Classification of medical X-ray images using supervised and unsupervised learning approaches

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Article Info

Article history:

Received Nov 21, 2022
Revised Feb 1, 2023
Accepted Feb 4, 2023

Keywords:

Content-based image retrieval
Feature extraction
Fuzzy logic
Medical image
Similarity matching
Support vector machine

ABSTRACT

Most of the traditional approaches for medical image storage are least capable and scanning of relevant matching images are quite difficult. The existing approaches of content-based image retrieval (C-BIR) are less focused with medical images. The available research works with fuzzy logic approaches are very less and not efficient for medical image retrieval. Thus, there is a need of research work that can address both supervised and unsupervised learning approaches for medical image retrieval. Hence, the C-BIR technique is evolved with overcoming above stated concerns. Hence, this manuscript introduces two different C-BIR techniques using a support vector machine (SVM) and a fuzzy logic-based approach for classification. These approaches work on the classification based on feature extraction, region of Interest (ROI), corner detection, and similarity matching. The proposed approach has been analyzed for image retrieval for accuracy. The outcomes of the proposed study enhance the classification performances with retrieval than existing techniques of C-BIR.

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1. INTRODUCTION

The sophisticated life of humans without exercise has posed life to diseases. Hence, there is a need for disease diagnosis for better medication and to reduce the death rate. The area of biomedical engineering helps to provide proper justification for the disease diagnosis. However, there is the lackness of clarity on the process of medical engineering in biology and medical field. The capturing and storing of large-sized medical images is possible through today's innovative programming and equipment innovation [1]. These images can be analyzed and processed for medical treatment. The traditional medical image storage and indexing approaches are mentioned as less effective [2]. However, identifying the respective similar image from the large database is quite a difficult task. Thus, the idea of content-based image retrieval (C-BIR) comes into mind as a better way of identifying similar images through feature matching. The existing approaches of data storage and image classification exhibit a two-step flow in which step 1 does the image component separation and step-2 by comparing the image components of the recognizable form [3].

This existing way of image retrieval is specific and they need more human intervention for image retrieval while C-BIR needs the least human intervention [4]. C-BIR gives better image retrieval performance even for large datasets where it allows the user to select an image as a query image. The query image can be kept aside from the database and retrieved similarly from among the database [5], [6]. The C-BIR technique helps to address the concerns of the retrieval such as scanning similar images from a large dataset. The C-BIR works with contents and visual components like shading and surface [7]. The existing content-based feature extraction methods are more in number while visual feature extraction-based approaches are limited in number. In visual component scope, the elements can be of general elements and space particular elements [8].

The visual components used for image indexing and similar image retrieval can be grouped as i) low level contents such as shape, shading and surface, ii) medium level contents represent the image by an article accumulation and their spatial connections, and iii) dynamic contents indicates the semantic and logical elements [9], [10]. These significance of the C-BIR technique makes more prominent in research area. Hence, this manuscript introduces two different C-BIR techniques using a support vector machine (SVM) and a fuzzy logic-based approach for classification. These approaches work on the classification based on feature extraction, region of interest, corner detection, and similarity matching. The proposed approaches are analyzed for image retrieval for accuracy. The manuscript is categorized as literature survey in section 2, method in section 3, results and discussion in section 4 and conclusion in section 5.

2. LITERATURE SURVEY

The research works focused with C-BIR using supervised and unsupervised learning approaches analyzed in this section to extract the research gap. Siradjuddin *et al.* [11], they have mentioned a Rocchio Algorithm with statistical distance and pre-filtering features for similarity matching and performed the image retrieval. Also used relevance feedback is used to enhance the performance of image retrieval. Raja *et al.* [12], a region of interest (ROI) based C-BIR is introduced by considering multilabel neighborhood propagation for edge detection and correlation. The study utilized a SVM approach for classification of high-level image retrieval. Zhao *et al.* [13], a disambiguation approach is illustrated to perform the instance level classification and achieve higher degree of efficiency, robustness, and accuracy in image retrieval. A survey has been done in [14], for C-BIR and various parameters with the different dataset have been mentioned in this paper. A semi-supervised learning approach is introduced in [15] for large database containing image retrieval. Grivei *et al.* [16], a SVM approach is presented with filtering and similarity matching for query image related results. The comparative analysis of [16] suggests better precision and computational efficiency.

