

DICOM Correction Item

Change Proposal Number: CP-174	
Abstract: Add support for JPEG-LS Transfer Syntaxes	
	Type of Change Proposal: Addition
Name of Document: Part 5: Data Structures and Encoding, Part 6: Data Dictionary	Version Number: PS 3.5-1999, PS 3.6-1999
Rationale for change: <p>The state of the art in lossless compression has improved considerably since the original JPEG processes were proposed and incorporated in DICOM.</p> <p>The JPEG working group has created a new standard, ISO 14495-1 (JPEG-LS) that defines a state of the art predictive scheme using a very effective statistical modeller with low complexity entropy coding and a run length escape mechanism. Experiments with large sets of medical images indicate a mean compression ratio of 3.81 for JPEG-LS in lossless mode compared with 3.06 for JPEG lossless mode with Huffman encoding choosing the best predictor for each image, or 2.80 for selection value 1 (the most commonly used in DICOM).</p> <p>Using JPEG-LS could result in considerable savings in transfer time or media space compared with the current DICOM transfer syntaxes. The JPEG-LS process is also extremely simple and fast compared to existing JPEG lossless. Several source code implementations are available freely on the Internet. No license fees are required to use the JPEG-LS standard.</p> <p>Since the bit stream syntax of JPEG-LS is almost identical to JPEG, the same encapsulation mechanism can be used in DICOM without any change.</p> <p>JPEG-LS also offers a so-called "near-lossless" mode that allows one to constrain the absolute error for pixels to a fixed value. This is a totally different approach to lossy compression compared to the DCT or wavelet based schemes, and may have interesting medical applications for visually lossless compression. It is still lossy, however.</p> <p>Accordingly, two new transfer syntaxes are proposed for JPEG-LS in DICOM, one for lossless compression and another for lossy (near-lossless) compression.</p> <p>Note especially that the JPEG-LS is added without requiring an implementation to support a "base-line" of existing JPEG lossless encoding, since:</p> <ul style="list-style-type: none">a) this is an unnecessary burden on implementers,b) a baseline of uncompressed is always available on the network, guaranteeing interoperability at this level, andc) baselines are not applicable for media since transfer syntaxes are fully specified in the media application profile. <p>However, the lossless mode of JPEG-LS is required to be supported as a baseline when the loss</p>	

Correction wording:

Item: Amend PS 3.5 Section 2 Normative references:

ISO/IS 10918-1	JPEG Standard for digital compression and encoding of continuous-tone still images. Part 1—Requirements and implementation guidelines
ISO/IS 10918-2	DRAFT: JPEG Standard for digital compression and encoding of continuous-tone still images. Part 2—Testing
ISO/IS 14495-1	<u>Lossless and near-lossless coding of continuous tone still images (JPEG-LS)</u>

Item: Add to PS 3.5 Section 8.2.3:

8.2.3 JPEG-LS IMAGE COMPRESSION

DICOM provides a mechanism for supporting the use of JPEG-LS Image Compression through the Encapsulated Format (see PS 3.3). Annex A defines a number of Transfer Syntaxes which reference the JPEG-LS Standard and provide a number of lossless (bit preserving) and lossy (near-lossless) compression schemes.

Note: The context where the usage of lossy (near-lossless) compression of medical images is clinically acceptable is beyond the scope of the DICOM Standard. The policies associated with the selection of appropriate compression parameters (e.g. compression ratio) for JPEG-LS lossy (near-lossless) compression is also beyond the scope of this standard.

The use of the DICOM Encapsulated Format to support JPEG-LS Compressed Pixel Data requires that the Data Elements which are related to the Pixel Data encoding (e.g. Photometric Interpretation, Samples per Pixel, Planar Configuration, Bits Allocated, Bits Stored, High Bit, Pixel Representation, Rows, Columns, etc.) shall contain values which are consistent with the characteristics of the compressed data stream. The Pixel Data characteristics included in the JPEG-LS Interchange Format shall be used to decode the compressed data stream.

Note: See also the notes in section 8.2.1.

Item: Add to PS 3.5 Section 10.5:

10.5 TRANSFER SYNTAX FOR A DICOM DEFAULT OF LOSSLESS AND LOSSY (NEAR-LOSSLESS) JPEG-LS COMPRESSION

One Transfer Syntax is specified for JPEG-LS Lossless Image Compression, and one Transfer Syntax is specified for JPEG-LS Lossy (Near-Lossless) Image Compression. The JPEG-LS Lossless Transfer Syntax shall be supported as a baseline if the JPEG-LS Lossy (Near-Lossless) Transfer Syntax is supported.

