Content Based Image Retrieval: A Review

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Abstract: Image recovery was one of the most thrilling and vibrant fields of computer vision science. Content-based image retrieval systems (CBIR) are used to catalog, scan, download and access image databases automatically. Color & texture features are significant properties for content-based image recovery systems. The content-based image retrieval (CBIR) is therefore an attractive source of accurate and quick retrieval. Number of techniques has been established in recent years to improve the performance of CBIR. This paper discusses why CBIR is important nowadays along with the limitations and benefits. Apart from applications, various feature extraction techniques used in CBIR are also discussed.

Keywords: Image recovery, Image Processing, CBIR, Feature Extraction

I.INTRODUCTION

Images are very important in the field of image processing, database applications and multimedia databases for image sorting. In other words, if retrieved information is an image set, this knowledge area is often known as an image recovery (Kaur and Sohi, 2016). This information is used as an image searching area. In modern times pictures are used in a variety of fields such as corporations, architecture, advertising, crime prevention, fashion and historical analysis for efficient operation. The image database is called a large collection of these images.

Image retrieval is one of broad database essential computer systems for viewing and collecting images. The text-based image retrieval approach (TBIR) and the content-based images recall approach (CBIR) are two approaches for image retrieval. The drawback of TBIR is manual annotation, which is difficult and costly for large databases. Researchers have been more interested in developing techniques for image recovery based on automatically generated characteristics, such as color, shape and texture – a technique generally referred to as content-based image recovery (CBIR) (Kumar et al., 2015). The principal aim of the CBIR research is the semantic difference between low visual characteristics and high image semantics (Bansal et al., 2016).

CBIR is the application of computer vision in large databases to solve an image retrieval problem. "Content-based" means that the search will evaluate the actual content of the image. The word 'content' in this context may refer to colors, shapes, textures or any other details that may be extracted from the image itself.

- One of the most commonly used technique is to examine color-based images based on the colors, because they are not subject to size or orientation of the images.
- Shape- Shape does not refer to the shape of an image but to the shape of a particular region that is being sought out.
- Texture- Texture measures look for visual patterns in images.

This is an image retrieval technique that searches user-based query images from large databases using visual features of a photo specifically shape, color and texture. CBIR is an interface between the semantic differences defined as the difference between a human brain (high-level) and a computer system (low-level) perception (Ali and Sharma, 2017). The human brain is capable of executing complex visual tasks at a much faster rate, but the computer system cannot. In CBIR, visual image content is represented as image features that are extracted using feature extraction methods that are computationally costly and also have a broad dimension, and these methods appear to be domain-specific automatic feature extraction methods. Human interference is therefore excluded (Wang et al., 2018).
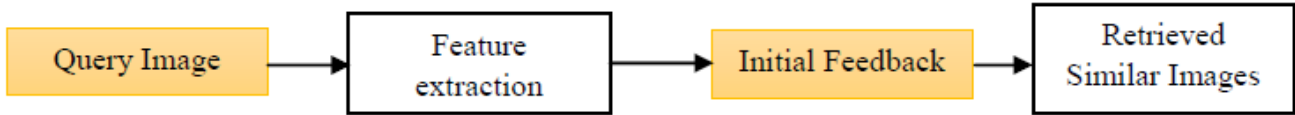
Figure 1. CBIR Workflow

A. Advantages and Disadvantages of CBIR

Advantages:
- Improves the retrieval accuracy.
- Less time requirement.
- Create robust feature set.

Disadvantages:
- Insufficient feature set.
- High semantic gap.
- Time consuming to label negative examples.

B. Applications of CBIR

In many applications, the CBIR technology has been used, including fingerprints, information systems about biodiversity, digital archives, crime prevention, medicine and historical research. Several of these applications are set out in this section.

Table 1. Applications of CBIR

Digital Libraries	• Geographical name information system (GNIS) • Texture descriptors • Satellite images and video data
Medical Applications	• Brain tumor image retrieval • Pathological image retrieval • Histological image retrieval
Remote Sensing Image Retrieval	• Geographic image retrieval • Satellite image retrieval • Aerial image retrieval
Forensic Applications	• Tattoo image retrieval • Camera identification based image retrieval • Glare based image retrieval
Security Applications	• Encrypted image retrieval • Biometric security system using CBIR • Airport video monitoring
Miscellaneous Applications	• E-commerce • Biodiversity Information System • Character image recognition

C. Feature Extraction Techniques

Feature extraction is the process of converting raw pixel values from an image into meaningful information that can be used in other techniques such as machine learning. This technique is useful for large image sizes to rapidly complete tasks such as image matching. The object representation is reduced. This is the method of extracting the most relevant information from raw data in clear terms. In image processing, the extraction feature starts from the initial set of measured data and builds derived values that are intended to be non-redundant and informative. The selection of features is related to the reduction of dimensionality. When input data to an algorithm is too large to be processed, it can be transformed into a reduced set of features. Feature extraction (Soora and Deshpande, 2017) is an important step in the construction of any classification of patterns and aims to extract the relevant information that characterizes each class. In this process, the relevant features are extracted from objects / alphabets in order to form feature vectors.

