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Correction Number CP-2301
Log Summary: Clarify applicability of RLE and JPEG 2000 Transfer Syntax to single bit images such as binary segmentations
Name of Standard
PS3.5
Rationale for Correction:
The RLE and JPEG 2000 compression scheme support compression of single bit images, but when CP 1653 clarified constraints for Transfer Syntaxes by adding to PS 3.5, it was not recognized that this should be explicitly supported for images with a Bits Allocated of 1, such as BINARY segmentations.
Correction Wording:

Amend DICOM PS3.5 as follows (changes to existing text are bold and underlined for additions and ~~struckthrough~~ for removals):

8.2.2 Run Length Encoding Image Compression

DICOM provides a mechanism for supporting the use of Run Length Encoding (RLE) Image Compression, which is a byte oriented lossless compression scheme through the encapsulated Format (see PS3.3 of this Standard). ??? defines RLE Image Compression and its Transfer Syntax.

Note

The RLE Image Compression algorithm described in ??? is the compression used in the TIFF 6.0 specification known as the "PackBits" scheme.

The use of the DICOM Encapsulated Format to support RLE Compressed Pixel Data requires that the Data Elements that 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 that are consistent with the compressed data.

The requirements when using a Standard Photometric Interpretation (i.e., a Defined Term from PS.3. C.7.6.3.1.2) are specified in Table 8.2.2-1. No other Standard Photometric Interpretation Values shall be used.

Table 8.2.2-1. Valid Values of Pixel Data Related Attributes for RLE Compression using Standard Photometric Interpretations

Photometric Interpretation	Samples per Pixel	Planar Configuration	Pixel Representation	Bits Allocated	Bits Stored	High Bit
MONOCHROME1	1	absent	0 or 1	<u>1</u> , 8 or 16	1-16	0-15
MONOCHROME2						
PALETTE COLOR	1	absent	0	8 or 16	1-16	0-15
YBR_FULL	3	0 or 1	0	8	1-8	0-7
RGB	3	0 or 1	0	8 or 16	1-16	0-15

Note

- These requirements were formerly specified in terms of the "uncompressed pixel data from which the compressed data was derived". However, since the form of the "original" uncompressed data stream could vary between different implementations, this requirement is now specified in terms of consistency with what is encapsulated.
- Those characteristics not implied by the definition of the compression scheme (e.g., always color-by-plane in RLE), can therefore be determined from the DICOM Data Element in the enclosing Data Set. For example a Photometric Interpretation of "YBR_FULL" would describe the color space that is commonly used to losslessly compress images using RLE. It is unusual to use an RGB color space for RLE compression, since no advantage is taken of correlation between the red, green and blue components (e.g., of luminance), and poor compression is achieved (note however that the conversion from RGB to YBR_FULL is itself lossy. A new photometric interpretation may be proposed in the future that allows lossless conversion from RGB and also results in better RLE compression ratios).
- DICOM Data Elements should not describe characteristics that are beyond the capability of the compression scheme used. For example, RLE compressed data streams (using the algorithm mandated in the DICOM Standard) are always color-by-plane.
- If RLE Compressed Pixel Data is decompressed and re-encoded in Native (uncompressed) form, then the Data Elements that are related to the Pixel Data encoding are updated accordingly. If color components are converted from YBR_FULL to RGB during decompression and Native re-encoding, the Photometric Interpretation will be changed to RGB in the Data Set with the Native encoding. It is permitted, however, to leave the YBR_FULL color components unconverted but decompressed in the Native format, in which case the Photometric Interpretation in the Data Set with the Native encoding would be YBR_FULL.
- A Bits Allocated (0028,0100) of 1 for monochrome images supports compression of Segmentation IOD Pixel Data with a Segmentation Type (0062,0001) of BINARY.**

8.2.4 JPEG 2000 Image Compression

DICOM provides a mechanism for supporting the use of JPEG 2000 Image Compression through the Encapsulated Format. ??? defines a number of Transfer Syntaxes that reference the JPEG 2000 Standard and provide lossless (bit preserving) and lossy compression schemes.

Note

The context where the usage of lossy 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 2000 lossy compression are also beyond the scope of this Standard.

The use of the DICOM Encapsulated Format to support JPEG 2000 Compressed Pixel Data requires that the Data Elements that 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 that are consistent with the characteristics of the compressed data stream. The Pixel Data characteristics included in the JPEG 2000 bit stream shall be used to decode the compressed data stream.

The requirements when using a Standard Photometric Interpretation (i.e., a Defined Term from PS.3. C.7.6.3.1.2) are specified in Table 8.2.4-1. No other Standard Photometric Interpretation Values shall be used.

