An Efficient Wavelet Compression of CT and MRI Images in an Online Textbook

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Abstract. An efficient lossless wavelet compression including a preview feature has been implemented into the case-based online textbook ODITEB in order to increase the speed of transmission of CT and MRI images. Already downloaded parts of the data are interpreted as a lossy compressed image which is immediately shown for preview. The first such preview has a compression ratio of about 1:30 compared to the original DICOM file. After a full download the compression ratio is 1:3 and the image is identical with the original one. ODITEB is supposed to be accessible also for students using a slow internet access.

1 Introduction

ODITEB (www.oditeb.de), a radiological online textbook for tumor diagnosis [1], has a case viewer as a centerpiece. Students have the possibility to see concrete patient data including x-ray images, CT and MRI slices. Unfortunately, each case has up to more than one hundred images which is a lot of data. Up to now, only students with a fast internet connection could adequately use ODITEB. Therefore the number of possible users has been very limited. In order to avoid this problem an efficient image compression and loading strategy has been incorporated.

'Efficient' here does not only mean high compression rate, but also a short decompression time. Furthermore, the compression has to be lossless because medically significiant details have to be preserved. On the other hand, a lossless compression allows much less data reduction than a lossy one.

2 Methods

2.1 Wavelet compression

The used algorithm compresses lossless. First parts of the data are interpreted as a lossy compressed image and immediately shown as a preview. During the download the image is permanently updated. When the image is totally downloaded, it is identical with the uncompressed original DICOM image. So, one gets the benefits of both lossy and lossless compression.

The algorithm uses a wavelet transformation followed by a coding that produces an embedded bitstream. The wavelet transformation reduces the correlation in the pixel data. After transformation the coefficients become much smaller. A handy side effect of the wavelet transform reveals the significance of a coefficient. The bigger it is the more important it is for the image.

The coding uses the gained information for data reduction and for the bitstream. Bitstream means that the first part of the data can be interpreted as lossy compressed image. For that reason the coding algorithm sorts the wavelet coefficients by size. The local information, i.e. where the coefficient used to be before sorting, is saved in a tree [2,3,4].

2.2 Loading strategy

Even at a high compression rate a user with a slow internet access has to wait too long for a lossless compressed image. Thus, the bitstream property is used for generating previews.

The problem is that a single new loaded bit might change the whole image. Therefore, after loading new data the whole decompression algorithm has to be recalculated again to show an updated preview. So, the more previews are shown the more time it takes to show the image in the end. For computers with a fast internet access it is a good choice to have just a few previews and for a computer with a slow connection the user appreciates seeing all of the data he already got and therefore many previews. We solve this problem by using different concurring threads (light weight processes) for loading, decompression, and the applet itself (Fig. 2). By this

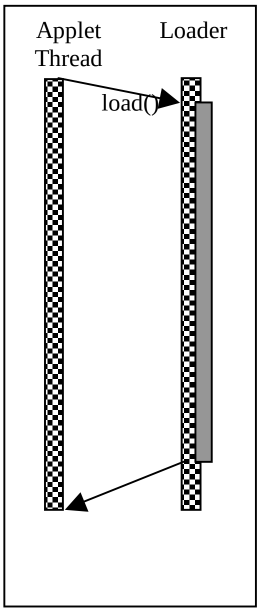

Fig.1 Sequence diagram of ODITEB 2.0

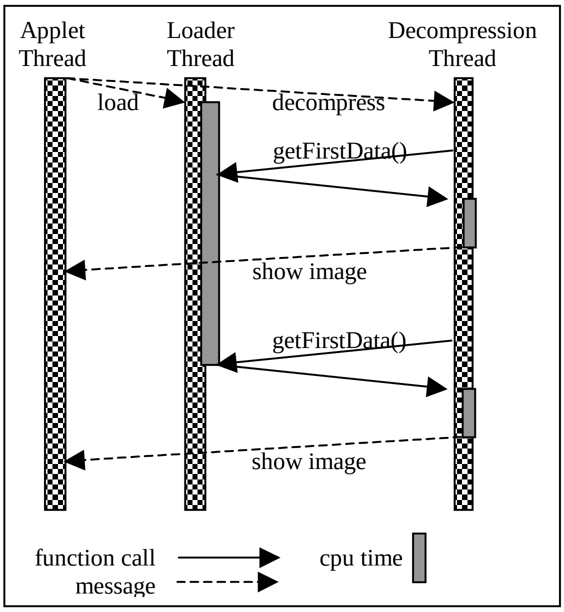

Fig.2 Sequence diagram of ODITEB 2.1

means, ODITEB automatically adapts the number of previews to its environment.