Feature extraction involves the features of the image to a distinguishable extent (Balan and Sunny, 2018). Average RGB, Color Moments, Co-occurrence, Local Color Histogram, Global Color Histogram and Geometric Moments are used to extract the characteristics of the image that need to be tested. Feature matching, on the other hand, involves matching the extracted features to produce results that show visual similarities.

1) Color-based CBIR Features

Color is an object's visual attribute which results from light that is emitted, transmitted or reflected. The color signal is an extension of the scalar signals of vector signals from the mathematical point of view. Color characteristics can be extracted from a histogram image. The color histogram's drawback is that two color histograms of the same color may be equal to each other. Color histogram is a common method used to represent color content (Latif et al., 2019).

1.1) Color Histogram

The histogram counts the number of pixels of each type and can be quickly created by reading each image pixel only once and increasing the appropriate bin of the histogram. Color histograms are relatively invariant in terms of translation, rotation of the image axis, small off-axis rotation, change in scale and partial occlusion (Putri et al., 2017).

1.2) Histogram of Oriented Gradient (HOG) Descriptor

One of the most commonly used descriptors for machine vision processing is the HOG descriptor (Hi et al., 2019). HOG captures the features by counting the gradient orientation occurrence. Traditional HOG divides the image into different cells and calculates a gradient orientation histogram over them. It is well suited for the detection of objects in images. In HOG, the amount and type of angle of gradient in the local areas of the image is calculated so that the features of the image can be captured effectively. The HOG method divides the image into small square cells, and the gradient angle of the histogram vector is calculated for each cell. HOG is widely used in the areas of object recognition as facial recognition. The process of computing HOG is explained in the figure below:
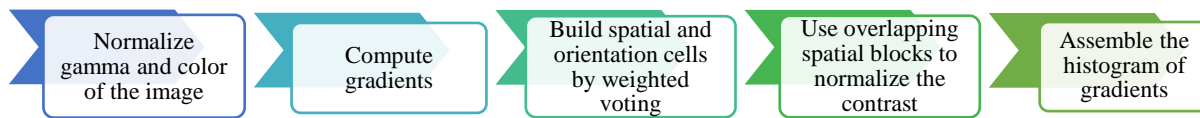
| Normalize gamma and color of the image | Compute gradients | Build spatial and orientation cells by weighted voting | Use overlapping spatial blocks to normalize the contrast | Assemble the histogram of gradients |

Figure 3. Flowchart of Computing HOG

2) Spatial Features

The spatial characteristics of an object are determined by its gray level, amplitude and spatial distribution. Amplitude is one of the simplest and most important features of the object. Amplitude reflects the absorption property of body masses in X-ray pictures and makes it possible to discriminate bones against tissues.

3) Transform Features

In general, the transformation of an image provides details on the data frequency domain. The image transformation characteristics are extracted with zone filtering. The feature mask is also known as a split or an aperture feature mask. For boundary and edge detection, high-frequency components are widely used. For orientation detection, angular slits can be used. When the input data originates within the Transform coordinate, extraction from the Transform function is also necessary.

4) Shape Features

Shape (Patel and Tandel, 2016)is an important basic feature used to describe the content of the image. But due to noise, occlusion, arbitrary distortion shapes are often corrupted, and the problem of object recognition has become more complex. Shape representation is primarily based on shape features that are either based on boundary shape information or boundary plus interior content. Various types of shape features are designed for object recognition, which are evaluated on the basis of how precisely those shape features allow one to retrieve similar shapes from the database (Liu et al., 2020). The shape of the object refers to the physical structure and the profile of the object. Spatial characteristics are often used to classify and match forms, recognize artifacts or calculate types. Moment, perimeter, area and orientation are other features used in the extraction technique of formal objects. The shape of the object is defined by its external limit, which abstracts from other properties such as color, content and structure of the material, as well as from other spatial properties of the object.

