의료영상 검색 응용을 위한 DWT 분해를 이용한 Edge Histogram Descriptor

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Edge Histogram Descriptor with DWT Decomposition for Medical Image Retrieval Applications

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Abstract

When faced with challenging diagnostic cases, radiologists often rely on public and/or internal databases to find similar cases that can aid in their decision-making process. Manually finding similar images in a large database is time-consuming and places a significant burden on their workflow. Several techniques are proposed to replace this labor-intensive task with an automated content-based medical image retrieval (CBMIR) system. However, conventional CBMIR systems often fall short due to the complex, overlapping, and noisy nature of medical images, making it difficult for clinicians to find accurate relevant images for diagnosis and research. To address these limitations, we propose a feature extraction technique that integrates edge histogram descriptor with discrete wavelet transform decomposition to define an image in a high-dimensional feature space for retrieval applications. The main advantage of proposed technique is that it does not rely on color information, which makes it suitable for grayscale medical images. Simulation analysis on brain tumor image dataset shows that proposed scheme achieves better retrieval performance (i.e., 5% higher mean average precision score) than conventional CBMIR schemes with a comparable computational complexity.

Ⅰ. INTRODUCTION

Content-Based Medical Image Retrieval (CBMIR) plays a crucial role in computer-aided disease diagnosis, treatment planning, and research by providing relevant images from a large database. However, intricate anatomical structures, frequent noise, and inherent variability in medical imaging data pose significant challenges in a CBMIR application. Unlike color image retrieval (e.g., [1]) where the color information can be leveraged, medical images are typically grayscale, which complicates the retrieval process. Color image retrieval systems tend to exhibit greater efficiency due to the availability of large datasets, and there are no strict requirements for accuracy. In contrast, CBMIR systems face challenges related to data scarcity, and the necessity to achieve near-flawless accuracy, as these systems directly impact clinical decision-making and patient outcomes.

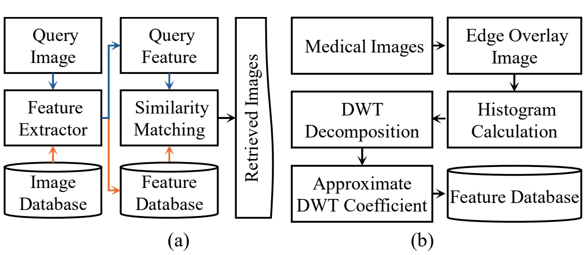


Fig. 1. (a) Proposed medical image retrieval framework. (b) An illustration of edge histogram descriptor with DWT

To address these challenges, we propose a CBMIR scheme that integrates edge detection with Discrete Wavelet Transform (DWT) decomposition to capture the essential features of medical images while reducing the dimensionality of the feature vector. This approach modifies the color image retrieval technique proposed in [2] by excluding the color information processing. For feature matching, the proposed scheme computes the minimum cosine distance between query and stored image feature vectors.

Ⅱ. METHODS

Fig. 1. shows our proposed CBMIR scheme that consists of two main modules: feature extraction and feature matching. The overall procedure is explained below:

Step 1). First, generate an edge map of the input medical image by applying an edge detection algorithm (e.g., Canny edge detector). Then, combine them together to produce an edge overlaid image that highlights its structural features.

Step 2). Calculate a histogram from the edge overlaid image as initial feature vector (ϕ) of size $M = 256$.

Step 3). Apply DWT decomposition to feature vector ϕ at various levels $l = \{1, 2, 3, 4\}$ to reduce its size as $\alpha = M/2^l$. At each decomposition level l, only the approximate DWT coefficients are retained to form the final feature vector φ.

Step 4). The final step is to compare the query image features φ_q with that of the stored images φ_s in the feature matching module using cosine distance metric.

Ⅲ. RESULTS AND DISCUSSIONS

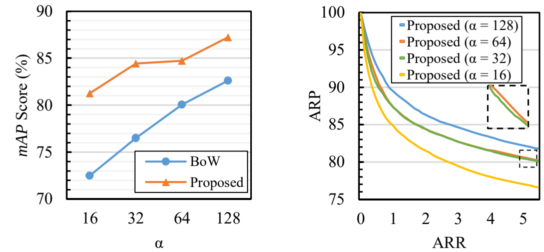
In this section, we evaluate the efficiency of proposed medical image retrieval scheme on brain tumor dataset [3] that consists of 2,124 images in total. These images are of varying sizes and are uniformly distributed among three tumor types. All these images were stored in the database, and for query they were rotated 90 degrees counterclockwise.

The efficacy of proposed CBMIR scheme was assess using precision, recall and mean average precision (*mAP*). In general, precision determines the proportion of relevant retrieved images, while recall measures the system's ability to correctly identify all relevant images. Additionally, the *mAP* score defined in (1) considers average precision (AP) across the ranked list positions where relevant images appeared.

$$mAP = \frac{1}{Q}\left(\sum_{q=1}^{Q} AP_q\right), \quad (1)$$

where, $AP_q = \frac{1}{G}\sum_{n=1}^{N} \frac{TP@n}{n} \times f(n)$ is the AP score for each query image. Also, N is the total number of images stored in the database, G is the number of ground-truth images for a query image, and $TP@n$ is the number of true positive matches at rank n. Also, if the n^{th} image is a ground truth, then $f(n) = 1$ otherwise, $f(n) = 0$. Higher values of these metrics indicate superior performance of an image retrieval.

The performance of proposed scheme was compared with Bag of Words (BoW) method implemented in [3] by varying the number of features (α) as shown in Fig. 2. (a). Here, the number of retrieved images was set to be 10. In terms of the *mAP* score, proposed scheme outperformed BoW method by 5% to 9% across different values of α. It is noteworthy that our approach is closely related to BoW technique, but when comparing with an advanced method proposed in [3], our scheme achieved 7% lower *mAP* score. However, this performance gain can be attributed to the learned distance metric, which is computationally expensive. For a fair comparison, when considering this technique with the Euclidean distance, its *mAP* score is degraded by 27% compared to ours. In addition, Fig. 2. (b) plots the Precision-Recall curve to analyze the impact of DWT decomposition on retrieval performance of proposed scheme. The curves are plotted by varying the number of retrieved images (i.e., 1 to 50). It can be seen that higher number of features is beneficial in retrieving larger number of images.



(a) (b)

Fig. 2. Performance comparison of image retrieval schemes. (a) is mAP score by varying feature vector size (retrieved images number is 10). (b) Precision-Recall curve (retrieved images number varied between 1 to 50).

IV. **CONCLUSION**

This study developed a histogram-based feature extraction strategy tailored to meet the requirements of grayscale medical image retrieval applications. Simulation results showed that proposed method outperformed conventional approaches on the same dataset, indicating its potential for improved retrieval performance in medical imaging. Histogram-based feature descriptors are invariant to perceptual encryption transformation functions. Therefore, in the future we are interested in implementing our scheme considering privacy preservation.

ACKNOWLEDGMENT

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government. (MSIT) (RS-2023-00278294).

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