Combined Edge Detection (CED) for Similar Images Retrieval and Re-ranking

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***Abstract*—Edge detection techniques are an essential and fundamental problem in machine learning, computer vision, and content-based image retrieval system. A big challenge in content-based image retrieval is feature extraction due to the well-known semantic gap. Edge detection methods are one of the strong features for characterizing images. We aim to maximize the similarity images and promote more relevant re-ranking images. We propose a Combined Edge Detection (CED) framework for image retrieval re-ranking. In this study, the Combined Edge Detection (CED) framework for multi-edge detection techniques that are Roberts, Sobel, Prewitt, Canny, and LoG (Laplacian of Gaussian) provides a solution for efficient retrieval in similarity images. Hence, from the experimental results, it is proved that the Combined Edge Detection Model (CED) can significantly and efficiently improve the retrieved results and minimize user effort.**

***Keywords*—Content-Based Image Retrieval (CBIR), Edge Detection, LoG (Laplacian of Gaussian) Combined Edge Detection (CED), Re-ranking.**

I. Introduction

Content-based image retrieval plays a significant role in computer vision, image processing, and machine learning. Image search and recognition research are being performed in ever-larger databases [1]. Generally, web images are closely related to the text annotations and URLs that get the web pages' results. For example, search engines, i.e., Google, Yahoo, etc., [1]. Text-based image retrieval is two classes 1. Annotate images with text, and 2. Image search with text only. We are using the keyword 'apple' as given a query image, and retrieved results are apple fruits, firm logo, apple company laptop, and apple fruits. These problems solving by CBIR, and it is widely role in an image retrieval system, and primary feature extraction method is color and edge detection, etc., Content-Based Image Retrieval (CBIR). However, it isn't very easy to the intentions of the users [2]. There are many disadvantages to keyword-based web image retrieval. 1. Text-based image searching does not describe the content of the images, 2. It does not capture user intention of images accurately. 3. The user may not have sufficient knowledge about the query image's content; hence, the query keywords' ambiguity may retrieve the irrelevant image. 4. The user also has to spend more time to find the exact image he desired. Another famous method is Content-Based Image Retrieval (CBIR) which plays a vital role in digital image processing to work on research topics in the multimedia field. The content-based image retrieval system is based on keywords, tags, etc [3].The CBIR systems have more challenges such as semantic gap, ambiguity results, more feedback, and limited performance level [4]. The study presents a Combined Edge Detection method (CED) designed from various edge features to address the problem. Content-based image retrieval system (CBIR) follows some crucial characters such as color, texture, shape, and edge features called low-level features. The edge detection method has its uses in a rapid range of image retrieval, image enhancement, image compression, image recognition, etc. Edge detection aims to determine image points at the image brightness that changes according to the convention having discontinuities [5] [6]. We propose a combined edge detection algorithm (CED) based on edge features that exploit spatial information by detecting the edges in an image. We offer an approach that follows specific important characteristics, there are steps: (1). Select the query image (2). Find the edge detection (3). Combined edge features, combined edge features computed from important edge detection methods like Roberts, Sobel, Prewitt, Canny, LoG (Laplacian of Gaussian). As a result, they provide strong edge features [7] [8]. (4). Analyse the image classification (5).Retrieve similar images, (6). Finally, prove the effectiveness of the performance. The paper is structured so that section 2. Provides an overview of edge detection techniques; section 3. Briefs the combined edge detection methods approach. Section 4. Displays the experimental result. Section 5. Does the performance of evaluation, and section 6. Concludes.

A. Main contribution

We discussed novel hybrid edge features combined, such as Roberts, Sobel, Prewitt, Canny, and LoG (Laplacian of Gaussian) features. Hybrid features are collected from the five classical edge methods. These features build up a framework for hybrid features and provide more similar images. This model computes the various edge features extraction and similarity metrics content of images attained from huge datasets. The hybrid features are extracted from edge operators. Thus, the operators are obtained from different edge dimensional

channels [7] [9]. Combined edge features aim to enhance the speed of more similar image retrieval, reducing feature dimensional. These features represent the various channels of the color images [10]. we have established the combined classical edge features to be a very effective method in CBIR techniques. This hybrid method improves the computational efficiency of the texture methods used when applied to the CBIR method. These features help find the effective image size and image objective from the widely used hybrid edge feature. The features are extracted from the images and used for simple texture methods to implement image size and image formation. [11]

B. Overview of edge detection techniques

1) Edge detection: The edge detection method plays a vast role in image processing. One of the challenging tasks is feature extraction, which is considered a fundamental problem in image analysis. Edges characterize the object boundaries, a useful feature for image segmentation, registration, and finding object scene [12]. Edge detection is defined as low-level feature extraction that can be extracted from the images. Many edge detection methods can be grouped into two categories 1. First-order derivatives or search-based approach and 2. Second-order derivatives are a zero-crossings-based approach. Search-based methods are defined as image intensity and detecting image contrast [9] [2]. The proposed system follows the edge detection techniques, we can seen in figure 1 which are as follows.