5) Contour-based methods

By using Contour-based techniques, boundary information will be extracted. The contour-based form representation technique will be further divided into a global approach and a structural approach. Global approach will not divide the shape into subparts, and full boundary information will be used to derive the feature vector and the matching process, so it is also known as a continuous approach (Liu et al., 2020). Structural methods break the boundary shape information into segments (subparts), called primitives, so this method is also known as a discreet approach. Generally, the final representation of the structural method is a string or graph (or tree) that will be used to match the image retrieval process.

6) Region-based methods

In the region-based technique, all pixels within the shape region, i.e. the whole region, are taken into account for the representation and description of the shape. Like contour-based methods, regionally based methods can also be divided into global methods and structural methods, depending on whether or not the shapes are divided into sub-parts.

7) Edge and Boundary Features

In digital image processing, edge detection is a technique used in computer vision to identify the boundary of an image in a photograph. This uses an algorithm that searches for pixel brightness discontinuities in an image that is converted to a grayscale. The points in the image where the brightness changes sharply are the sets of curved line segments called the edges. This is a fundamental problem in the processing of images. Image edges are areas with a high contrast intensity and a jump in intensity from one pixel to the next can create a major variation in the quality of the image. Edge image detection decreases the volume of data and filters out unimportant data while retaining significant image properties. Much of the research on edge detection has been devoted to the development of optimal edge detectors that provide the best trade-off between detection and localization performance. The edges depend on the size and the edges may have certain edges, but the edges will have no width at a certain point. All objects are placed and their basic characteristics such as area, perimeter and shape can be easily measured if the image edges are accurately identified. Therefore, the edges are used for the scene's boundary and segmentation evaluation.

The edge-based approach strategy is to detect the boundary of the object using the edge detection operator and then to extract the boundary using the edge information. The problem with the detection of edges is the presence of noise which results in random variation in the level from pixel to pixel. Thus, the ideal edges are never encountered in real images.

8) Gabor Filter

A Gabor filter, named after Dennis Gabor (Schroder et al., 2015), is a linear filter used for texture analysis in the processing of images. This means, essentially, it investigates whether similar frequency material occurs in different directions in the field around the point or region of analysis in a localized region. Frequency and orientation representations of Gabor filters are claimed by many contemporary vision scientists to be similar to human visual systems.

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The texture representation and discrimination were found to be especially suitable. A 2D Gabor filter is a gauze-modulated kernel function of a sinusoidal plane wave in the spatial region (see transformation in Gabor).

9) Texture-based CBIR

Texture is a repeated information pattern or structural structure with frequent intervals. Surface applies, in a general sense, to surface characteristics and appearance of an object by its elementary component size, form, density, arrangement, and proportion. As texture feature extraction a basic stage for collecting these features via a texture analysis process. Texture feature extraction is a key function in different image processing applications, such as remote sensing, medical imaging, and content-based image recovery, given the significance of texture information (Chaugule and Mali, 2014).

The texture segmentation allows an image division into a number of unbundled regions based on texture properties, such that each region is uniform in relation to other texture characteristics. Texture synthesis is a common technique for creating large textures from typically small textures, for the application of surface or scene rendering texture mapping

(Hoang, 2019). The shape from texture reconstructs three dimensional surface geometry from texture information. For all these techniques, texture extraction is an inevitable stage.

10) Statistical-based Feature Extraction

Statistical methods characterize the texture indirectly according to the non-deterministic properties that manage the relationships between the gray levels of an image. Statistical methods are used to analyze the spatial distribution of gray values by computing local features at each point in the image and deriving a set of statistics from the distributions of the local features (Tahir and Fahiem, 2014). The statistical methods can be classified into first order (one pixel), second order (pair of pixels) and higher order (three or more pixels) statistics. The first order statistics estimate properties (e.g. average and variance) of individual pixel values by waiving the spatial interaction between image pixels. The second order and higher order statistics estimate properties of two or more pixel values occurring at specific locations relative to each other. The most popular second order statistical features for texture analysis are derived 93 from the co-occurrence matrix. Three types of statistical texture features are available:
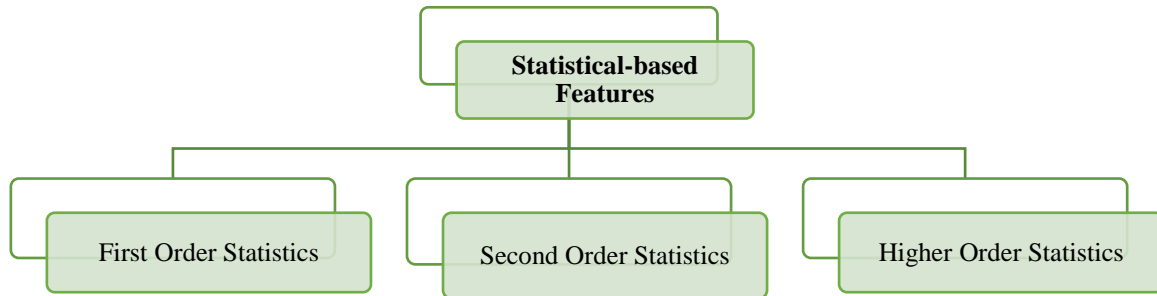
Figure 4. Statistical-based Features