Mezzoud *et al.* [17], an approach for disease diagnosis mechanism using C-BIR is introduced for histopathological images. The outcomes of the study yield higher accuracy and better retrieval in support of medical research. A similarity matching process is [18] for radiological images. The study has enhanced the retrieval performance with higher precision of medical images. Zhu *et al.* [19], an unsupervised learning approach is presented with visual hashing to increase C-BIR performance. The study has considered web images for C-BIR and found to be effective in retrieval. Chauduri *et al.* [20], a graph theory-based image retrieval is introduced that eliminates the cost and computational time of multi-label annotating images. The process of diagnosing cancer in the early stage is very much essential. Hence, the multi-parametric prostate MRI tool can be useful in prostate cancer diagnosis [21], have interpreted with CBIR. A comparative analysis is conducted with deep learning based CBIR’s and achieved diagnostic medical imaging retrieval [21]. The cancer diagnosis mechanism through C-BIR is presented in [22], by using MRI tool (of multi-parametric).

Ahmed *et al.* [22], various complex datasets are trained and classified for C-BIR technique. This study has yield higher precision, F-score and recall for the complex datasets. A survey work of [23], have discussed various aspects of supervised and unsupervised mechanisms for C-BIR to match similar images to the query image. Qaznfari *et al.* [24], fuzzy relevance is used to perform C-BIR through gradient learning approach and achieved efficient image retrieval. The multi-dimensional features of the medical images are considered for retrieval in [25], and achieved efficient retrieval through similar features matching. A type-2 fuzzy membership functions are used to extract features [26]. The outcomes of the study yield higher accuracy in retrieval for three different medical image databases.

Further, the biomedical engineering has offered significant aspects for the medical research area. The medical practitioners are mainly focused on early detection, diagnosis of diseases to reduce the health risk factors through medical image processing [26], [27]. The advancement in medical research eases disease diagnosis though idea of image retrieval [28]. Battur and Jagadisha [29], they presented a discrete-wavelet-transform as well as bhattacharya co-efficient for the retrieval of the medical image. In this paper, they have used a grey-level-cooccurrence matrix which provides information for the pixel values. From the analysis of the research background gives an idea of research gap and is described. Many of the image retrieval techniques has been presented in recent past as discussed in research background and by which research gap is extracted. Most of the traditional approaches for medical image storage are least capable and scanning of relevant matching images is quite difficult. The existing C-BIR approaches with supervised and unsupervised learning approaches are rarely considered in the research area and it lacks with comparative analysis. The existing approaches of C-BIR are less focused with medical images. The available research works with fuzzy logic approaches are very less and not addressed with comparative analysis for medical image retrieval. Thus, there is a need of research work that can address the both supervised and unsupervised learning approaches for medical image retrieval. Hence, this manuscript contributes to the research area by presenting SVM based C-BIR for medical image retrieval by capturing edge histogram, block division and colour layout features. Also, a fuzzy logic based edge detection is presented by which edges are used to perform the image retrieval. A comparative analysis is conducted in the proposed work that highlights the significance of the image retrieval with various correl database images. The elaborated design of the proposed image retrieval techniques are discussed in sections.

3. METHOD

In this section, the proposed method has been given. In this section the classification of medical images using retrieval and classification algorithm have been discussed. Further, the classification of the algorithms has also been discussed. An SVM classifier algorithm and a fuzzy logic algorithm for the classification of the C-BIR has been discussed in this section.

3.1. Classification of medical images using retrieval

The research work introduces the C-BIR techniques using a SVM and a fuzzy logic-based approach for classification. These approaches works on the classification based on feature extraction, region of interest (ROI), corner detection, and similarity matching. The block diagram of the proposed C-BIR techniques for classification is given in Figure 1.