2) Roberts edge model: Robert's edge operator is a simple method. Its main aim is to determine the difference between pixels of an image [13]. It is simple to implement and measure the 2D spatial gradient of an image. Roberts operator consists of a pair of 2×2 convolution masks, lets us take $'A'$ which denotes both G_x and G_y images representing vertical and horizontal derivative approximation [14]. This method is similar to the sobel operator, which is discussed in the sub section of 3. The Roberts mask is given below in the form of equations.

$$G_{x,y} = \begin{pmatrix} -1 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} 0 & -1 \\ 1 & 0 \end{pmatrix} \tag{1}$$

$$|G| = \sqrt{G_x^2 + G_y^2} \tag{2}$$

$$|G| = |G_x|\,|G_y| \tag{3}$$

$$\Theta = arctan\,(G_x + G_y) \tag{4}$$

3) Sobel edge model: The Sobel edge detector is the first-order derivatives and gradient-based method. The operator is similar to the Prewitt operator, which performs a 2-D spatial gradient computation on an image [9] [15]. The Sobel operator consists of 3×3 kernels and lets us take $'A'$ which denotes both G_x and G_y images representing vertical and horizontal derivative approximation. Sobel operators are computationally calculated as given below. Sobel operator mask calculates magnitude or strength of the edge , approximate strength, the orientation of the edge

$$G_x = (p_2 + 2p_3 + p_4) - (p_0 + 2p_7 + p_6) \tag{5}$$

$$G_y = (p_6 + 2p_5 + p_4) - (p_0 + 2p_1 + p_2) \tag{6}$$

$$G_x = \begin{pmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{pmatrix} G_y = \begin{pmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{pmatrix} \tag{7}$$

4) Prewitt operator edge model: Prewitt edge detector is a first-order derivative method consisting of two templates: 1. G_x and G_y. G_x is a vertical template along tree rows. 2.G_y is a horizontal template G_y along with three columns. The edge direction is measured in degrees where 0^0 and 360^0 are horizontal, and 90^0 are vertical [6]. Both templates are on a 3×3 operator. Compute the pixels at the central pixel $[i, j]$ as given below. Here G_x and G_y are approximations at $[i, j]$.

$$\begin{pmatrix} p_0 & p_1 & p_2 \\ p_7 & (i,j) & p_3 \\ p_6 & p_5 & p_4 \end{pmatrix} \tag{8}$$

$$G_x = (p_2 + cp_3 + p_4) - (p_0 + cp_7 + p_6) \tag{9}$$

$$G_y = (p_6 + cp_5 + p_4) - (p_0 + cp_1 + p_2) \tag{10}$$

$$G_x = \begin{pmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{pmatrix} G_y = \begin{pmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{pmatrix} \tag{11}$$

5) Laplacian of Gaussian (LoG) model: LoG operator follows the second-order derivatives [12]. We give an input image, a Gaussian kernel convolution mask in the image. It is minimized by smoothing the appearance before edge enhancement [16]. It calculates second-order derivatives single pass. LoG operator is extremely sensitive to noise [15]. LoG operator is computationally faster in calculating the following equation:

$$\begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix} \tag{12}$$

$$LoG = \Delta^2 G\,(x, y) = \left[\frac{G^2 + G^2 - 2\sigma^2}{\sigma^4}\right] \times e \frac{-x^2 + y^2}{2\sigma^2} \tag{13}$$

6) Canny edge model: Canny edge techniques follow multistage algorithms, which are as follows 1. Noise Reduction 2. Find the intensity gradient 3. Non-maximum suppression 4. Hysteresis thresholds. A canny edge detection technique extracts different features from different objects [14]. Canny edge detection finds edges with a low error rate and accurate edges. The operator's detected edge point is accurate, which is localized on the center of the edges, and image noise should not make false edges. It provides good and reliable detection [17].