In contrast to structural features, these characteristics can be easily identified. By contrast to statistical features, statistical features are not influenced by noise or distortions. There are a variety of techniques for statistical characteristic extraction, including: zoning, histogram estimates, crossings and distances, n-tuples (Vithali and Kumbharana, 2015).

11) Structural-based Feature Extraction

Structural approaches represent texture by well-defined primitives and a hierarchy of spatial arrangements of those primitives. The description of the texture needs the primitive definition. The advantage of the structural method based feature extraction is that it provides a good symbolic description of the image; however, this feature is more useful for image synthesis than analysis tasks. This method is not appropriate for natural textures because of the variability of micro-texture and macro-texture (Vithlani and Kumbharana, 2015).

Topological and geometrical features are the based on the structural properties. The geometrical and topological features with high tolerance to distortions and style changes can reflect various global and local characteristics. The representation of this sort can also encode some information about the object's structure or provide some information about the kind of components that make up it. The four categories can be grouped into different topological and geometric representations (Mohamed et al., 2015):

a) Graphs and Trees

b) Coding
c) Extraction and Counting of Topological Structures
d) Estimation and approximation of geometric features

12) Euler Number based Feature Extraction

Euler number of an image is defined as the number of objects in the region minus the number of holes in the objects. Numeral '0', '4', '6', and '9' will have the Euler number 0 and '1', '2', '3', '5', and '7' will have Euler number 1. The Euler number is an intrinsic property of objects that can be used to describe the shape topology. In (Azula et al., 2014), the authors propose two equations based on the pixel geometry and connectivity properties, which can be used to compute, efficiently, the Euler number of a binary digital image with either thick or thin boundaries. Although computing this feature, the authors' technique extracts the underlying topological information provided by the shape pixels of the given image. The correctness of computing the Euler number using the new equations is also established theoretically (Pal et al., 2018).

The Euler number is an integer that categorizes a data according to the number of holes. Categories are: positive number for a character with no holes, zero for a character with one hole, and a negative number for a character with two holes.

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In (Matsuoka et al., 2018), the proponents created a system that accepts a handwritten text image as input, undergoes processing stages and outputs a text based on the features extracted per character using the Diagonal Feature Extraction, and classification using Euler Number with the use of the Modified One-Pixel Width Character Segmentation Algorithm. A total of 100 handwritten text images are used in evaluating the system. The system achieved a character recognition rate of 88.7838% and word recognition rate of 50.4348%.

13) Feature Extraction using Geometrical Features

This method removes the geometrical characteristics of the character. These features are based on the basic lines which shape the skeletons of the character. This system gives a feature vector as its out-put. The various steps involved in geometric method are (Pithadial et al., 2015):

- Initially in preprocessing (binarization, skeletonization) is done on the input image.
- The discourse of universe will be selected, features extracted from the character image will include the positions of different line segments in the character images.
- After the second step, the image will be divided into equal size of windows, and the feature is done on individual windows.
- To extracting the different segments of line in a particular zone, the entire skeleton in that zone will be traversed. So that fixed pixels in the character skeleton were defined as starters, intersections.
- After that the line of each segment is determined, based on this information feature vector is formed and each of the zone has a feature vector corresponding to it. The contents of each zone vector feature are:
  a) Number of horizontal lines
  b) Number of vertical lines
  c) Number of diagonal lines on the right
  d) Number of Left diagonal lines
  e) Uniform Length of all horizontal lines
  f) Normalized Length of all vertical lines
  g) Uniform correct of all diagonal lines

The geometric-based features extraction operation is used in (Mistry et al., 2017) for extracting the local characteristics (landmarks) of a set of emotion expressions (anger, happiness, sadness, surprise) for images of BOSPHORUS database as training stage, then the classification operation is done by using of the threshold method (Euclidean distance) between the distances of neutral image and the expression image. The trained system is used for feature extraction and classification for 3D video film (stereoscopic) as testing stage. This method is implemented on 40 3D video films that were recorded, 10 video films for each expression of the four basic emotion; the ratio of discrimination is 85%.