Table 8.2.4-1. Valid Values of Pixel Data Related Attributes for JPEG 2000 Transfer Syntaxes using Standard Photometric Interpretations

Photometric Interpretation	Transfer Syntax	Transfer Syntax UID	Samples per Pixel	Planar Configuration	Pixel Representation	Bits Allocated	Bits Stored	High Bit
MONOCHROME1	JPEG 2000 (Lossless Only)	1.2.840.10008.1.2.4.90	1	absent	0 or 1	1, 8, 16, 24, 32 or 40	1-38	0-37
MONOCHROME2	JPEG 2000	1.2.840.10008.1.2.4.91						
PALETTE COLOR	JPEG 2000 (Lossless Only)	1.2.840.10008.1.2.4.90	1	absent	0	8 or 16	1-16	0-15
YBR_RCT	JPEG 2000 (Lossless Only)	1.2.840.10008.1.2.4.90	3	0	0	8, 16, 24, 32 or 40	1-38	0-37
	JPEG 2000	1.2.840.10008.1.2.4.91						
YBR_ICT	JPEG 2000	1.2.840.10008.1.2.4.91	3	0	0	8, 16, 24, 32 or 40	1-38	0-37
RGB	JPEG 2000 (Lossless Only)	1.2.840.10008.1.2.4.90	3	0	0	8, 16, 24, 32 or 40	1-38	0-37
	JPEG 2000	1.2.840.10008.1.2.4.91						
YBR_FULL	JPEG 2000 (Lossless Only)	1.2.840.10008.1.2.4.90	3	0	0	8, 16, 24, 32 or 40	1-38	0-37
	JPEG 2000	1.2.840.10008.1.2.4.91						

Note

These requirements are specified in terms of consistency with what is encapsulated, rather than in terms of the uncompressed pixel data from which the compressed data stream may have been derived.

When decompressing, should the characteristics explicitly specified in the compressed data stream be inconsistent with those specified in the DICOM Data Elements, those explicitly specified in the compressed data stream should be used to control the decompression. The DICOM Data Elements, if inconsistent, can be regarded as suggestions as to the form in which an uncompressed Data Set might be encoded, subject to the general and IOD-specific rules for uncompressed Photometric Interpretation and Planar Configuration, which may require that decompressed data be converted to one of the permitted forms.

The JPEG 2000 bit stream specifies whether or not a reversible or irreversible multi-component (color) transformation [ISO 15444-1 Annex G], if any, has been applied. If no multi-component transformation has been applied, then the components shall correspond

to those specified by the DICOM Attribute Photometric Interpretation (0028,0004). If the JPEG 2000 Part 1 reversible multi-component transformation has been applied then the DICOM Attribute Photometric Interpretation (0028,0004) shall be YBR_RCT. If the JPEG 2000 Part 1 irreversible multi-component transformation has been applied then the DICOM Attribute Photometric Interpretation (0028,0004) shall be YBR_ICT.

Note

1. For example, single component may be present, and the Photometric Interpretation (0028,0004) may be MONOCHROME2.
2. The application of a JPEG 2000 Part 1 reversible multi-component transformation is signaled in the JPEG 2000 bit stream by a value of 1 rather than 0 in the SGcod Multiple component transformation type of the COD marker segment [ISO 15444-1 Table A.17]. No other Value of Photometric Interpretation than YBR_RCT or YBR_ICT is permitted when SGcod Multiple component transformation type is 1.
3. Though it would be unusual, would not take advantage of correlation between the red, green and blue components, and would not achieve effective compression, a Photometric Interpretation of RGB could be specified as long as no multi-component transformation [ISO 15444-1 Annex G] was specified by the JPEG 2000 bit stream. For some applications the use of RGB is permitted, e.g., Whole Slide Microscopy Images, to allow conversion to DICOM from proprietary formats without loss due to color space transformation. Alternative methods of decorrelation of the color components than those specified in [ISO 15444-1 Annex G] are permitted as defined in PS3.3, such as a Photometric Interpretation of YBR_FULL; this may be useful when converting existing YBR_FULL Pixel Data (e.g., in a different Transfer Syntax) without further loss.

In either case (Photometric Interpretation of RGB or YBR_FULL), the value of SGcod Multiple component transformation type would be 0.

PS3.3 may constrain the Values of Photometric Interpretation for specific IODs.
4. Despite the application of a multi-component color transformation and its reflection in the Photometric Interpretation Attribute, the "color space" remains undefined. There is currently no means of conveying "standard color spaces" either by fixed values (such as sRGB) or by ICC profiles. Note in particular that the JP2 file header is not sent in the JPEG 2000 bit stream that is encapsulated in DICOM.
5. If JPEG 2000 Compressed Pixel Data is decompressed and re-encoded in Native (uncompressed) form, then the Data Elements that are related to the Pixel Data encoding are updated accordingly. If color components are converted from YBR_ICT or YBR_RCT to RGB during decompression and Native re-encoding, the Photometric Interpretation will be changed to RGB in the Data Set with the Native encoding.
6. The upper limit of 40 on Bits Allocated (0028,0100) and 38 on Bits Stored (0028,0101) reflects the maximum JPEG 2000 sample precision of 38 and the DICOM requirement to describe Bits Allocated (0028,0100) as multiples of bytes (octets).
7. **A Bits Allocated (0028,0100) of 1 for monochrome images supports compression of Segmentation IOD Pixel Data with a Segmentation Type (0062,0001) of BINARY.**