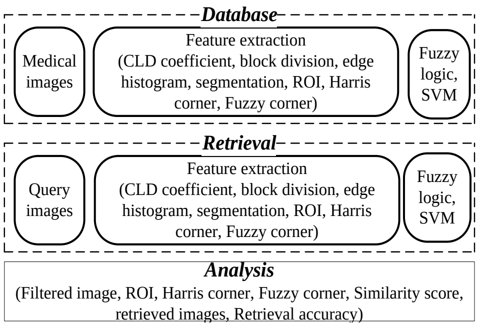
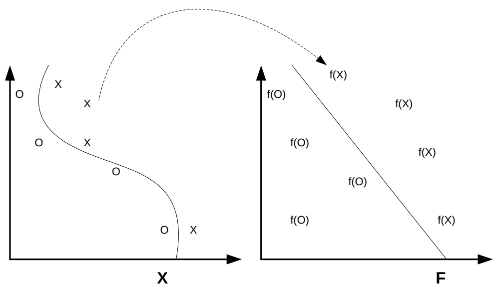


Figure 1. Block diagram of the proposed C-BIR techniques for classification

The proposed C-BIR techniques used correl database of medical images containing X-ray images of brain, chest, mammogram, spine, hand, and ankle. These database images are considers for feature extraction edge histogram, block dimension, color layout, ROI, Harris corner, and fuzzy corner. All the database images are trained for feature extraction. Further, a query image is selected for image retrieval through fuzzy logic and SVM by considering feature extraction like edge histogram, block dimension, colour layout, ROI, Harris corner, and fuzzy corner. These images with similar features matching are considered for classification. The similarity score for both query and database images are calculated to retrieve similar images. The image database is considered as two sets vector of dimension ‘n’ and hyperplane construction is performed to enhance the margin between retrieval image and query image. A kernel method is considered in SVM approach for maximum margin classifier which uses kernel function. The kernel method maps the data to the high dimensional kernel space implicitly. The margin classifier is determined in kernel space and decision function in the original space (i.e., non-linear data) [30]. The classification of this data into linear data from feature space in kernel space can be performed by using SVMs as shown in Figure 2. The data merging in the original space has been shown using Figure 2(a) and the data merging in the original space by using function ‘F’ has been shown in Figure 2(b). The proposed SVM mechanism aims to find an optimal hyperplane to distinguish relevant and irrelevant vectors by maximizing the size of the classification margin.

The SVM based C-BIR approach improves the speed of image retrieval for large databases and brings higher rate of accuracy in retrieval. The SVM approach is significant because it does not contains unsupervised clustering and labelled data. The image clustering meant with similarity measures and classification via SVM approach [31]. Similarly fuzzy logic based approach for classification through corner detection aims to detect the ROI of database images. The median filter is used to extract the ROI through global threshold feature. Further layer segmentation of dimension reduction type is applied to get the layer segmented image from the ROI extracted image with customized function. The prime concern of handling the fuzziness and features on

Harris corner point detection is used and then optimization is adapted for optimization through fuzzy corner points. The database image is subjected to gray image conversion if it is a colour image. The resizing of the image is conducted and applied with median filtering that determines the output pixel values by median of neighbourhood pixels. The median filtering removes the outlier without compromising the image sharpness. Further, ROI is extracted from the medical image in a rectangular square by using Otsu method that converts the grayscale image into binary image. The layer segmentation is used in the proposed work that parts the image into various parts to identify the relevant information. During the operation of layer segmentation, the ROI image part matrix is converted as intensity image of black and white. Then image reshaping is performed and obtained a segmented image. The image corners represents the unique features of the image and that helps in recognition of the image objects. These corners composed of high curvature that are not meant by illumination. The corner matrix is used to detect the corner features. The Harris corner points are considered in the proposed work. Further, the fuzzy corner points are identified by using the S-function. In order to detect the medical image corners, fuzzy rules are used that considers four pixel values as inputs and yields single output. These fuzzy sets are belongs to white and black membership function.



(a) (b)

Figure 2. Data merging in the original space of (a) kernel space and (b) by function 'F'

3.2. Classification of algorithms

This section meant with elaboration of classification algorithms like SVM classifier and fuzzy logic. The algorithm of SVM classifier for image retrieval. In this section both the algorithms have been discussed. Further, a flowchart of the proposed work using the SVM classifier algorithm as well as the fuzzy logic algorithm have been discussed.