Feature extraction and classification for Malayalam OCR (Neha et al., 2015) by using geometrical properties is discussed in (Raveena et al., 2017). Accuracy of Handwritten recognition system does not depend on the number of features extracted. It is only based on what features we extracted. Geometrical features are language oriented features that uniquely classify each and every characters in a language. A set of geometrical features are used in this system. Four step pre-processing and Multiclass SVM is used in this system.

II.REVIEW OF LITERATURE

(Choudhary et al., 2014) proposed an integrated content-based image retrieval technique that extracts both color and texture features. To extract the color feature, the color moment (CM) is used on the color images and to extract the texture feature, the local binary pattern (LBP) is used on the grayscale image. Then both the color and texture features of the image are combined to form a single vector feature. In the end, similarity matching is performed by Euclidian distance, which compares the feature vector of the database images to the query images. LBP is mainly used for the recognition of the face.

(Zhu, 2014) suggested a new Adaptive Index Structure Graphics Processing Unit (GPU) called the Plane Semantic Ball (PSB) to simultaneously minimize the function of the retrieval process and maximize parallel acceleration of the underlying hardware. In PSB, semantics are embedded in the generation of representative pivots and multiple balls are selected to cover more detailed reference features. For PSB, the online retrieval of CBIR is factored into individual components that are effectively implemented on the GPU. Comparative tests with the GPU-based brute force method show that the proposed approach can achieve high speed with little information loss. In addition, PSB is compared to the state-of-the-art, random ball cover (RBC) method on two typical image datasets, Corel 10 K and GIST 1 M.

(Kaur et al., 2016) illustrated that CBIR blends the contents or features of an image, such as color, texture, edges rather than keywords, labels relevant to an image. This paper provided a systematic literature analysis of various imaging techniques, addressing basic principles and accessible methods with their study gaps. Retrieval techniques based on features such as HSV, Color Moment, HSV and Color Moment, Gabor Wavelet and Wavelet Transform, Edge Gradient are studied and implemented in this research. A retrieval approach is proposed based on the combination of color, texture and edge features of the image. Quality assessment of the image retrieval techniques studied and the proposed technique is conducted using parameters such as Sensitivity, Specificity, Retrieval Score, Error Rate and Accuracy. The experimental findings of the performance assessment indicate that the suggested method outperforms other techniques.

(Meena et al., 2016) proposed a system for the recovery, from a large series of distinct images, of images associated with a query image. It follows an approach based on the segmentation of the image to extract the different features present in the image. The above-mentioned functions which can be stored in vectors referred to as the feature vectors of the database image are comparable and the image data is sorted in decreasing similarity order. The same is handled in the cloud. The CBIR framework is a Windows Azure platform-built program. A large number of images have to be processed in parallel to identify them based on a similarity to a given query image from the user. Many instances of the algorithm run on Microsoft data centers that run Windows Azure virtual machines. In the CBIR, visual image content is represented in the form of image features that are extracted automatically and there is no manual intervention, thus eliminating dependence on humans at the extraction stage.

(**Alhassan et al., 2017**) proposed a fusion-based retrieval model for merging color and texture image features based on different fusion methods. Following the implementation of proposed Wang image dataset retrieval model, which is widely used in CBIR, the results show that the CombMEAN fusion approach has the best and highest precision value and has outperformed both the individual color and texture retrieval model in both the top10 and the top20 images.

CBIR depends on the image extraction feature, which is a visual feature, and these features are extracted automatically, i.e. without human interaction. (**Ali and Sharma, 2017**) used the SIFT feature extraction algorithm for the extraction feature, which basically gives us a key point in the image. SIFT image feature algorithm provides a set of imaging features that are not valuable, so we use the BFOA (Bacteria foraging optimization algorithm) optimization technique to reduce the complexity, cost, energy and time consumption. Then, to check the similarity, a deep neural network is trained and the validation and texting phases are carried out accordingly, which lead to better performance compared to previous techniques.