Item: Amend PS 3.5 Section A.4:

A.4 TRANSFER SYNTAXES FOR ENCAPSULATION OF ENCODED PIXEL DATA

...

- c) The encoding of the Data Elements of the Data Set shall be as follows according to their Value Representations:

...

- All items containing an encoded fragment shall be made of an even number of bytes greater or equal to two. The last fragment of a frame may be padded, if necessary, to meet the sequence item format requirements of the DICOM Standard.

- Notes:
1. Any necessary padding may be added in the JPEG **or JPEG-LS** compressed data stream as per ISO 10918-1 **and ISO 14495-1** such that the End of Image (EOI) marker ends on an even byte boundary, or may be appended after the EOI marker, depending on the implementation.
 2. ISO 10918-1 **and ISO 14495-1** defines the ability to add any number of padding bytes FFH before any marker (all of which also begin with FFH). It is strongly recommended that FFH padding bytes not be added before the Start of Image (SOI) marker.

Item: Add to PS 3.5 Section A.4.3:

A.4.3 JPEG-LS IMAGE COMPRESSION

The International Standards Organization ISO/IEC JTC1 has developed an International Standard, ISO/IS-14495-1 (JPEG-LS Part 1), for digital compression and coding of continuous-tone still images. (See Annex F for further details.)

A DICOM Transfer Syntax for JPEG-LS Image Compression shall be identified by a UID value, appropriate to its JPEG-LS coding process.

Two Transfer Syntaxes are specified for JPEG-LS:

1. A Transfer Syntax with a UID of 1.2.840.10008.1.2.4.80, which specifies the use of the lossless mode of JPEG-LS. In this mode the absolute error between the source and reconstructed images will be zero.
2. A Transfer Syntax with a UID of 1.2.840.10008.1.2.4.81, which specifies the use of the near-lossless mode of JPEG-LS. In this mode, the absolute error between the source and reconstructed images will be constrained to a finite value that is conveyed in the compressed bit stream. Note that this process can, at the discretion of the encoder, be used to compress images with an error constrained to a value of zero, resulting in no loss of information.

If the object allows multi-frame images in the pixel data field, then each frame shall be encoded separately. Each fragment shall contain encoded data from a single-frame image.

For all images, including all frames of a multi-frame image, the JPEG-LS Interchange Format shall be used (all parameter specifications shall be included).

Item: Add to PS 3.5 Section F.2:

F.2 ENCAPSULATED JPEG-LS ENCODED IMAGES

The International Standards Organization (ISO/IEC JTC1/SC2/WG10) has prepared an International Standard, ISO/IS-14495-1 (JPEG-LS Part 1), for the digital compression and coding of continuous-tone still images. This standard is known as the JPEG-LS Standard.

Part 1 of the JPEG-LS Standard sets out requirements and implementation guidelines for the coded representation of compressed image data to be interchanged between applications. The processes and representations are intended to be generic in order to support the broad range of applications for color and grayscale still images for the purpose of communications and storage within computer systems.

The JPEG-LS Standard specifies a single lossy (near-lossless) code process that can achieve lossless compression by constraining the absolute error value during encoding to zero. The lossless and lossy (near-lossless) coding is based on a predictive scheme with statistical modeling, in which differences between pixels and their surround are computed and their context modeled prior to coding, with a run-length escape mechanism. This scheme achieves consistently better compression in lossless mode than the lossless processes of JPEG defined in ISO 10918-1, with less complexity.

Though a different coding process from those specified in ISO 10918-1 is used, the syntax of the encoded bit stream is closely related.

A single JPEG-LS process is used for bit depths up to 16 bits.

Inclusion of a JPEG-LS coded image in a DICOM message is facilitated by the use of specific Transfer Syntaxes that are defined in Annex A.

Item: Add to PS 3.6 Registry of DICOM unique identifiers (UID)

Table A-1
UID VALUES

UID Value	UID NAME	UID TYPE	Part
1.2.840.10008.1.2.4.80	JPEG-LS Lossless Image Compression	Transfer Syntax	PS 3.5
1.2.840.10008.1.2.4.81	JPEG-LS Lossy (Near-Lossless) Image Compression	Transfer Syntax	PS 3.5