3.2.1. SVM classifier algorithm for classification

The multiple images from medical database are considered for feature extraction (Step-1). The database images composed of different image types and are catogorized. The features like block division, edge histogram, and CL descriptor coefficients are extracted using SVM approach. These extracted features are helpful in image retrieval through feature similarity matching. i) input: Query image, database of medical images, query image and ii) output: similarity matching.

Begin Step-1: Consider database images→ Chose→ Medical images→ Group→ Medical images→ Feature extraction→ CL coefficient, block division, and edge histogram→ Use→ SVM and train→ Save→ Database (trained images).

Begin Step-2: Image retrieval→Chose→Query image→Feature extraction→CL coefficient, block division, and edge histogram→Retrieve→Similar matched images.

3.2.2. Fuzzy logic for classification

The multiple images from medical database are considered for feature extraction (Step-1). The database images composed of different image types and are catogorized. The median filter is used for database images and performed thresholding to obtain quality image. Further, layer segmentation is applied to extract the ROI of medical image. The corner detection is performed that involves Harris corner detection and in which fuzzy approach is used to find the optimized form of corners i.e., fuzzy corners. These extracted features are helpful in image retrieval through feature similarity matching. The flow chart of the proposed C-BIR techniques using a SVM and a fuzzy logic-based approach for classification is given in Figure 3. i) Input: Query image, Database of Medical images, Query image and ii) Output: Similarity matching.

Begin Step-1: Consider database images→ Chose→ Medical images→ Group→ Medical images→ Feature extraction→ Layer segmentation, ROI, Harris corner, and Fuzzy corners→ Use→ Fuzzy logic and train→Save→Database (trained images).

Begin Step-2: Image retrieval→Chose→Query image→Feature extraction→layer segmentation, ROI, Harris corner, and Fuzzy corners→Retrieve→Similar matched images, End.

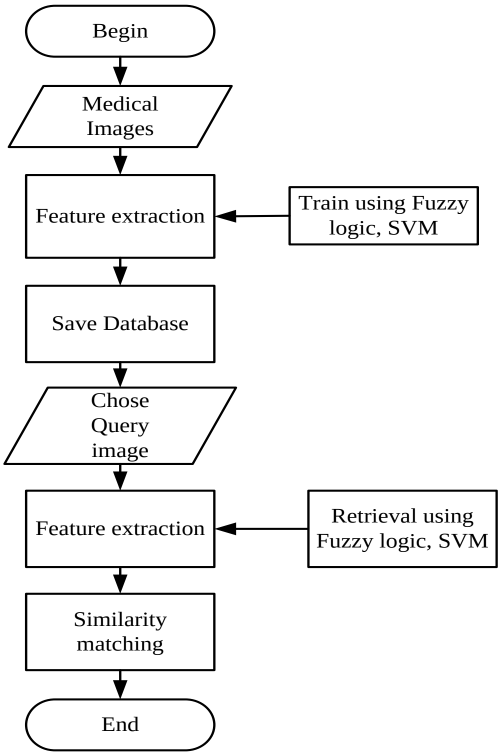


Figure 3. Flow of proposed C-BIR techniques using SVM and a fuzzy logic-based approach for classification

4. RESULTS AND DISCUSSION

The confusion matrix is used for validation of the proposed classification model. Using a confusion matrix, the parameters like accuracy (Acc), precision (Pr), recall (Re), and f-measure (Fm). The Acc is calculated by using,

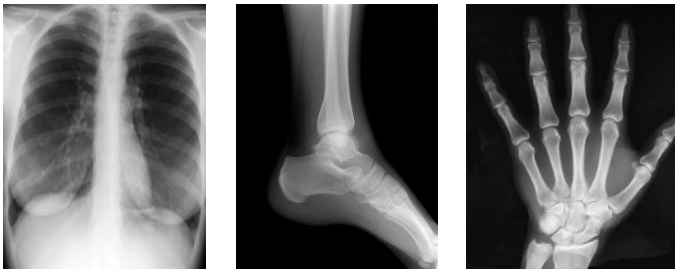
$$Acc = \frac{T_p+T_n}{T_p+T_n+F_p+F_n} \quad (1)$$

