Progressive and interactive modes of image transmission: optimized wavelet-based image representation

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Introduction

Enhancement of image data transmission for telediagnosis and PACS/RIS applications. We look for scalable image data representation to increase diagnostic quality of progressively encoded, transmitted and reconstructed image exams in relation to amount of processed bits. Energy packing in the areas of diagnostically important image features and extraction of pathology symptoms was sought.

We studied and designed the following compression modes and conditions to make image representation more user friendly:

a) possibility of interactive influence on the parameters of transmitted data stream;

b) region of interest (ROI) progression;

c) diagnostic quality progression;

d) useful interface.

Materials

We used images of different modality, especially huge mammograms and radiograms. Mammograms were collected from 3 Warsaw medical centers. Other reference mammograms were taken from DDSM. Radiograms were collected from Internet sources. More medical test images were taken from JPEG and JPEG2000 test data files. Over 100 images were considered. Network infrastructure of Warsaw University of Technology was used in the experiments.

Methods

First of all JPEG2000-based image encoder (accepted by DICOM) was optimized but other multi-scale decompositions and data stream forming techniques were considered. We studied a possibility of wavelet decomposition enhancement (kernels and subband distribution) and modified rate-distortion optimization by improvement of a procedure of data stream creation and forming. We performed our experiments in collaboration with radiologists.

- JPEG2000 medical standard

An important reason for this DICOM acceptance was that it allows transmission of images with improving resolution and quality, which will be extremely useful in teleradiology and in some PACS network environments. The adoption of JPEG2000 as a standard by the ISO and its inclusion into DICOM is a validation of the newer technology and the logical result of the desire for a more advanced yet standardized method of compression and transmission of medical images.

- Acceleration of coding: faster rate control

Standard quality and precise rate control procedure was accelerated by proposed algorithm of information selection with passes sorting (ISPS). Time consuming iterative procedure was replaced by R-D sorting of successive data block.

- Optimization of coding: selection of decomposition and progression

Useful interface with clearly defined options of coding process was realized. Experimental selection of coding parameters allowed establishing JPEG2000 presets for mammograms, radiograms, CT, MR and US exams. The following parameters were optimized: wavelet base, multiscale decomposition, progression mode.

- Acceleration of transmission: Progressive Interactive Internet Codec (PIIC)

Essential codec feature is progressive image data stream decoding and reconstruction in interactive process. High performance of 'image source device' – 'image diagnosis station' connection was assured.

Results

High efficiency of progressive and interactive transmission was realized. Significantly increased quality of images in comparison to JPEG2000 (part I) and JPEG coders was noticed. PSNR and subjective rating was used as the image quality measures. Moreover, accelerated compression process was achieved and different progression modes were verified (interactively ROI-oriented, layers, resolution and precincts-oriented).

Conclusions

JPEG2000 standard describes effective tools for progressive image data transmission in digital medical imaging applications: PACS-RIS, telediagnosis, CADs. However, optimization of data transformation, selection and stream forming procedures can significantly improve standard implementations available nowadays in the market. Diagnostic quality enhancement and accelerating coding process of applied compression tools can actually improve image-oriented real-time diagnostic systems.