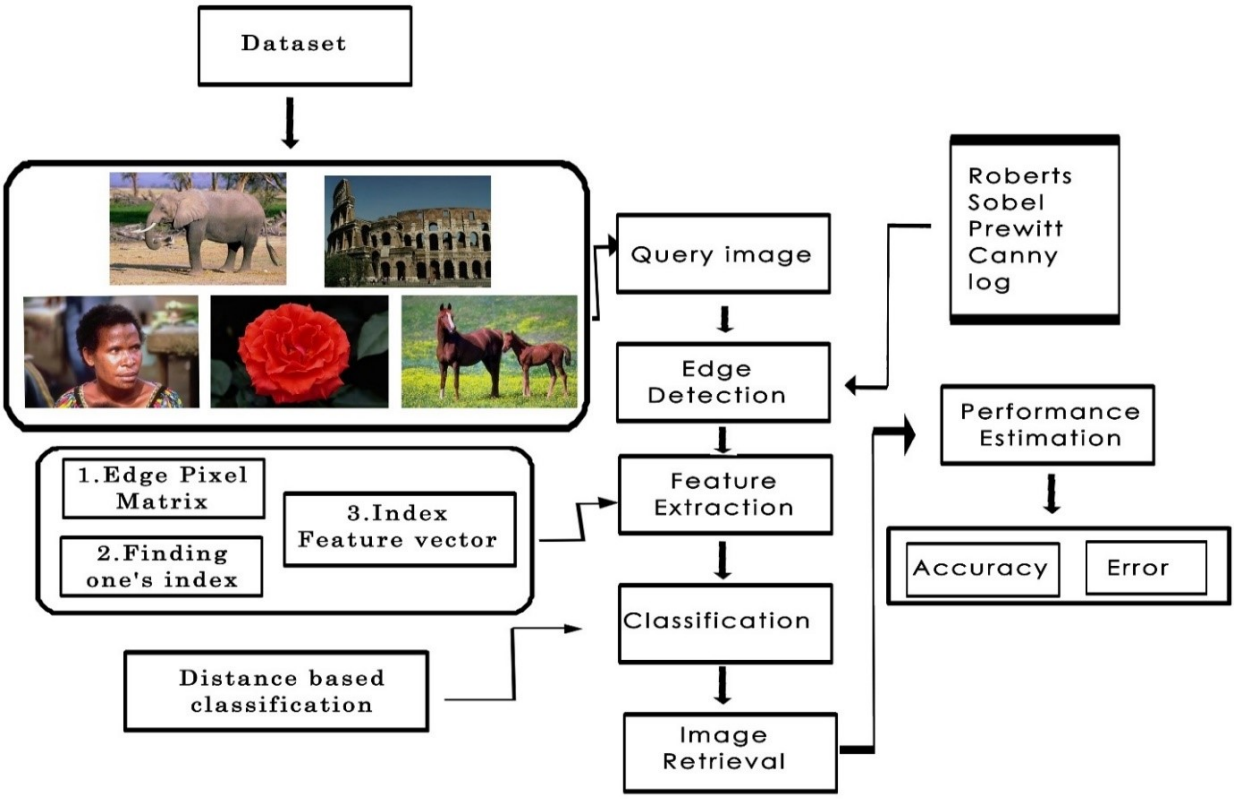

Fig. 1. Overview of Edge Detection Techniques

II. Proposed method for Combined Edge Detection (CED)

We propose a Combined Edge Detection (CED) framework for image re-ranking. This approach follows multi-edge detection techniques: Roberts, Sobel, Prewitt, Canny, LoG (Laplacian of Gaussian), which computes the multiple edges features using the gray level and shape information of edges map. We aim to maximize the image retrieval combined edge detection, leading to the improvement of relevant re-ranking image results [18]. Figure 1 shows the proposed method is the Combined Edge Detection framework (CED). The proposed system employs five different edge detection image features such as sobel edge detection, Canny edge detection, etc. Combined edge detection features can measure the image similarity between the image and huge database images. The similarity metric uses the combined distance features are calculated and the complex task solved through (CED) proposed method. As a result, the best image retrieval and performance analysis achieved [19] [12].

III. Algorithm

Input: Select one Image from the Repository Dataset
Output: As Results Re-ranking image has been retrieved.

1) Select a Query Image from the huge Database.
2) Calculate the edge features values in each edge method
3) Compute all the edge pixel values from the first-order and second-order derivatives
4) Construct and combine all edge features and pixel values for single array values.
5) Construct the feature extraction vectors, which computes the edge pixel matrix, finding the Index feature vector'
6) It is based on the outcome of image feature values by comparing the query image With various huge database images.
7) Retrieve the images based on the best matches by Re-ranking images.
8) Finally, perform the evaluation based on precision, recall, and error rate.

The proposed Combined Edge Detection (CED) algorithm is computationally attractive. It computes some essential features with a limited number of selected pixels from the edge region. The proposed techniques follow specific steps such as 1. Select the query image 2. Find the edge detection features 3. Combine with multiple features. 4. Analyse the classification. 5. Retrieve the similar images, 6. Perform the evaluation process.

1) Select the query image: We chose one specific image from the Huge database. The experiment was conducted using the Corel dataset with the selected image size of JPEG format. One thousand images contain ten categories, with each type carrying 100 images, and it is stored in the JPEG format. The

dimensions of the images are 256×256.

2) Finding of the edge detection features: This module has strong features to characterize an image. It follows robust techniques to extract edge regions of an image through edge detection methods like Roberts, Sobel, Prewitt, Canny, and LOG, followed by computation using the global features and shape information of the edge map [6].