$$Pr = \frac{T_p}{T_p+F_p} \quad (2)$$

$$Re = \frac{T_p}{T_p+F_p} \quad (3)$$

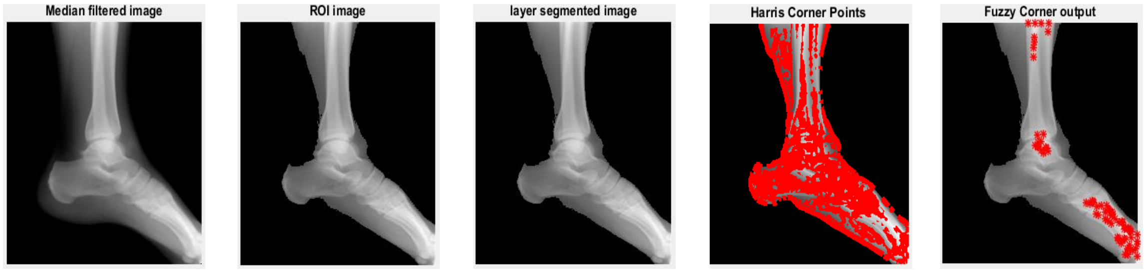
$$Fm = \frac{2\times Pr\times Re}{Pr+Re} \quad (4)$$

The obtained results from the proposed C-BIR techniques using SVM and fuzzy logic-based approach for classification are discussed in this section. The sample images of the database are given in Figure 4. In the Figure 5, the features which have been abstracted has been shown. Further, the features extracted for ankle database after training the database using Fuzzy logic and SVM based C-BIR are given in Figure 5(a) and Figure 5(b) respectively.



Chest database Ankle database Hand database

Figure 4. Different database images



Median filtered image ROI image Layer segmented image Harris corner points Fuzzy corner points

(a)

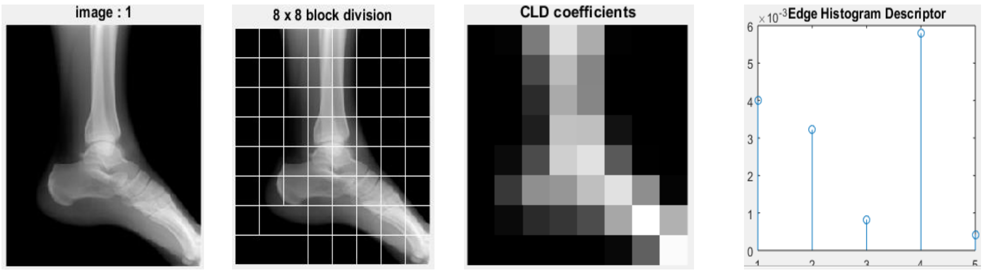


Image: 1 8×8 block division CLD coefficients Edge histogram descriptor

(b)

Figure 5. Features extracted for (a) ankle database using fuzzy logic and (b) ankle database using SVM

The selected images are catogorised with specific database name and trained using SVM and fuzzy logic. Further, the process of retrieval by choosing a query image from ankle database for features matching. This process gives the retrieved images with similar features obtained using fuzzy logic and SVM classifier as shown in Figure 6. The similarity matching score of the query image with database images is represented in Figure 7 where with similar texture, shape, and color features is given in Figure 7. The selected query image of ankle with similar texture, shape, and color features has highest matching score. The performance of the proposed C-BIR technique is performed by comparing with existing works that uses similar Corel database as tabulated in Table 1. The observation suggests that the proposed C-BIR approach is more accurate than existing techniques. The retrieval accuracy of the proposed C-BIR technique is performed by comparing it with existing works that use a similar corel database as tabulated in Table 2. The observation suggests that the proposed C-BIR approach is more accurate than existing techniques.