A hybrid feature based efficient CBIR system is proposed by (**Mistry et al., 2017**) using a variety of distance measurements. The Gabor wavelet transform is used with spatial domain features including color auto programming, color moments, HSV histogram features and frequency domain functions like moments when using SWT. Furthermore, to enhance the accuracy of binarized statistical image features, color and edge directivity descriptor features are used to develop an efficient CBIR system.

A retrieval approach is proposed by (**Seth and Jindal, 2017**) based on the combination of color, texture and edge features of the image. Quality assessment of the image retrieval techniques studied and the proposed technique is conducted using parameters such as Sensitivity, Specificity, Retrieval Score, Error Rate and Accuracy. (**Stubendek and Karacs, 2018**) resents a new approach to improving automatic target recognition (ATR) performance by adjusting the Gabor filter in an adaptive manner. The Gabor filter adopts a two-layer network structure and its input layer constitutes an adaptive nonlinear extraction feature, while the weights between the output layer and the input layer constitute a linear classifier. From the statistical properties of the high- range profile (HRRP), its extracted non- degree of features is traced to extract the discriminatory features of Gabor atoms. Two experimental examples show that the simple-structured Gabor Filter approach has a higher recognition rate for HRRP radar target recognition compared to several existing methods.

(**He et al., 2019**) presented a literature survey on Content Based Image Retrieval (CBIR) techniques based on texture, color, shape and location.

Content-based image retrieval (CBIR) extracts features from images to support image search. (**Chatterjee et al., 2019**) reviews some of the basic CBIR algorithms that derive color, texture and shape features, and then shows how image features can be extracted from the compressed domain, in particular from JPEG images, without the need to completely decompress images.

(**Unar et al., 2019**) suggested a critical approach to CBIR that blends visual and textual characteristics in order to obtain identical images. First, the method classifies the query image as textual and non-textual. When any text appears in a photo, then the image of a query is defined as textual, and the text is identified as a Text Word Bag. The visual highlighting features are extracted and shaped as a bag of visual words if the query image is classed as non-textual. The process then fuses visual and textual features and related images from the top are obtained on the basis of the fused function vector. It supports three methods of recovery: image query, keywords and both.

One of the most common filters was the Gabor filter. In fact, Gabor filter-based feature extractor is a Gabor filter bank, which has parameters defined by Gaussian envelope frequencies, orientation and smooth parameters. Different parameters were proposed in the literature, and filter banks generated by these parameter settings generally function well. But filter banks built accordingly cannot be ideal from the perspective of pattern classification. By integrating feature selection (i.e. filter selection) into the design process, (**Liu et al., 2020**) proposes a new approach to Gabor bank filter design. Stream selection is twofold in the configuration of the stream banks. First of all, the selection of the filter creates a compact Gabor filter bank and thus reduces texture extraction's computational complexity. Secondly, the filter bank of the Gabor filter bank designed to achieve low-dimensional representation with an increased sample-to-feature ratio.

Table 2. Comparison of Feature Extraction Techniques

S. No.	Reference	Feature Extraction Technique	Contribution
1.	(Unar et al., 2019)	Visual and Textual	It supports three methods of recovery: image query, keywords and both, in order to obtain identical images.
2.	(Mistry et al., 2017)	Color	To enhance the accuracy of binary statistical image features, color and edge directivity descriptor features are used to develop an efficient CBIR system.
3.	(Ali and Sharma, 2017)	Visual	To check the similarity, a deep neural network is trained and the validation and texting phases are carried out accordingly.
4.	(Schroder et al., 2015)	Gabor-filter	Optimized GFB parameter for acoustic event detection.
5.	(Liu et al., 2020)	Gabor-filter	To achieve small-scale representation with an improved sample-to-feature ratio.

III. CONCLUSION AND FUTURE SCOPE

The most prominent element of all media files is photos. Image Retrieval is an effective and reliable tool for heavy-duty databases monitoring. Content-based image recovery method allows the user to address an image query in order to retrieve images in the data base in a similar way to the image query. The scope of CBIR is currently very small in day-to-day operations and has enormous potential in numerous fields, including Image Search for Media, Home Entertainment, Criminal Detection, Missing Vehicle Detection, Consumer Products to Search for any specific product based on color, shape, size and features.

The drastic rise in image storage sizes has encouraged the development of effective and reliable recovery systems.CBIR continues to sustain a steady rate of growth in research as image compression, digital image processing, and image extraction technology become more advanced. Furthermore, CBIR development contributes substantially to the development of powerful process power and faster and cheaper memories. This architecture promises a wide variety of potential CBIR applications. Additional developments in the design and efficiency of content-based picture recovery systems are being further developed and studied.

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