listed in class list. It is easy to compare with image signatures because the size of image is quite large as compared to an image statistical analysis. Figure 1a shows the work flow of offline system.

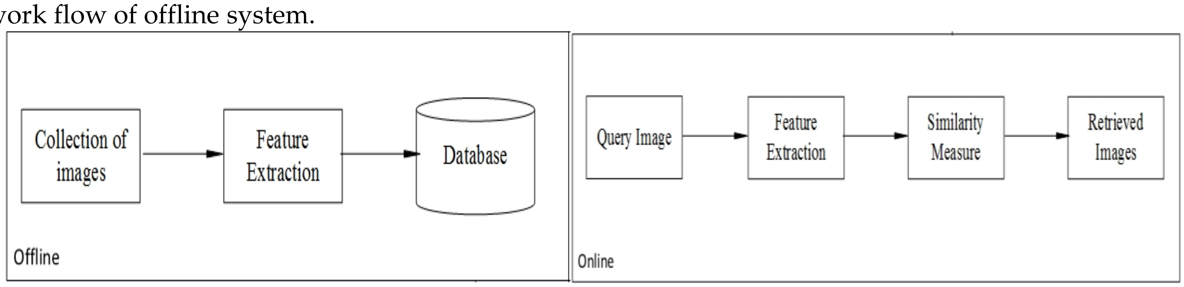

Figure 1. Online & Offline system flow

The created database is a list of features categorized in different classes and can be saved as index list at the top of the image database.

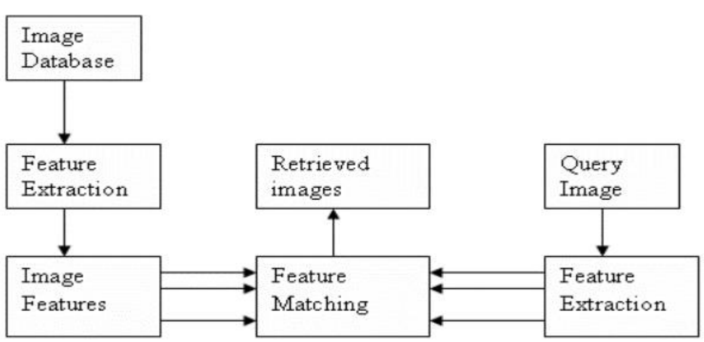

Figure 2. The CBIR proposed Working Model

While in the online part the query image is provided by the user to the system from the GUI and features are extracted and the distances are measured and compared with the indexed signatures from pre-saved datasets signatures. Figure 1b shows the working model of offline. The beauty of this system is indexing the feature lists so that system took less time and shows better results.

Query image Histogram is calculated in YC_BC_R domain, a color space family. Y is used as the luma component, and C_B and C_R are the red and blue chroma components. 'Y' acts as gamma-corrected RGB primaries.

$$"Precision = \frac{No.of\ relevant\ images\ retrieved}{\text{Total image retrieved}}" \quad (1)$$

$$"Recall = \frac{\text{No.of relevant images retrieved}}{\text{Total image in the database}}" \quad (2)$$

For checking the similarity of the images, we used histogram[35] intersection and Euclidean distance. These equations use color information's for comparison 3 determined the color intersection of h and v while their cumulative distance is measured in Eq. 4.

$$"Histogram\ Intersection\ [11] = d\ (h, g) = \frac{\sum \min(h(x), g(x))}{\min\ (|h|, |g|)}" \quad (3)$$

$$"Euclidean\ Distanced(p, q) = \sqrt{(q1 - p1)^2 + (q2 - p2)^2}" \quad (4)$$

```
Input: Query image Q, Database images x_i^db
Output: N Relevant Retrieved Images
Begin
1.  Calculate x^query=Φ(Q)
2.  While i=1:M //where M is the number of images in database
     Compare xquery with x_i^db
       IF(Matched)
          Then: N_j = x_i^db
          j=j+1
       ELSE
          i=i+1
       EndIF
3.  EndWhile
4.  Print N_j //where Nj contains retrieved images
End
```

Figure 3. Implemented Algorithm

The algorithm shown in Figure 3 is our proposed algorithm, which is implemented in MATLAB. When the query image is passed as input, the system first calculates the Euclidean distance of the image. Then, in each While loop cycle, the Euclidean distance of the query image is compared with the feature vector of each image from the feature database. If both vectors match, then that vector is stored in an array. At the end of the while loop, the array is printed as an output, which contains the relevant images to the input query image.

4. Results & Discussion

We use 100 testing images against 673 training images listed in databases for each category of the images. To determine the performance of proposed CBIR system the precision and recall is calculated by given ratio in Eq. 1 and Eq. 2.

The system is tested on images of different categories, and the precision and recall against each test image are calculated and shown in Table 3, performance evaluation.

