Image and Vision Computing 28 (2010) 449–457

Contents lists available at ScienceDirect

Image and Vision Computing

journal homepage: www.elsevier.com/locate/imavis

SVD lossy adaptive encoding of 3D digital images for ROI progressive transmission ☆

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ARTICLE INFO

Article history:
Received 18 August 2006
Received in revised form 26 June 2009
Accepted 11 July 2009

Keywords:
3D digital images
Singular value decomposition encoding
Lossy progressive transmission
Region of interest (ROI) transmission

ABSTRACT

In this paper, we propose an algorithm for lossy adaptive encoding of digital three-dimensional (3D) images based on singular value decomposition (SVD). This encoding allows us to design algorithms for progressive transmission and reconstruction of the 3D image, for one or several selected regions of interest (ROI) avoiding redundancy in data transmission. The main characteristic of the proposed algorithms is that the ROIs can be selected during the transmission process and it is not necessary to re-encode the image again to transmit the data corresponding to the selected ROI. An example with a data set of a CT scan consisting of 93 parallel slices where we added an implanted tumor (the ROI in this example) and a comparative with JPEG2000 are given.

1. Introduction

The process of progressive transmission (Fig. 1) can be described in the following seven steps:

(1) An image is acquired and stored in the image server.
(2) In the server, the image is decomposed into "pieces", called *regions*, in a chosen way: these regions can be parts of the original image, parts of some transformation of the image or parts of an appropriate encoding of some transformation of the image.
(3) A region of the decomposed image is chosen, following given criteria, and then is transmitted to the client.
(4) The client uses the received data (regions) to make an approximation of the original image, using an adequate reconstruction algorithm.
(5) A new region among the untransmitted ones is chosen and the server transmits it to the client.
(6) The client adds the just received region to the already transmitted ones, and uses the whole set of received regions to reconstruct a new approximation of the original image with improved quality.
(7) Steps 5 and 6 are repeated until
   (a) the transmission is stopped if the image appears not to be of interest, or
   (b) the transmission is stopped if a better approximation is not needed, or
   (c) the complete set of data is received if the full data set seems to be desirable, or
   (d) a feature within the image that seems to be of interest now and the process should be modified to begin transmitting subsets corresponding to this feature.

Except in 7(c), bandwidth and a large amount of daily network traffic are saved improving the network performance.

7(a), 7(b) and 7(c) have been widely considered from different points of view, for instance, using some interpolation techniques [1,2], or wavelets [3–5], or other types of transforms [6], or decorrelation techniques [7], or introducing adaptive strategies in the progressive transmission [8].

However, in this paper we are interested in 7(d), to be precise; the scenario where, during the progressive transmission of an image, the client observes an emerging detail of interest, stops the transmission, selects a sub-image containing the detail, also called region of interest (ROI), and the process continues with the progressive transmission of the ROI.

The described scenario, when the client selects the ROI, may be tackled in two ways: (a) the server receives the ROI coordinates, encodes the ROI using data from the original image and transmits it progressively; (b) the server receives the ROI coordinates and it has the image encoded in such a way that allows the progressive transmission of its ROIs immediately without additional computations.

☆ This paper has been supported by the grant Programa de Incentivo a la Investigación 2005 de la UPV No. 5706 and the Generalitat Valenciana Grant AE06/001.

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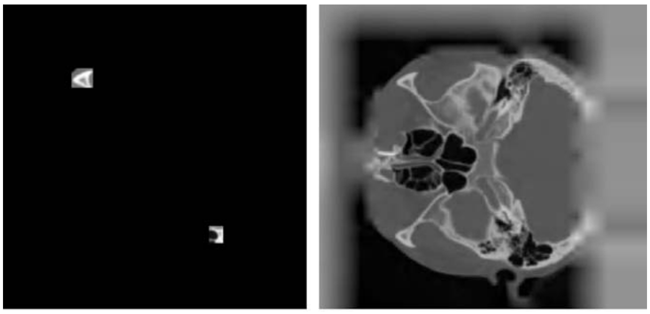
doi:10.1016/j.imavis.2009.07.004



(a) (b)

Fig. 11. Reconstruction of the ROIs at PSNR 30 dB using (a) the proposed method with singular vectors quantized with 13 bits, (b) JPEG2000.

Moreover, the proposed method improves performance when small and separated ROIs have been selected and when the gray-level resolution increases. Both methods are comparable at low ratios.

Finally, this paper has been written under an algorithmic point of view in order to allow straightforward design and implementation of automatic processes for progressive transmission of 3D images and their ROIs, in a transparent form for the final user.

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