3) Combine edge detection features: The edge detection method is well known as low-level features extracted from objects or images more than any shape information. It is defined as image contrast or intensity. Edge detection techniques follow two are 1. First order 2. Second-order detection. The first-order detection is defined as combined with more than one method, such as Roberts, Prewitt, Sobel, and Canny edges. Second-order only Laplacian of Gaussian (LOG). It helps the user to analyse the images and classify them, algorithm part is discussed the feature extraction methods.

4) Retrieval of similar images: In this module, it is challenging to retrieve similar images. It is necessary to compute the distance from that query image to every image present in the vast database images. Euclidean distance can find the distance metrics and retrieve similar images [13].In this (CED) proposed method presents a robust technique for extracting essential edge features by popular edge detection methods such as roberts, sobel, canny, prewitt, LoG (Laplacian of Gaussian) [5] [4].

5) Performance: CED methods experimentally proved, as shown in table 1, each technique is taken by the top twenty retrieval results of each image sets.

IV. Distance Metrics

Euclidean distance metrics are mostly used in image processing techniques: medical images, shape matching, and face recognition [5]. City block distance is also called manhattan distance or absolute value distance; it has the robustness to outliers' object, it measures the two given vectors by computing the square root and adding the below formula's squared absolute difference [8]. Minkowski distance, this metrics can be used for quantitative and ordinal variable, the generalized of the combined distance metrics can be followed by the re-ranking algorithm. This distance metric contains two points, q and t. q denotes the query image, and t represents the database images. If $q = (q_1, q_2, q_3 q_4 \ldots . q_n)$, $t = (t_1, t_2 t_3 t_4 \ldots . t_n)$ in two points measure the Euclidean distance n-space images in pixels values. These measure between two points, I and D, with n dimensions as given in the below formula.

$$Dist_{Euc}\left(q_i, t_i\right) = \sum_{i=1}^{n} \left(q_i - t_i\right)^2 \tag{14}$$

$$Dist_{City}\left(q_i, t_i\right) = \sum_{i=1}^{n} \left|\left(q_i - t_i\right)\right| \tag{15}$$

$$Dist_{MinKw}\left(q_i, t_i\right) = \left[\sum_{i=1}^{n} \left(\left|q_i - t_i\right|\right)\right]^{\frac{1}{p}} \tag{16}$$

TABLE I
Performance of precision,recall and F-measure

Query Images	F1-Score	Precision	Recall
African Faces	0.79	0.90	0.71
Beach	0.87	0.93	0.82
Buildings	0.80	0.92	0.71
Buses	0.84	0.99	0.73
Dinosaurs	0.84	0.99	0.73
Elephants	0.73	0.88	0.72
Flowers	0.82	0.97	0.72
Horses	0.95	0.95	0.85
Mountains	0.87	0.93	0.82
Food	0.84	0.99	0.73
Average	0.83	0.94	0.75

V. Experimental evaluation

This section is essential in establishing the experimental database. We experimented with Combined Edge detection Methods (CEM), and the experiment contained five necessary steps 1. Sobel edge detection, 2. Prewitt edge detection, 3. Roberts edge, 4. Laplacian of Gaussian, 5. Canny edge detection. The combined edge detection design framework provides a convenient image retrieval system similar to the web image retrieval methods [5] The experiment contained three essential aspects. (1). Comparison of combined edge detection method (CED) and other existing similar edge detection methods. (2). The combined edge detection method provided the most convenient image retrieval interface. (3). Precision, recall, and accuracy achieved. Figure 6 shows the obtained results.we selected one query image from the Corel data set. For example, "Dinosaurs" extracts multiple edges features like Roberts, Prewitt, Sobel, Canny, and LoG. Figure 5 shows the combined edge features information. It computes all the edge features that provide similar images. Figure 7 shows retrieved the top twenty images [9].

1) Corel datasets: We conducted several experiments using Corel datasets. There are various types of CBIR image datasets such as Corel dataset, Wang dataset, ZuBuD dataset, Coil-100 Dataset, UW Dataset INRIA Holiday Image dataset. [20],and Google, Flickr images, etc. Corel dataset contains 1000 images organized in ten classes, with each class possessing 100 images such as african faces,beach,buses,dinosaurs and elephants etc.

VI. Performance analysis

We conducted famous experiments using retrieved images from Corel dataset. CBIR system followed three important metrics first, Precision, second, Recall and third F1-Score using the equations 17 to 19. Both precision and recall are broadly used in Content-Based Image Retrieval (CBIR) [8]. Precision one of CBIR's critical performance analysis as TP is defined as the total number of relevant images retrieved [7]. Moreover, TP+FP denotes the total number of the image retrieved.