Table 3. Performance Evaluation

Name of Query Image	Category Name	Relevant Images	Precision	Recall
6.jpg	Bonfire	4	0.26	0.036
620.jpg	Convocation	15	1	0.0157
42.jpg	Face Painting	9	0.6	0.126

100.jpg	Farewell Football Team	15	1	0.258
201.jpg	Paintball	11	0.73	0.207
172.jpg	Repelling	15	1	0.365
192.jpg	Shooting and Archery	4	0.26	0.210
257.jpg	Sketching and Painting	7	0.46	0.114
346.jpg	Sky Lanterns	15	1	0.214
385.jpg	Wall Graffiti	8	0.53	0.041

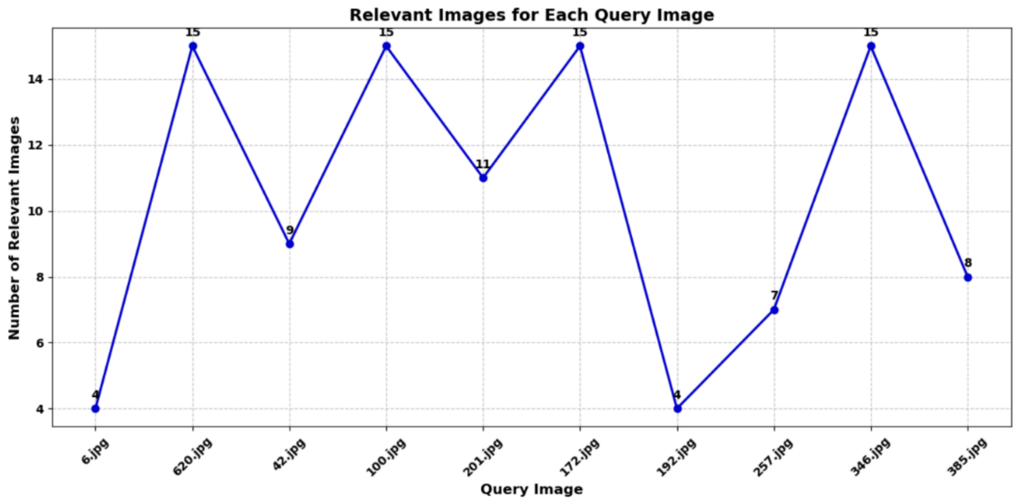

Figure 4. Relevant image for Each Query Image

In Figure 4 Content-Based Image Retrieval (CBIR) system demonstrates the number of relevant images retrieved when users search with query images through this table. The query images within this database represent three distinct categories that include Bonfire alongside Paintball and Wall Graffiti. The number of database images marked as relevant by the system appears in the "Relevant Images" column for each query. The categories of Convocation and Farewell Football Team, along with Repelling and Sky Lanterns, reached a maximum of 15 relevant images.

This bar graph illustrates the precision and recall values for different query images in a Content-Based Image Retrieval (CBIR) system. It shows that images like *620.jpg*, *100.jpg*, *172.jpg*, and *346.jpg* achieved a precision of 1.0, indicating all retrieved images for those queries were relevant. Recall values, however, remain comparatively lower across most queries, with *172.jpg* achieving the highest recall of about 0.36**.** This highlights that while some queries are highly precise, their ability to retrieve a larger proportion of all possible relevant images (recall) is limited.

Table 4. Comparison of the average recalls obtained by the proposed method and other standard retrieval systems

Class	Proposed Method	Dubey [36]	Xiao[37]	Kundu [38]
6.jpg	0.036	0.08	0.07	0.09
620.jpg	0.0157	0.06	0.06	0.06
42.jpg	0.126	0.07	0.06	0.10
100.jpg	0.258	0.10	0.10	0.12
201.jpg	0.207	0.10	0.10	0.08
172.jpg	0.365	0.06	0.05	0.16

192.jpg	0.210	0.09	0.09	0.11
257.jpg	0.114	0.09	0.08	0.15
346.jpg	0.214	0.05	0.05	0.11
385.jpg	0.041	0.07	0.06	0.11
Average	0.158	0.075	0.071	0.111

