Lossless Compression of ROI in Coronary Angiogram Sequences

Zahra Saffaryazdi

me@nastaran-saffar.me

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Department of Electrical and Computer Engineering

Isfahan University of Technology, Isfahan 84156-83111, Iran

S. Samavi, Prof. (Supervisor), samavi96@cc.iut.ac.ir

M. Davarpanah Jazi, Assist. Prof. (Supervisor), mdjazi@cc.iut.ac.ir

Abstract

One of the most important reasons of heart attack is the narrowing of arteries. Coronary angiography is an efficient x-ray examination for diagnosing coronary artery diseases and diagnosing blocked arteries. Also the abnormalities in the blood vessels such as stenosis can be diagnosed. During the angiography procedure, a narrow tube, that is called a catheter, enters the vessel from groin region. After placing catheter in the heart or in the entrance of the feeding arteries of the heart a contrast agent is injected through. Then a number of X-Ray images, which are called angiogram, are taken. Blood vessels become visible after the injection and an expert can diagnose coronary artery diseases without the need for a hard invasive operation .

For a patient this procedure takes 4 to 5 minutes during which about 4000 images are taken. The size of these images is typically 512×512 pixels. Usually these images are taken at a speed of 30 frames per second with at least 8-bit pixels. The size of the raw data in this procedure is approximately 2.5 GB. Storage and transmission of this large amount of data is a challenge for hospitals. Efficient compression of these data files is an inevitable requirement.

Image sequences from digital angiography contain areas of high diagnostic interest. Loss of information due to compression for regions of interest (ROI) in angiograms is not tolerable. Due to the sensitivity of the medical data in medical images, lossless methods are preferred. But the maximum compression ratio in these methods is about 2 or 3:1. The compression ratio in the Lossy methods is always higher than those of the lossless methods. On the other hand, in the lossy methods some important medical details may be lost and diagnostic errors may occur . By analysing angiogram images it is concluded that large areas of each frame does not contain diagnostically important information. Therefore it is concluded that using of lossy methods for some parts of an image can be medically acceptable.

In the literature a lot of work is done on the lossless and lossy compression of the angiogram images. Some of these researches identify a region of interest (ROI) and allocate more bit budget for the diagnostically important regions. These methods are based on both 2D and 3D techniques similar to the video compression methods.

Researchers compared inter-frame and intra-frame methods such as wavelet, DCT and motion estimation algorithm in a study. Then they presented a lossy method that first removes spatial correlation by using wavelet, and then temporal correlation by motion estimation. Also researchers have presented an ROI-based method where by modelling image motions, the image is segmented into diagnostically important and diagnostically non-important regions. Then the images are compressed with a 3D SPIHT algorithm. In mentioned method the ROI is compressed with more accuracy. In another study researchers have replaced DCT with wavelets in MPEG and compressed these images in a lossy manner. Also a modified H.264 video compression method applied for the compression of the 3D Angiogram images. In another research a lossless method that worked based on the motion estimation and a context adaptive predictor was presented.

In this thesis both lossy and lossless techniques are applied to the angiogram images. In these images there are regions where no vessels are present. Therefore preserving all of the details of these regions would not serve the diagnostic procedures. In our method we either do not store any data for some of these regions or encode them in a lossy manner. For regions where arteries are present, lossless encoding is applied. In our method, first of all, all frames are partitioned into non-overlapped blocks. The blocks are categorized into ROI and non-ROI ones by applying an edge detection algorithm. Then we removed some of the blocks using temporal correlations among the non-ROI blocks of consecutive frames. Also by some loss of information in the rest of non-ROI blocks based on quantization or by application of an integer wavelet, we decrease the volume of data. We used different prediction methods for the ROI and Non-ROI blocks based on different characteristics of these blocks based on spatial and temporal correlations. We identified nine contexts based on the intensity and importance of each block. By applying theses contexts to all of the blocks of a sequence we took advantage of the context modelling. In the final step we coded every context with adaptive arithmetic coding. The implementation results show that our algorithm is more successful in compression of the angiograms as compared to standard compression routines such as JPEG-LS and JPEG-3D .

Key Words

Coronary Angiography, angiogram sequences, Region of Interest, compression, context modeling