- Precision shows the closeness of measured values and the ratio of accurate positive observations. It refers to the

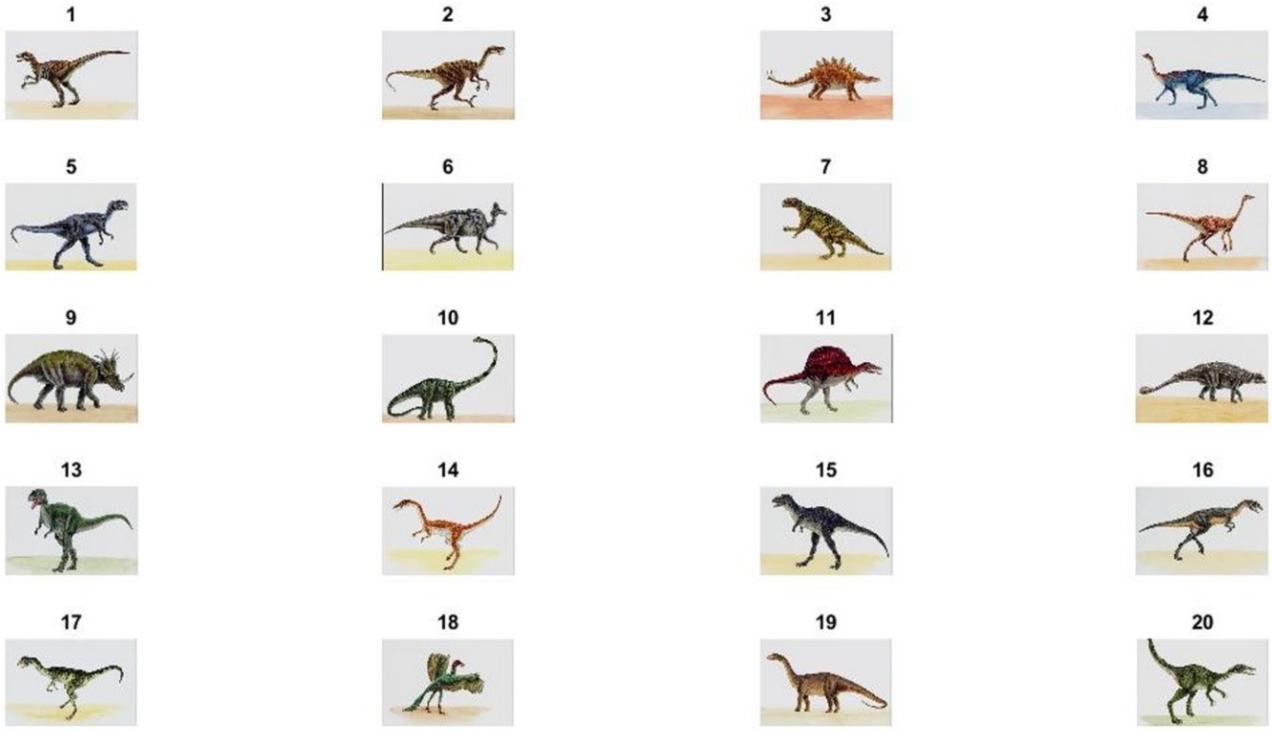

Fig. 2. Top twenty images are retrieved using (CED) method

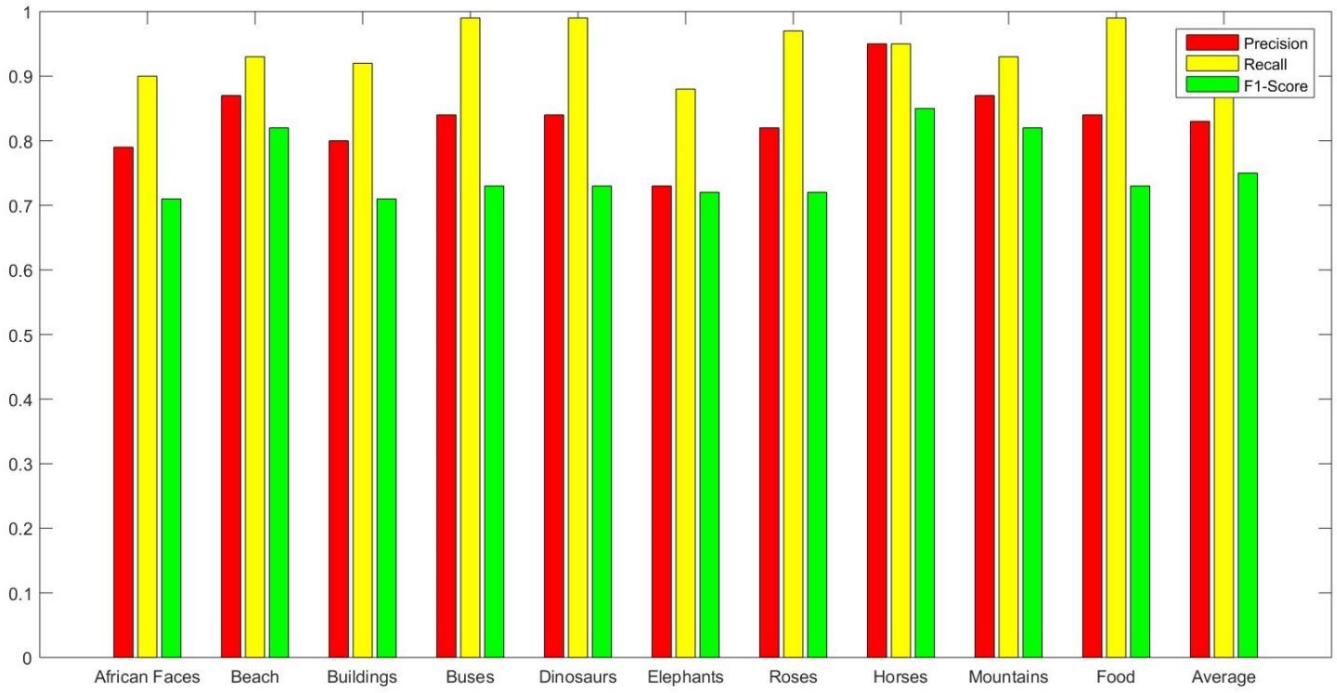

Fig. 3. Performance of Precision,Recall and F-measure

