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Image retrieval using indexed histogram of Void-and-Cluster Block Truncation Coding

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ABSTRACT

This paper presents a simple approach to improve the image retrieval accuracy in the Void-and-Cluster Block Truncation Coding compressed domain. The proposed approach directly derives an image descriptor from the Ordered Dither Block Truncation Coding (ODBTC) data stream without performing the decoding process. The Color Histogram Feature (CHF) is generated from the two ODBTC color quantizer, while the Halftoning Local Derivative Pattern (HLDP) is constructed from the ODBTC bitmap image. The similarity between two images are measured from their CHF and HLDP features. Three schemes are involved to improve the image retrieval accuracy, including the similarity weight optimization, feature reweighting, and user relevance feedback optimization. An evolutionary stochastic algorithm is exploited to optimize the similarity weight and feature weight in the nearest neighbor distance computation, as well as in the query update of relevance feedback optimization. Section 5 shows that the proposed scheme yields a promising result, and thus it can be a very effective candidate in addressing the content-based image retrieval and image classification task.

1. Introduction

The main goal of image retrieval system is to retrieve a set of images from a collection of images in the database to meet the user requirements using the similarity parameters such as the image content similarity, edge pattern similarity, texture similarity etc. An image retrieval system should offer an easy way to efficiently access, browse, and retrieve images from a database with a given query image in real-time applications.

Many schemes have been developed to solve and improve the retrieval accuracy of the content-based image retrieval. One of them is the image retrieval system using the feature descriptor constructed from the compressed data stream [5–13]. This strategy reduces the computation time for feature extraction since most of the images are already stored in the compressed domain, and the compressed bit streams are not necessary to be decoded in the feature extraction. In [5–7], an image feature is directly computed from the Block Truncation Coding (BTC) and halftoning-based BTC compressed data stream without performing the decoding process. In this scheme, the system operates in two phases, i.e. indexing and searching. In the indexing phase, the image feature for all of images in database are extracted and stored in database as feature vector. In the searching phase, when a user submit a query image, the system extracts the image feature and subsequently the similarity criterion is used to compare this

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feature with the feature vector in database to retrieve a set of relevant images to the user.

The Ordered Dither Block Truncation Coding (ODBTC) [1,2] compresses an image with a low computation requirement. The ODBTC offers the parallelism advantage in which several image block can be processed concurrently. Compared to the BTC scheme, the ODBTC employs the dither array Look-Up-Table (LUT) as threshold values to generate the bitmap image rather than the fixed average value (mean value) employed in the typical BTC approach. The BTC computes the first and second moments to produce two quantizers, i.e., high and low means, while the ODBTC simply identifies the minimum and maximum values in an image block. As a result, the ODBTC offers its superiority in terms of image compression [1,2], image watermarking [3], reversible data hiding [4], and content-based image retrieval (CBIR) [5–7].

To improve the retrieval rate, several strategies have been proposed in the literature, including the optimization process for finding the similarity weight constant [5], and incorporating user feedback [14,15], etc. In this paper, the effectiveness of ODBTC scheme is incorporated into the CBIR domain. In this system, the ODBCT extracts the image feature without really performing an image compression to obtain a set of quantizers, and the ordered dither bitmap image. The image feature is generated from the ODBTC data stream. The proposed method employs two image features, namely Color Histogram Feature (CHF) extracted from the two ODBTC color quantizers, and the Halftoning Local Derivative Pattern (HLDP) obtained from the ODBTC bitmap image. The CHF computation is faster than that of the Color- Co-occurrence Feature (CCF) [7] calculation, since the CHF avoids the color co-occurrence matrix and histogram binning computation performed on CCF. The HLDP also reduces the computational time by avoiding the bit pattern indexing as conducted on Bit Pattern Feature (BPF) [7] calculation. As documented in Section 5, the proposed scheme can provide a promising retrieval performance compared to the state-of-the-art schemes.

The rest of this paper is organized as follows. We give a brief introduction of Ordered Dither Block Truncation Coding (ODBTC) and Vector Quantization (VQ) in Section 2. Section 3 presents the proposed ODBTC image retrieval system. Several strategies to improve the retrieval strategy are delivered in Section 4. The extensive experimental results are reported at Section 5. Finally, we draw the conclusion at the end of this paper.

2. Void-and-Cluster Block Truncation Coding

This section provides a review of the Ordered Dither Block Truncation Coding (ODBTC) for color image compression. The ODBTC technique compresses an image in effective way by involving the Look-Up-Table (LUT) strategy. The dither array is constructed using the Void-and-Cluster strategy in the training stage. The ODBTC employs this dither array to generate a bitmap image, and simultaneously it produces two extreme quantizers, namely minimum and maximum quantizers. The ODBTC offers a great advantage in its low computational complexity for generating the bitmap image and two extreme quantizers. In addition, the ODBTC scheme yields a better reconstructed image quality compared to that of the typical BTC method. The detail comparisons between ODBTC and BTC image compressions can be found at [1,2].

BTC and ODBTC have the same characteristic in which the bitmap image and two extreme values are produced at the end of encoding stage. In contrast to the BTC, ODBTC avoids mathematical operation, i.e. multiplication and division, for obtaining the bitmap image and two extreme quantizers. In BTC scheme, the two quantizers and its image bitmap are produced with the first-order moment, second-order moment, and variance value computation, causing a high computational burden. Suppose that an image F of size $M \times N$ is firstly partitioned into multiple non-overlapping blocks of size $m \times n$. The ODBTC produces a single bitmap image $\mathrm{bm}(x,y)$ and two extreme quantizers ($q_{\min}$ and $q_{\max}$). The bitmap image has the same size with the original image. The two extreme quantizers, consisting RGB color information, are obtained by searching the minimum and maximum values over all pixels in each image block. Fig. 1 shows the schematic diagram of joint image compression and retrieval system using the ODBTC method. The ODBTC is not only able to compress an image, but also it can be used to index an image in a CBIR system.

Let $D(x,y)$ be an ODBTC dither array, where $x=1,2,\ldots,m$ and $y=1,2,\ldots,n$. The scaled version of dither array is requested for generating the bitmap image. To further reduce the computation burden, the scaled dither array can be pre-computed and stored in the LUT for later usage. This strategy can be very useful in practical application required the real-time computation. The scaled dither array can be offline pre-computed as follow:

$$D^d(x,y) = d\frac{D(x,y) - \min_{\forall x,y} D(x,y)}{\max_{\forall x,y} D(x,y) - \min_{\forall x,y} D(x,y)}, \quad (1)$$

where d denotes the dither array index in LUT, i.e.

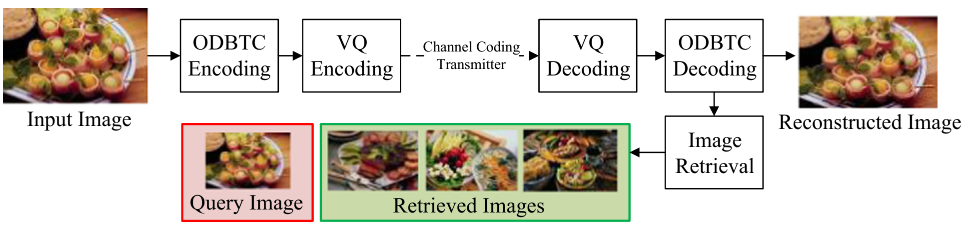

Fig. 1. Schematic diagram of joint image compression and retrieval.