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Segmentation-based compression: New frontiers of telemedicine in telecommunication

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ABSTRACT

This study proposes a novel segmentation-based compression scheme for new frontiers of telemedicine in telecommunication, where the aim is to improve the information transfer and communication between patients and medical staffs in telemedicine. The system mainly consists of improved watershed transform and modified vector quantization. Improved watershed transform is proposed to segment a medical image into several closed regions via region growing, which can achieve more efficient computation and classification. Modified vector quantization is proposed to analyze these regions with different compression rates according to the importance of the regions to simultaneously preserve important features and reduce the size of images. Experimental results indicate that the proposed system is robust and performs better than several previous methods. It is also suggested being suitable for the applications of telemedicine in telecommunication.

1. Introduction

Since the beginning of communication, technical uses have been limited to a few well-understood electrical and electromagnetic technologies, such as telegraph, telephone, networks, radio, microwave transmission, fiber optics, and communications satellites. In the past decade, however, the potential of unconventional technologies has become increasingly apparent, and a wide variety of concepts and applications are in the process of development (Ren et al., 2014). For example, complex baseband samples are compressed between baseband units and radio subsystems with distributed architecture under the constraints of wireless system in signal delay and hardware implementation. It can significantly lower the data rate while maintaining an acceptable distortion. Currently, telephone, networks, and communications satellites are the most popular new technologies for telecommunication. Although commercial applications of the segmentation-based compression technologies are still problematic, researchers currently involved in telecommunication have recognized the importance of telecare and telemedicine assessment using novel segmentation-based compression approaches (Yang, 2012). Segmentation-based compression technology is a novel concept that segments and compresses data before they are transfer to a distant place. More specifically, the data are segmented into several subdata. These subdata are then compressed with different compression rates according to their importance to preserve the information of important portion of subdata and reduce the size of total data at the same time, which can greatly improve the information transfer and communication for the applications of telecommunication, telemedicine, and telecare.

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2. Objective

Segmentation-based compression is a new technology (Joseph and Baskaran, 2011; Ren et al., 2014) that provides an alternative concept for quickly transferring information from one place to another by segmenting and compressing data before transmission. Further, segmentation-based compression might be a highly feasible method to assist medical staffs in telemedicine. Compression based on the segmentation of data or information associated with hospital and commercial databases have grown rapidly in the last decade. Segmentation-based compression analysis is based on segmentation and compression using the state-of-the-art or novel algorithms. For this, the conventional compression approach can be enhanced by means of several ways. These include, preprocessing, and an effective selection of the most appropriate parameters is known to improve the performance (Grinstead et al., 2008; Ren et al., 2014). However, the data and information are generally non-stationary and chaotic. This suggests that it is necessary to provide a robust and good-performance system for the applications of telemedicine in telecommunication.

3. State of the art

In general, segmentation-based compression procedures contain two main processes, image segmentation and compression. Image segmentation is an important process since it greatly affects the efficacy and effectiveness of compression rates. Image segmentation based on region-based techniques usually partitions pixels with common image properties into a region. The region-based watershed algorithm is an automated and unsupervised technique extensively used for segmentation. However, it has several inherent shortcomings, such as oversegmentation, sensitivity to noise, and poor detection of thin or low signal to noise ratio structures.

A large variety of approaches have been presented for the determination of watersheds (Couprie et al., 2011; Grau et al., 2004; Huang and Chen, 2004). A common framework, power watershed, is extended for graph-based image segmentation that includes the graph cuts, random walker, and shortest path optimization algorithms (Couprie et al., 2011). Viewing an image as a weighted graph, these algorithms can be expressed by means of a common energy function with differing choices of a parameter acting as an exponent on the differences between neighboring nodes. However, it still encounters the problems of sensitivity to noise and poor detection of low contrast structures even if it has partly overcome the drawbacks of oversegmentation. A marker-based watershed method (Grau et al., 2004) is proposed for knee cartilage and white matter/gray matter segmentation in magnetic resonance images. Although it improves segmentation results via the use of probability information, atlas, and markers, it is considerably difficult to be extended and applied to other fields. An integrated technique (Huang and Chen, 2004) that combines the advantages of neural network classification (Doukas et al., 2011; Saprikis, 2013) and morphological watershed segmentation is used to extract precise contours of breast tumors from medical ultrasound images. However, the segmented results are easily influenced by the convergence of neural network, which results in inaccurate segmentation. In the present study, we propose improved watershed transform to segment a medical image into several closed regions via region growing. In addition to resolving the shortcomings of conventional watershed, it can also achieve more efficient computation and more accurate classification.

For the compression process, vector quantization (VQ) is usually adopted to perform codebook design from training vectors (Riskin et al., 1990; Yang et al., 2011; Horng, 2012). The purpose of VQ is to create a codebook for which the average distortion caused by the approximation of a training vector and a codevector in the codebook is minimized. It can be considered as a clustering process where the training vectors are classified into specific classes based on the minimization of the average distortion between the training vector and codebook vectors. However, it is usually difficult to find an appropriate codevector in the codebook to minimize the average distortion. In addition, neural-network-based techniques (Uğuz, 2012) have been applied for VQ to produce the effects of batch and on-line operations. In VQ, the whole image is divided into blocks and mapped onto a neural network with each input representing a training vector and each output neuron representing a codevector of the codebook. However, it would produce overtraining and lead to poor reconstruction because of small blocks and outliers. The present study proposes modified vector quantization to overcome the above-mentioned issues and analyze segmented regions with different compression rates according to the importance of the regions to simultaneously preserve important features and reduce the size of images.

4. Materials and methods

4.1. Data acquisition and description

Three datasets were used to evaluate the performance of the proposed scheme.

In the first dataset, histological volume data were analyzed from a series of 50 µm thick c-Fos immuno-histochemistry-stained histological sections of the rat brain cut (Hsu, 2011). The c-Fos staining is used to enhance the contrast of brain cell bodies to make feature extraction procedure smoothly. There are total 97 slices in the volume data. Each image is acquired from slices in 1392 × 1040 pixel 24bit RGB format. However, with this instrument frozen tissue is cut with a microtome and the revealed block-face surface imaged. The sequential images are registered by virtue of the accurate repositioning of the tissue. Tissue differentiation is achieved by systemic staining.