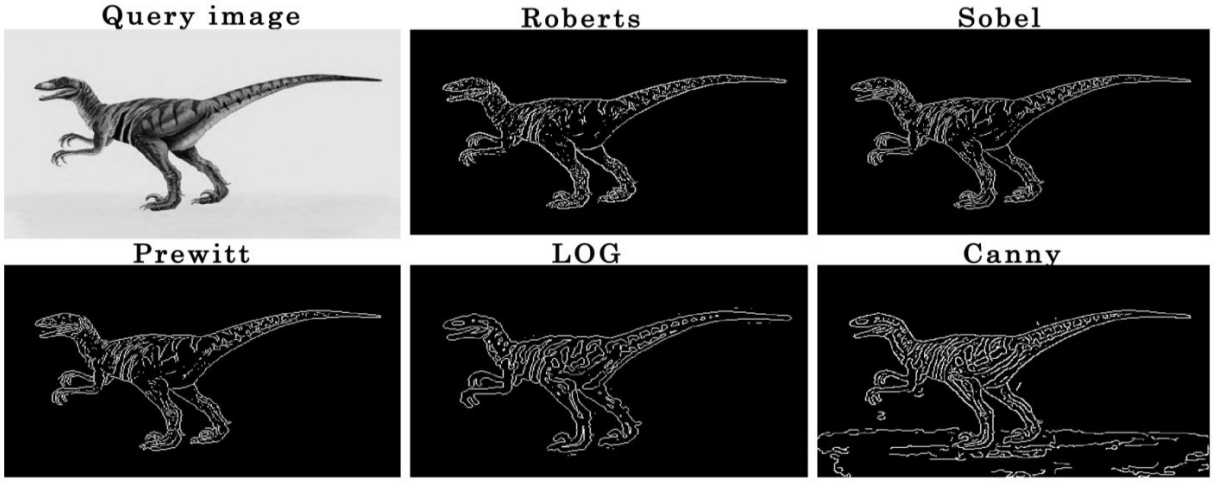

Fig. 4. Query as 'Dinosaurs' image with each edge method

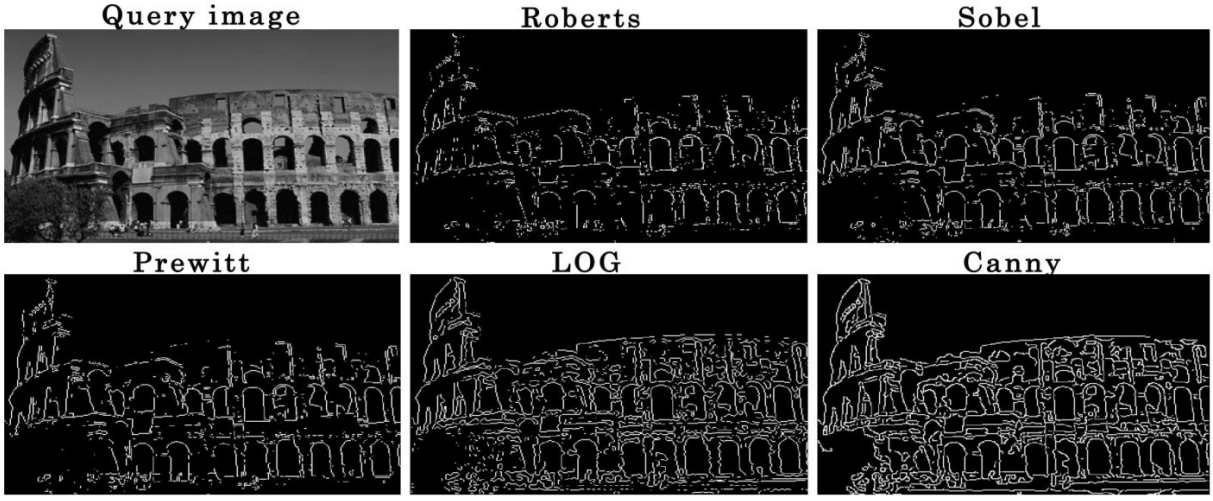

Fig. 5. Query as 'Buildings' image with each edge method

ratio of the number of retrieved images (T_b) and the total number of images $(T_b + F_p)$.

