Chapter XXIX
Advanced ROI Coding Techniques for Medical Imaging

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ABSTRACT

Medical images are often characterized by high complexity and consist of high resolution image files, introducing thus several issues regarding their handling. Current compression schemes produce high compression rates, sacrificing however the image quality and leading this way to unenviable examination. Region of Interest (ROI) coding has been introduced as an efficient technique for addressing such issues, by performing advanced image compression and preserving quality in diagnostically critical regions. This chapter discusses the basic ROI approaches and provides an overview of state of the art ROI coding techniques for medical images along with corresponding results.

BACKGROUND

Medical imaging has a great impact on medicine, especially in the fields of diagnosis and surgical planning. Proper assessment requires high image quality, which is translated into higher requirements for storage capacity and transmission bandwidth in applications like electronic health records and telemedicine applications. Medical image compression can reduce redundancy of the image data in order to be able to store or transmit data in an efficient form. Compression can be lossy or lossless; Lossy compression methods, especially when used at low bit rates, achieve higher compression ratio and size/rate reduction but also introduce compression artifacts. Lossless compression methods may also be preferred for high value content, such as medical imagery or image scans made for archival purposes. The tradeoff between lossy and lossless image compression can be addressed by introducing the Region of Interest (ROI) coding; for most medical images, the diagnostically significant information is localized over relatively small regions of interest. In this case, region-based coding offers better utilization of the available bit rate since the high quality should be maintained only for the aforementioned diagnostically significant regions and the rest of the image can be encoded at a lower bit rate.

INTRODUCING BASIC CONCEPTS OF ROI CODING

The functionality of Region of Interest (ROI) is important in medical applications where certain parts of the image are of higher diagnostic importance than others. In such a case, these regions need to be encoded at higher quality than the background. During image transmission for telemedicine purposes, these regions are required to be transmitted first or at a higher priority. In transformation-based ROI coding methods, the coefficients associated with the ROI are transferred ahead of those associated with the background. Therefore, when an image is coded with an emphasis of ROI, it is necessary to identify the coefficients required for the reconstruction of the ROI. Thus, a ROI mask is introduced to indicate which coefficients have to be transmitted exactly in order for the receiver to reconstruct the ROI. Usually, the wavelet transform (Burrus et. al., 1998; I. Daubechies, 1998) is applied to the image at the encoder side and the resulting coefficients not associated with the ROI are scaled down (shifted down) so that the ROI associated bits are placed in higher bit planes The mask in wavelet domain is a map pointing out all the related coefficients for the reconstruction of the ROI. The corresponding locations of the coefficients in next scale are calculated from the current scale. An example calculation of the ROI mask is as follows (Liu et. al. 2004):

Let R^n the wavelet domain of an image and $\Omega \in R^n$ the Region of Interest. The characteristic function $\chi_\Omega(x)$ is defined as:

$$\chi_\Omega(x) = \begin{cases} 1, & \text{if } x \in \Omega \\ 0, & \text{if else} \end{cases} \qquad (1)$$

Then the ROI mask will be generated according to:

$$g_i(x) = (\tilde{W}_i \circ x_\Omega)(x) + \tilde{I}_i x_\Omega(x) \qquad i \in \Lambda \qquad (2)$$

where $\tilde{W}_i$ stands for the wavelet operator for the i^{th} subband, Λ is the index set of all subbands and $\tilde{I}_i$ is identity operator equipped with down-sampling operation respectively.

ROI coding has been applied on different types of medical images. For instance, MAXSHIFT of JPEG2000 (ISO/IEC JTC 1/SC 29/WG 1 (ITU-T SG8), JPEG 2000 Part II Final Committee Draft, 2000), set partitioning in hierarchical trees (SPIHT) (A. Said and W.A. Pearlman, 1996), embedded block coding with optimized truncation (EBCOT) (Taubman, 2000), adaptive integer wavelet transforms (IWTs) (Minami et. al. 2001) and region-based discrete wavelet transform (RB-DWT) (S. Li and W. Li, 2000) are the most common transformations utilized for region coding on still medical images. Variations of the aforementioned algorithms have been proposed for application on volumetric (i.e. three dimensional) images (e.g., 3D SPHIT (Xiong et. al., 1998)). Additional techniques allow the implementation of multiple and arbitrary ROI coding as well as dynamic coding for scalable medical image compression. Regarding medical video compression, similar techniques allow the annotation of regions with higher diagnostic importance within the video sequence (Liu et. al., 2004). Figure 1 presents two medical image samples and a medical video image compressed using ROI coding.

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