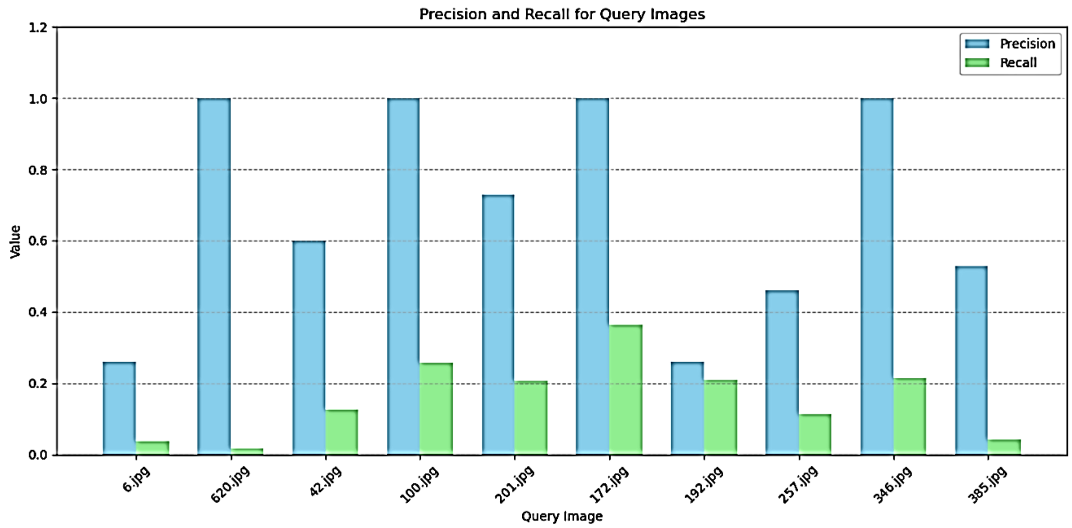

Figure 5. Precision and Recall for Query Images

The table 4 and Fig 6 compares the average recall values achieved by the proposed CBIR method against three existing retrieval systems Dubey, Xiao, and Kundu across various query images. The proposed method consistently outperforms the others in most cases, with the highest average recall of 0.158. This indicates its superior ability to retrieve a larger proportion of relevant images from the database.

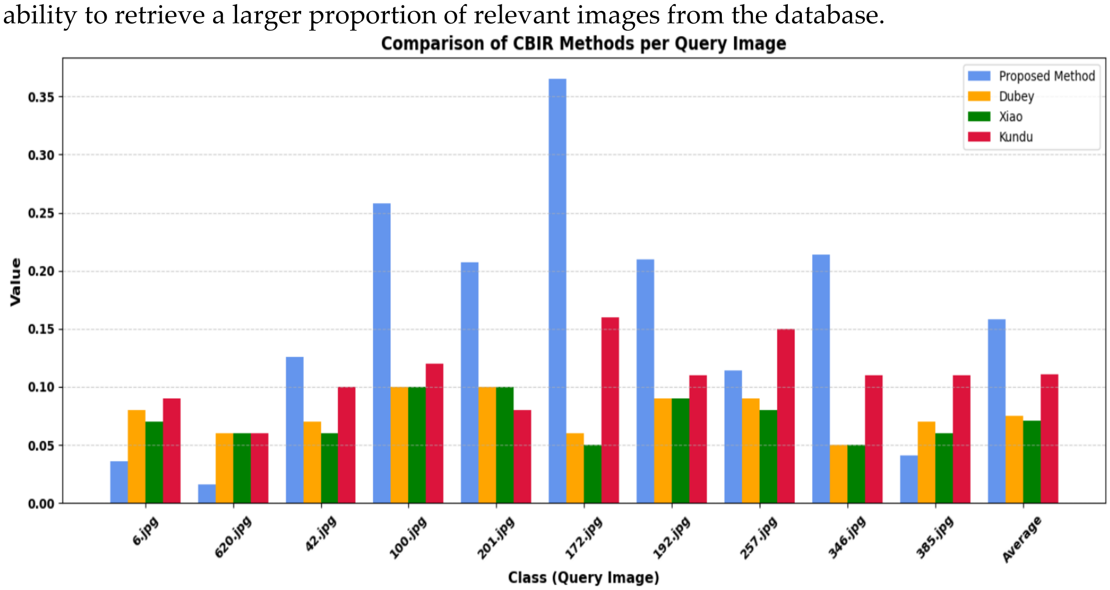

Figure 6. Comparison of the average recalls obtained by the proposed method and other standard retrieval systems.

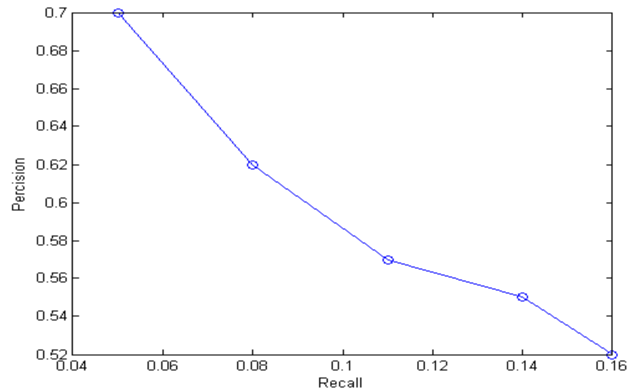

Figure 7. P-R graph

The cumulative precision is obtained as 0.53, and total recall is recorded as 0.041, which shows a good result approach as compared to the existing systems, as shown in Figure 5. The CBIR is a general system, and its evaluation is still in progress.

Query	**Retrieved image**

Figure 8. Test Input / Output

Different images from the testing set are passed to the system as query input. The relevant images are retrieved from the image database and shown as an output on the system, as shown in Figure 5.

5. Conclusion

As internet data is gradually increasing from GBS and TBS to big data, the value of CBIR systems is increasing. Many authors work on CBIR and have proposed different solutions. We developed a two-layer system with an online and offline feature extractor. The proposed system shows better efficiency as compared to other systems due to its indexing in databases and the pre-feature signature indexing. We trained our system on images of events that happened at the university. The images are obtained from the university website and compiled to create a dataset for our proposed system. Then, the features of each image are extracted and stored in matrix form in a separate database named feature-database during training. We tested it on over 650 images from the dataset. We got almost 100% retrieval and recall results. In the future, the model will be enhanced for the generic images and will improve the retrieval efficiency with overall performance.

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