$$Precision = \frac{T_p}{T_p + F_p} \tag{17}$$

- Recall explains the ability of a classification model to identify all relevant images.

$$Recall = \frac{T_p}{T_p + F_n} \tag{18}$$

- F1-Score is a single metric which is the harmonic mean and weighted average of precision and recall. It makes the balance between Precision and Recall.

$$F1Score = \frac{2 \times Precision \times Recall}{Precision + Recall} \tag{19}$$

In contrast, recall is called (TP) as the total number of retrieved relevant images, and TP+FN is defined as the total number of relevant images. The precision, which is defined as the returned list, as TP (True Positive) is greater than the number of positive images plus several false positive (FP) images retrieved. Recall defines the number of positive (TP), which is greater than the number of positive plus many false negatives [14]. we used three important evaluation metrics are 1. Precision 2. Recall 3. F1-Score and performance level presented in table I. Figure 3 shows the measure values where its efficiency and accuracy are evaluated over the Corel database using precision, recall and F1-Score.

Corel dataset contains 1K images in ten categories: African faces, beach, bus, etc. During the process, out of ten categories, one query image "Dinosaurs" was selected to find out the similarities between the query images and database images Finally, the experiment's outcome was measured using precision and recall as shown in Figure 3 [21].

We selected one query image from the Corel database to retrieve the top twenty images, which is similar to the selected query image. It proves the overall performance evaluation of

TABLE II
COMPARISON OF PROPOSED METHOD WITH EXISTING METHOD

S. No	Query Images	PM	J. Annorses	ElAlami et al	Chuen et al	L.K. Pavithra
1	African faces	0.82	0.86	0.703	0.683	0.81
2	Beach	0.86	0.81	0.561	0.540	66
3	Building	0.83	0.50	0.571	0.562	0.78
4	Buses	0.97	0.86	0.876	0.888	0.96
5	Dinosaurs	1.00	1.00	0.987	0.992	0.1
6	Elephants	0.87	0.84	0.675	0.658	0.70
7	Flowers	0.88	1.00	0.914	0.891	0.90
8	Horses	0.89	1.00	0.834	0.803	0.98
9	Mountains	0.96	0.56	0.536	0.522	0.67
10	Food	0.87	0.76	0.741	0.733	0.77
11	Average	0.89	0.819	0.739	0.727	0.83