Table 1. Performance analysis

Method	Retrieval accuracy
Epischina *et al.* [32]	90.09
Tarjoman *et al.* [33]	97.03
Shivamurthy [34]	97.00
Proposed classification approaches	97.22

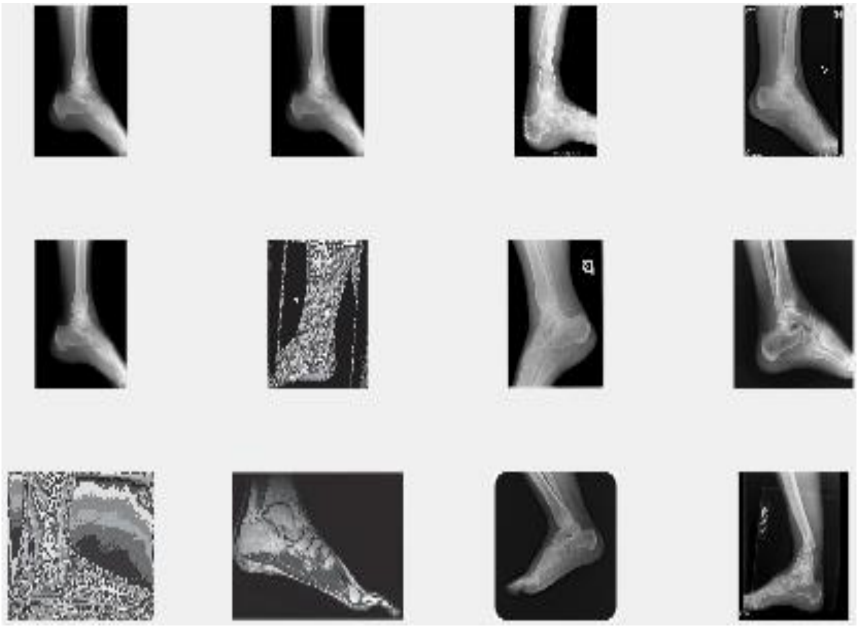


Figure 6. Retrieved images from database

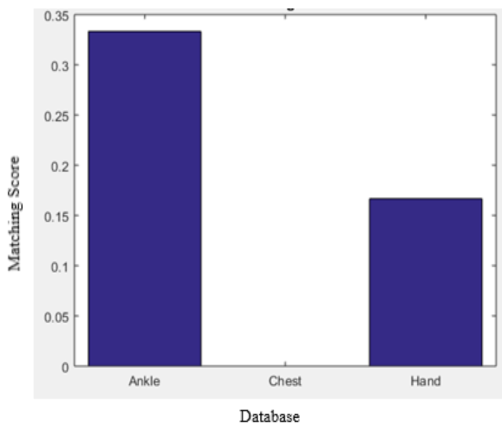


Figure 7. Similarity matching score

Table 2. Retrieval accuracy

Method	Retrieval accuracy (%)
Tarjoman *et al.* [33]	90.09
Shivamurthy [34]	97.03
Battur and Jagadisha [29]	97.00
Proposed classification approaches	99.9

The validation of the proposed method is conducted by using a confusion matrix. The confusion matrix in machine learning helps to know the efficiency of the proposed classification model. Using the confusion matrix the parameters like accuracy, error rate, recall, precision, and F-measure are calculated. The performance analysis is given in Table 3.

Table 3. Performance analysis

Parameter/Method	Accuracy (%)	Recall	Precision	F-measure
Praveena *et al.* [35]	98.88%	98.85%	99.90%	99.48%
Kumar and Mohan [36]	86.80%	91.7%	79%	84.9%
Proposed method	99.9%	85%	70.8%	77.25%

5. CONCLUSION AND FUTURE WORK

The advancement in medical research eases disease diagnosis though idea of image retrieval. Many of the image retrieval techniques has been presented in recent past as discussed in research background and by which research gap is extracted. Most of the traditional approaches for medical image storage are least capable and scanning of relevant matching images is quite difficult. The existing C-BIR approaches with supervised and unsupervised learning approaches are rarely considered in the research area and it lacks with comparative analysis. The existing approaches of C-BIR are less focused with medical images. Hence, this manuscript contributes to the research area by presenting SVM based C-BIR for medical image retrieval by capturing edge histogram, block division and color layout features. Also, a fuzzy logic-based edge detection is presented by which edges are used to perform the image retrieval. A comparative analysis is conducted in the proposed work that highlights the significance of the image retrieval with various correl database images. The observation suggests that the proposed C-BIR approach is more accurate than existing techniques. The performance analysis of the proposed approach suggests a higher accuracy of retrieval in medical images and it will classify the retrieved image category effectively. Thus, the proposed approach can be considered for medical image retrieval research and the study can be further extended with future research.

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