JPEG 2000 in Medical Applications

Release 0.1

Mathieu Malaterre[1]

February 3, 2006

[1]Kitware Inc., 28 Corporate Drive Clifton Park 12065, NY

Abstract

The DICOM Working Group 4 (compression group) has approved in November 2001 the use of JPEG 2000 compression as part of the DICOM[4] standard. This document describes how this wavelet transform-based image compression algorithms is now integrated via GDCM[1] and OpenJPEG[2] in the Insight Toolkit ITK `www.itk.org`. GDCM version 1.2 also brings more features at user level for selecting Series, or refining result.

Contents

As of today (02/03/2006), GDCM 1.2 has been merged into ITK CVS, as well as revision 1.0 of OpenJPEG.

1 JPEG2000 Overview

JPEG2000 [5] is an image-encoding standard that provides a feature set vital to the medical imaging community. JPEG2000 provides high compression with image quality superior to all existing standard encoding techniques. This high compression and quality performance is due to the adaptation of wavelet transforms. Wavelet transforms are mathematical formulas that represent complex structures in the image, thereby compressing an extremely large amount of image data into a relatively small amount of compressed data. This compression technique allows applications to save compressed images with higher compression ratios and better image quality as compared to any other software currently in production.

The JPEG2000[3] is a complete independant specification from the usual JPEG you were used to. Indeed the standart is much broader and people useally mislead with JPEG, with in fact the JPEG 8bits lossy compression. For more info about the differences in between the different JPEG norm, go to the official JPEG website www.jpeg.org

1.1 Some key advantages of JPEG 2000 vs. JPEG

The JPEG2000[6] lossless compression option enables the archival of compressed lossless images, eliminating any concerns of the impact of compression on image quality for diagnostic purposes. Achievable compression ratios in lossless mode are 2:1 to 3:1. The scalability of JPEG2000 provides a significant benefit over traditional lossless JPEG.

- Wavelet based : better compression quality
- Scalable by resolution, quality, color channel, location in image.
- Lossless encoding, including lossy to lossless scalability
- Deep bit depths, up to 38 bits.
- Region of Interest encoding and progressive decoding.
- Error resilience.

1.2 Legal issues

During JPEG 2000 development, the mathematical background of the compression method was subject to multiple patent litigation. Most notably by LizardTech, claiming US patent #5,710,835 (developed by Los Alamos National Laboratories, and licensed by Lizardtech). In October 2005, the US Court of Appeals for the Federal Circuit affirmed ER Mapper did not infringe LizardTech patent http://www.ermapper.com/jpeg2000/standards/legal_october.pdf.

> It has always been a strong goal of the JPEG committee that its standards should be implementable in their baseline form without payment of royalty and license fees, and the committee would like to record their disappointment that some organisations appear to be working in conflict with this goal. Considerable time has been spent in committee in attempting to either arrange licensing on these terms, or in avoiding existing intellectual property, and many hundreds of organisations and academic communities have supported us in our work.
>
> The up and coming JPEG 2000 standard has been prepared along these lines, and agreement reached with over 20 large organisations holding many patents in this area to allow use of their intellectual property in connection with the standard without payment of license fees or royalties.

http://www.jpeg.org/newsrel1.html

As a side note, although JPEG 2000 format supports lossless encoding, it is not intended to completely supersede all lossless image file formats. For instance the PNG file format (Portable Network Graphics) is more space-efficient in the case of images with many pixels of the same color.

2 Managing a Series of files

Most of the time the user received a set of unorganized DICOM files. The first step is then to organize, order this list of file properly in order to reconstruct the 3D volume. This task can be time consuming, and therefore we need to provide the user with a set of functionalities to help him achieve this.

2.1 Applying restrictions on known values

The first case is when the user knows which slides he need to look at, or run his algorithm on. In this case the user has a knownedlget the DICOM library has not. For instance let say that on the 1000 files he is working on, the user wants to select only the slice 500 to 600. For this he would do the following code:

```
typedef itk::Image<unsigned short,3>            ImageType;
typedef itk::GDCMImageIO                        ImageIOType;
typedef itk::GDCMSeriesFileNames                SeriesFileNames;

ImageIOType::Pointer gdcmIO = ImageIOType::New();
SeriesFileNames::Pointer it = SeriesFileNames::New();

// Get the DICOM filenames from the directory
gdcm::SerieHelper *sh = it->GetSeriesHelper( );
// This is the specific DICOM Tag that contains :
//      0020 0013 IS 1 Instance Number
sh->AddRestriction(0x0020, 0x0013, "500", gdcm::GDCM_GREATEROREQUAL);
sh->AddRestriction(0x0020, 0x0013, "600", gdcm::GDCM_LESSOREQUAL);
it->SetInputDirectory( argv[1] );
```

2.2 Applying restrictions on unknown values

An other case is that the user does not know in advance the value. In the process of saving of anonymizing the DICOM files, the Series UID is then not enough to specificaly designate a Series. Therefore the user need to specify the DICOM library to look for other DICOM tag in order to refine the notion of Series. This is also done through the AddRestriction call, but this time on the itk::GDCMSeriesFileNames object. Another great example is during a dual echo time acquisition (T1 and T2), the series are interlaced, and therefore need to de-interlaced for further post processing.

```
typedef itk::GDCMSeriesFileNames NamesGeneratorType;
NamesGeneratorType::Pointer nameGenerator = NamesGeneratorType::New();

nameGenerator->SetUseSeriesDetails( true );
// Refine on the Echo Time
nameGenerator->AddRestriction("0018|0081" );

nameGenerator->SetDirectory( argv[1] );
```

3 Acknowledgements

We would like to thank the OpenJPEG (www.openjpeg.org) project for releasing an open source implementation of the JPEG2000 codec. In particular, thanks to Antonin Descampe for fixing the 'well known' 16bits j2k issue.

References

[1] Eric Boix, Mathieu Malaterre, Benoit Regrain, and Jean-Pierre Roux. *The GDCM Library*. CNRS, INSERM, INSA Lyon, UCB Lyon, http://www.creatis.insa-lyon.fr/Public/Gdcm/. (document)

[2] A. Descampe, F. Devaux, H. Drolon, D. Janssens, and Y. Verschueren. *OpenJPEG*. Université Catholique de Louvain (UCL), Belgium, http://www.openjpeg.org. (document)

[3] Michael W. Marcellin, Michael J. Gormish, Ali Bilgin, and Martin P. Boliek. An overview of JPEG-2000. In *Data Compression Conference*, pages 523–544, 2000. 1

[4] NEMA. The dicom standard. Technical report, NEMA, http://medial.nema.org/, 2004. (document)

[5] Alexis Tzannes and Touradj Ebrahimi. Jpeg 2000 for medical imaging applications. Technical report, ISO/IEC JTC1/SC29 WG1 Committee, November 2002. 1

[6] Lev Weisfeiler. Some key advantages of jpeg 2000. Technical report, Aware Inc., http://medical.nema.org/Dicom/minutes/WG-04/2002/2002-02-27/Weisfeiler.doc, February 2002. 1.1