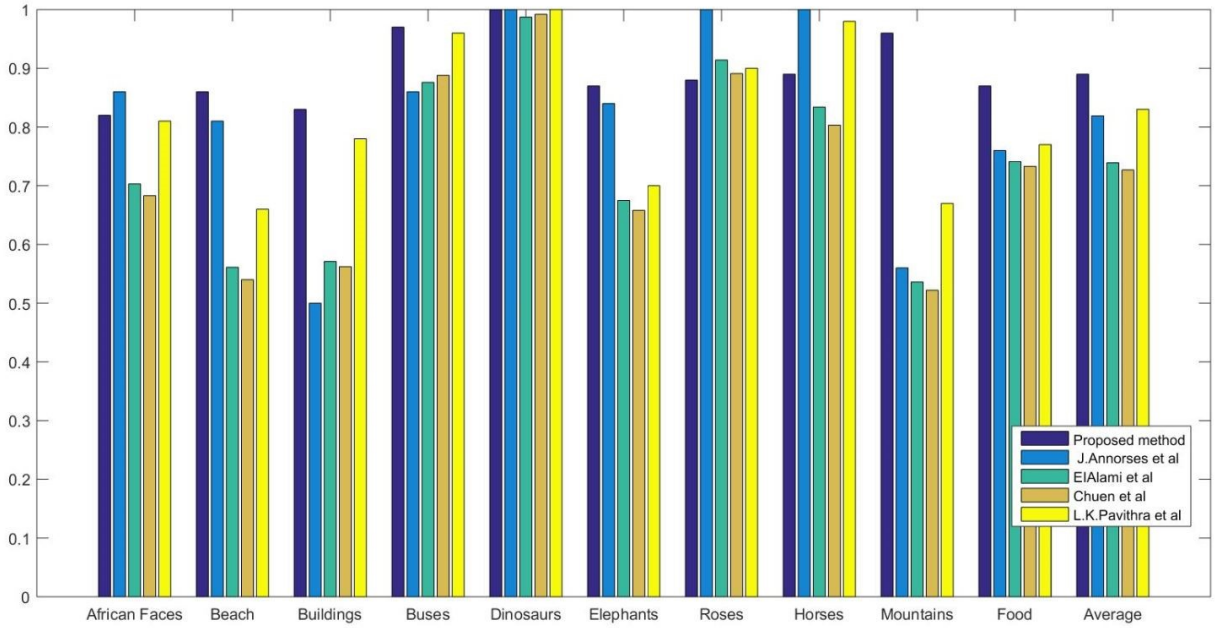

Fig. 6. Comparison of Proposed Method and existing Methods

Algorithm 1: Combined Edge Detection Method

```
Result: Query image and trained data
FindFeatureExtraction(queryimage);
while read n do
    Read the all Images ;
    if Convert query image to gray image then
        n=i ∈ type of feature extraction method;
        for i=1 to n do;
        FeaExQueryImg find (q, i);
    else
        return FeaExQueryImg ;
    end
end
```

the proposed method is successful. The results of the top twenty images are retrieved, as shown in Figure 7 and 2. The combined edge detection method is also called a hybrid approach [16]. It provides the right order to get an enhanced top twenty similar image. Hence, according to table II, the proposed method proves that the average execution time is drastically reduced compared to an existing process. It is implied that the proposed work gives an accurate total average of 0.89 % concerning the most similar images selected through the query images on the Corel database. Consequently, precision and recall proved the combined edge detection method (CED). First, the CED method followed the feature extraction from the multiple edge method, then it computed the single features that were retrieved using the Corel database [22]. Finally, Figure 6. Show the proposed framework improved the retrieved result besides enhancing the accuracy and sensitivity. Thus, the result retrieval performance levels was significantly improved when compared to other existing methods.

VII. CONCLUSION

This paper has presented a new model of combined edge detection that is computationally attractive. It computes different edge features with a limited number of selected pixels from

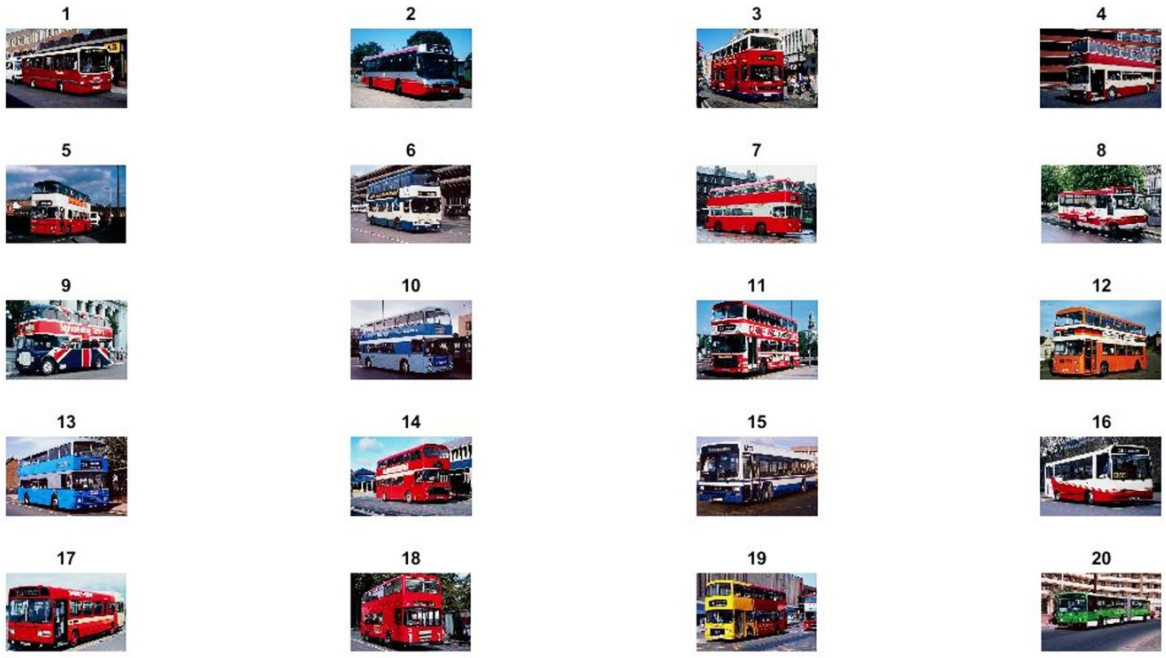

Fig. 7. Top twenty images are retrieved using (CED) method

the edge regions. The proposed method provided enhanced results compared to other edge detection methods, which is less responsive to noise and provided more similar images. This method has experimented on the Corel dataset, which proved the defects of most of the pictures. The evaluation results demonstrated that the performance of this proposed combined edge detection method (CED) is better than an individual edge detection method in terms of accuracy and retrieval time.

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