As a welcome side effect the applet is fully usable while loading an image. This has not been possible in the pervious version (Fig. 1).

The codec has been implemented in JAVA and it is part of the applet. A user does not download any plug-ins or executables.

3 Results

The algorithm has been integrated in the ODITEB case viewer written in JAVA. The first preview shows an image compressed at 16KB of data, which means a compression rate of more than 1:30 at CT images which is sufficient for a fairly good first impression. The image becomes sharper and sharper by successive updating.

Fig. 3 shows the measured compression rates. The given data are average numbers from a test with 859 different images from ODITEB. The computer used for time measurements was a Pentium II with 400Mhz and 128MB RAM running under Windows NT. That means, it was not a high-end machine. But even though the average decompression time of an image sized formerly 525KB is less than 2.5 seconds. Images sized 130KB in the DICOM format can be decompressed at even 0.5 seconds. The vertical lines in Fig. 3 indicate different stacks of images of a case in ODITEB. Since there are higher frequencies in images of a lung than in images of the rectal section, the latter ones can be compressed more effectively. Another reason for these clusters is a different quality of the image. The better the quality the better is the compression ratio. Images of one stack are mostly taken by the same device.

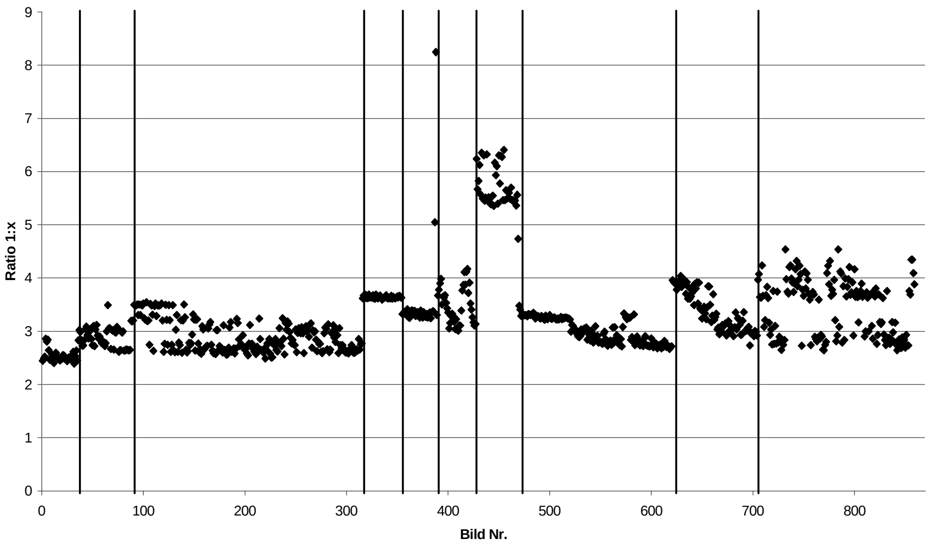

Fig 3. Compression rates. The images are ordered by cases.

The necessary time is even shorter if a mere part of the data is used for the preview. Updating reduces the artifacts of the wavelet transformation that blur the image. The fully loaded data contains a lossless compressed image at a ratio of 1: 3.2 (see Fig. 3). The decompression takes such a few time even in JAVA with a not too powerful computer, that the compression can be used together with a fast internet access like DSL without slowing down the transmission. As a welcome side effect the space used on the server and therefore the traffic is reduced at the ratio of 1:3.2, too. That also means that the offline version of ODITEB on CD may have times more cases.

The first preview of an image sized formerly 525KB is shown after about 5 seconds with an ISDN connection and 6 seconds with a modem connection. This can be calculated and also be observed in real use. The first preview is sufficient for a quite good overview of the image but it is insufficient for segmentation or filtering. A full download of an image of that size takes less than half a minute via ISDN and about 45 seconds via modem, in average.

Meanwhile, the applet is fully usable. Before the implementation of the compression the applet showed its first reaction after more than two minutes using a modem while it did not react to mouse clicks at all.

4 Discussion

The compression clearly helped to reduce transmitted data. ODITEB became more user friendly especially for people with a slow internet access by showing very soon a preview, by reducing the downloading time and by using a concurrent loading mechanism. By these means the number of possible users could be enlarged because the big group of users with a slow internet access can now use ODITEB without waiting unreasonably long.

5 References

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